Jeevika Weerahewa
Andrew Jacque *Editors*

Agricultural Policy Analysis

Concepts and Tools for Emerging Economies

Springer

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Foreword

This volume is a most welcome contribution at a time when, more than ever, debates about major policy initiatives and measures need to be based on careful, rigorous scientific analysis of the issues and evidence rather than on assertions and sweeping generalisations ungrounded in theory or facts.

The absence of scientific analysis enables vested interests to capture and corrupt policy debates using so-called common-sense arguments. Unfortunately, 'common sense' tells us that the earth is flat and the sun moves around the earth; it is scientific analysis that helps us to go beyond the surface appearance to understand the deeper reality. This volume presents a clear conceptual framework, and the essential tools and techniques for policy analysis with illustrative examples of their application to agricultural sector issues, thereby enabling deeper analyses of public policy.

This volume will help train a new generation of policy analysts and, hopefully, they will contribute to analytically informed, evidence-based discussions.

Though the focus of the volume is on agricultural policy analysis, the conceptual framework and methodology presented and elaborated in this volume are applicable more widely to public policy analysis in general.

The coverage of topics is both comprehensive and appropriate. The basic economic concepts underlying policy analysis are presented very clearly, and the various chapters elaborate on practical applications of specific tools and techniques always maintaining the rigour of the underlying theoretical framework. The chapters explain how policy analysis needs to take into account the fact that agricultural sector policies (and indeed many public policies) have multiple goals and objectives, that some products or services (such as environmental services) are not marketed, and that the impact and repercussions of a particular policy may be felt beyond the immediate target sector or sub-sector (particularly important in the case of agriculture, where the sector is not only large in terms of its output and employment but also affects the entire population as consumers).

The appropriate tools and techniques are described and their applications nicely illustrated with case study applications.

The discussion of 'second-best' analysis, policy analysis in the presence of specific constraints and 'distortions' (deviations from the standard assumptions of a competitive market), is particularly welcome. Policy analysis must be based on recognition of the existence of these 'distortions', and identifying what is 'optimal' in the presence of these constraints. Unfortunately, much standard sectoral analysis is based on the usually unstated, and totally unrealistic, assumption that the rest of the economy operates with perfectly competitive markets.

I congratulate the co-editors, Professor Jeevika Weerahewa and Dr Andrew Jacque, and their colleagues who contributed to the individual chapters, for producing this valuable volume. Professor Weerahewa and Dr Jacque have drawn on their extensive experience of policy analysis, research, and teaching to identify the theory and analytical tools needed by policy analysts in a developing country, and structured the volume to meet those needs very effectively.

This is a book that can (and should) be used widely in teaching and training policy analysts, and in advanced undergraduate and postgraduate courses on economic policy. But it also deserves to find a wider audience among all those interested in serious, rigorous, and analytical discussions of public policy in Sri Lanka and internationally.

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Sisira Jayasuriya

Preface

A coherent development policy is a cornerstone in achieving the Sustainable Development Goals (SDGs). Many developing nations often accord a prominent position in their development agenda to agriculture and reform of policies governing agriculture. The latter involves identification of policy goals taking into consideration society's expectations; assessment of policy problems and their underlying causes; consideration of policy options; design of policy instruments; and selection of economically, socially, and politically feasible policy instruments to achieve the policy goals.

Policy instruments are the tools used by governments to influence the behaviour of economic agents in a society for the purpose of achieving specific policy goals. Policy instruments provide incentives as well as disincentives through compulsion, regulation, sanction, incentive, or suasion promoting some behaviours and discouraging others. Some of the most common policy instruments used in reforming agricultural sectors are domestic and trade taxes; subsidies; quantity restrictions on trade; restrictions on agricultural land transactions; changes in regional institutions mobilising savings and delivering credit and insurance; standards and certifications; zoning; changes in public investment priorities towards infrastructure; irrigation; research; and extension.

The types of policy instruments used by a government to achieve its policy goals are stated in national policies, acts, and regulations. In the Sri Lankan context, national policies present a set of statements articulating directives to achieve certain development objectives. The approval on national policies is granted by the cabinet of ministers. Acts are new laws approved by the parliament. Regulations are the directives gazetted subsequent to enactment of an act of parliament and generally consist of specific rules governing the use of a resource. The detailed implementation mechanisms are presented in projects and programmes.

Coherent policy instruments are imperative to bring the actions of numerous and varied private sector agents involved in production and marketing in line with policy goals. Generally, sector policy goals are multifaceted and often involve some significant trade-offs among the goals. Consequently, a policy instrument designed to achieve a given policy goal might act as a hindrance to achieving another policy goal. For example, an incentive to promote high-yielding varieties which are chemical fertiliser responsive could lead to unintended human health hazards and environmental degradation, while improving land productivity and farmer incomes.

Policy analysis is the science and art of evaluating various intended and unintended effects of alternative policy instruments. It primarily involves identification of cause–effect relationships. It adopts empirical approaches which are rooted in economic theory to envisage the economic behaviour of various market participants. Various quantitative and qualitative techniques are used in policy analysis with data extracted from published sources and gathered through large primary surveys. The core of this book on agricultural policy analysis is a step-by-step guide illustrating the methodology of conducting policy analysis, with examples drawn mainly from the agriculture sector of Sri Lanka.

The book is organised into 5 sections and 19 chapters. Section I provides an introduction to policy analysis, markets versus state and agriculture-based development. In Chap. 1, Jeevika Weerahewa provides an overall introduction, including the key terms used and justification for conducting policy research and policy analysis. Weerahewa takes the readers through various interconnected topics fundamental to policy analysis: the need for interventions in markets; how such interventions are implemented and communicated to the general public; policy process and policy analysis versus policy research; and what constitutes a policy analysis. In Chap. 2, H. M. Gunathilake provides a detailed overview of public policy and discusses the role of the state in a market economy through various examples from Sri Lanka and other developing countries. He emphasises the need for countries to develop institutions to emerge from the middle-income trap. In Chap. 3, D. V. Pahan Prasada discusses connections among agriculture, development, and policy and illustrates the extent to which the agricultural sector contributes towards economic growth, equity and equality, and environmental objectives.

Section II of the book presents key concepts, approaches, and measures used in policy analysis. The section begins with an overview on the global trade environment by Emalene Marcus-Burnett in Chap. 4. It presents the nature of commitments with the World Trade Organisation taking examples from Sri Lanka and a few other developing nations. In Chap. 5, Andrew Jacque presents the theoretical underpinnings of policy analysis and illustrates fundamental theoretical effects of government interventions. Starting with a discussion of welfare analysis in a general equilibrium setting, Jacque shows the welfare effects of specific policies using a partial equilibrium approach. In Chap. 6, Erandathie Pathiraja, Chatura Wijethunga, and Krishnapillai Sooriyakumar present key measures adopted by economists in measuring competitiveness and provide a series of numerical examples highlighting various methods to measure competitiveness at various points in the value chain. Focusing on agricultural markets in developing countries, the authors show how the degree of competitiveness is measured at various market levels using multiple indices. In Chap. 7, Sarath S. Kodithuwakku explains how case study research is adopted in the context of policy analysis with special reference to qualitative methods.

The next two sections of the book highlight the tools of policy analysis along with detailed descriptions of the policies analysed using alternative tools. Section III is devoted to the effects of various regulatory reforms made at the local and global level and section IV to the effects of various programmes and projects at a regional level.

Applied general equilibrium models are theoretically rigorous and their development requires high-level knowledge in economic principles and numerical skills. As a result, readymade models such as the Global Trade Analysis Project (GTAP) have become popular among applied policy analysts. In Chap. 8, Sumali Dissanayake shows how a policy experiment may be conducted using GTAP to find out the potential effects of various regional trading agreements. Gravity models have become the workhorse in applied trade analysis in the recent past. In Chap. 9, Senal A. Weerasooriya sets forth a step-by-step guide to estimate a gravity model to ascertain the effects of trade facilitation measures. Agricultural marketing issues have been at the centre of problems in Sri Lanka, and most interventions have attempted to increase production without paying much attention to marketing. In Chap. 10, Pradeepa Korale-Gedara presents the chronology of agricultural marketing interventions in paddy, discussing how market integration measures can be adopted to indirectly measure the overall effects of marketing interventions. In Chap. 11, Jeevika Weerahewa shows how market models can be used to simulate various price policies using a partial equilibrium approach.

Section IV addresses projects and programmes related to irrigation, tank restoration, extension, land tenure, land use, and climate change adaptations. Provision of irrigation water has been at the core of agriculture development agenda in most of the countries in their early stages of development. In Chap. 12, Sunil Thrikawala, Christof Batzlen, and Pradeepa Korale-Gedara show how an extended cost benefit analysis may be conducted to evaluate the worthiness of irrigation projects. In Chap. 13, Sahan T. M. Dissanayake and Shamen P. Vidanage provide a detailed account of how an economic valuation exercise is carried out when the commodity under consideration is non-marketed. Specifically, they examine how a choice modelling exercise may be performed to value ecosystem services provided by the village tank cascade system. Provision of agricultural extension has been treated as something that needs to be funded by the state in Sri Lanka; yet there is uncertainty concerning the anticipated benefits. In Chap. 14, Wasantha Athukorala explains how a randomised control trial may be conducted to ascertain the effects of a given extension provision. Land policies shape the entire rural setting. Land is an asset, and the ownership and ability to manage land are critical factors determining kinships. In Chap. 15, Dilini Hemachandra walks through various land reform policies adopted by Sri Lanka and how data gathered from primary surveys is being used to assess the effects of a land reform policy. In Chap. 16, Thaagarajah Ramilan and Jeevika Weerahewa discuss how effects of land use policy regulations are evaluated using bioeconomic models. L. H. P. Gunaratne presents how Sri Lankan farmers adopted to climate change shocks in Chap. 17.

Section V presents two case studies from Sri Lanka's agri-food sector. In Chap. 18, Nihal Atapattu presents a case where political interests grew to dominate the agenda of an economic programme in Sri Lanka. In Chap. 19, Jeevika Weerahewa, together with Dilini Hemachandra, Devesh Roy, and Buddhi Marambe, looks at the agri-food policy response of Sri Lanka to Covid-19 and discusses a potential strategy for the long run. Andrew Jacque ends the volume with an epilogue.

The book is intended for policy analysts attached to various government and non-governmental organisations. Also, undergraduate and graduate students following courses on agricultural policies and conducting thesis research will find this book useful. It is hoped that readers will gain some insight into the diverse analytical tools used by agricultural economists to analyse various policies. At the end of this book, readers will be able to analyse agricultural policies themselves employing one or more of the analytical techniques presented here, or design a project to obtain the assistance of an expert for analytical techniques which require certain specific knowledge and skills.

The editors wish to thankfully acknowledge the financial and technical support provided by the Technical Assistance to the Modernisation of Agriculture Programme, Sri Lanka (TAMAP) and editorial assistance provided by Nicola Perera.

Peradeniya, Sri Lanka — Jeevika Weerahewa
Colombo, Sri Lanka — Andrew Jacque
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Andrew Jacque is the international agriculture public policy expert on the European Union-funded Technical Assistance to the Modernisation of Agriculture Programme in Sri Lanka (TAMAP). His abiding interest is policy, strategy, planning, and implementation for agricultural and rural development and food security. In agricultural science, he holds a Diploma from the Eastern Caribbean Institute of Agriculture and Forestry and a BSc from the University of the West Indies in Trinidad and Tobago. In agricultural economics, he has an MSc, specialising in agricultural marketing, from Michigan State University and a PhD (specialising in economic development and policy analysis) from Purdue University, USA. Jacque's early professional career was as a public officer in the Ministry of Agriculture in Trinidad and Tobago and his work in agricultural policy includes assignments with the Ministry of Agriculture in Trinidad and Tobago, Grenada, St. Vincent and the Grenadines, and Sri Lanka, and with the Food and Agriculture Organisation. Jacque has lectured postgraduate courses at the University of the West Indies, worked as the senior agricultural economist with the consultancy firm Landell Mills Ltd. in the UK, and had roles as a key expert on development projects in countries in Africa, the Caribbean, and the Pacific regions.

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Abbreviations

AAP	Applied administered price
ADF	Augmented Dicky Fuller test
AFTA	ASEAN Free Trade Area
AGE	Applied general equilibrium
AMDP	Accelerated Mahaweli Development Project
AMS	Aggregate Measure of Support
AoA	Agreement on Agriculture
APTA	Asia Pacific Trade Agreement
APSIM	Agricultural Production Systems sIMulator
ARI	Accounting rate of interest
ASC	Alternative-specific constant
ASEAN	Association of Southeast Asian Nations
ASMP	Agriculture Sector Modernisation Project
ATCWG	Agricultural Technical Cooperation Working Group
AVE	Ad-valorem Equivalent
BCR	Benefit–cost ratio
BIMSTEC	Bay of Bengal Initiative on Multi-Sectoral Technical and Technical Cooperation
CAGR	Compound Annual Growth Rate
CBA	Cost–benefit analysis
C-D	Cobb–Douglas
CES	Constant elasticity of substitution
CGE	Computable general equilibrium
CEPII	Centre for Prospective Studies and International Information
CIF	Cost, insurance, and freight
COMTRADE	United Nations Commodity Trade Statistics Database
CRI	Consumption rate of interest
CWE	Cooperative Wholesale Establishment
DAD	Department of Agrarian Development
DDT	Dichlorodiphenyltrichloroethane
DEC	Dedicated Economic Centre
DF-GLS	Dicky Fuller-generalised least squares test
DRC	Domestic resource cost

DSD	Divisional Secretariat Division
DSSAT	Decision Support System for Agrotechnology Transfer
DSU	Dispute Settlement Understanding
DWL	Deadweight loss
ECCA	Economics of climate change adaptation
ETCA	Economic and Technology Co-operation Agreement
EBA	Everything But Arms
ECM	Error correction model
EDB	Export Development Board
EIRR	Economic Internal Rate of Return
EM	Extensive margin
E-NPV	Economic net present value
EPC	Effective protection coefficient
ESS	Ecosystem services
EU	European Union
FAO	Food and Agriculture Organisation
FC	Fixed costs
FE	Fixed effect
FERP	Fixed external reference price
FFTW	First fundamental theorem of welfare
FI	Frequency Index
FIRR	Financial internal rate of return
F-NPV	Financial net present value
FOB	Free on Board
FTA	Free Trade Agreement
GATT	General Agreement on Tariffs and Trade
GCI	Global Competitiveness Index
GCM	Global circulation model
GDP	Gross domestic product
GE	General equilibrium
GHG	Greenhouse gas
GND	Grama Niladhari Division
GNPC	Gross nominal protection coefficient
GoSL	Government of Sri Lanka
GDP	Gross domestic product
GSP	Generalised system of preferences
GTAP	Global Trade Analysis Project
GSTP	Global System of Trade Preferences among Developing Countries
GTA	Greater Toronto Area
GVC	Global value chain
HFIAS	Household Food Insecurity Access Scale Score
HHI	Hirschman–Herfindahl Index
HS	Harmonised Commodity Description and Coding System
IBRD	International Bank for Reconstruction and Development

ICT	Information and communication technologies
IDA	International Development Association
IM	Intensive margin
IMF	International Monetary Fund
IOR ARC	Indian Ocean Rim Association for Regional Co-operation
IPPC	International Plant Protection Convention
IRD	Internal Revenue Department
IRR	Internal rate of return
ISIC	International Standard Industrial Classification
ITC	International Trade Centre
ITO	International Trade Organisation
i-TIP	Integrated Trade Intelligence Portal
KARI	Kenya Agriculture Research Institute
KOSHIDS	Kimira-Oluch Smallholder Irrigation Development Study, Kenya
L	Learner index
LDC	Least Developed Countries
LP	Linear programming
LTTE	Liberation Tigers of Tamil Eelam
MC	Marginal cost
MCN	Mercosul Common Nomenclature
MERCOSUR	Southern Common Market
MFN	Most Favoured Nation
MMNL	Mixed multinomial logit
MPCS	Multi-Purpose Co-operative Society
MPI	Multidimensional Poverty Index
MPS	Market price support
MRP	Maximum retail price
NPV	Net present value
MRT	Marginal rate of transformation
MWP	Maximum wholesale price
MWTP	Marginal willingness to pay
NCRCS	New Comprehensive Rural Loan Scheme
NLDB	National Livestock Development Board
NNPC	Net nominal protection coefficient
NPC	Nominal protection coefficient
NPF	National Policy Framework: Vistas of Prosperity and Splendour
NPPI	National Policy for Primary Industries
NPR	Nominal protection rates
NPV	Net present value
NRCS	New Comprehensive Rural Loan Scheme
NTB	Non-tariff barrier
NTM	Non-tariff measure
OECD	Organisation for Economic Co-operation and Development
OFC	Other Food Crops
OIE	International Office of Epizootics

OLS	Ordinary least squares
OPEC	Organisation of the Petroleum Exporting countries
PA	People's Alliance
PAM	Policy Analysis Matrix
PAR	Photosynthetically active radiation
PDoI	Provincial Department of Irrigation
PE	Partial equilibrium
PFP	Partial factor productivities
PI	Prevalence Score
PMB	Paddy Marketing Board
PPF	Production possibility frontier
PPML	Poisson pseudo-maximum likelihood
PPP	Purchasing power parity
PS	Producers' surplus
PTA	Preferential Trading Agreement
PVB	Present value of benefits
PVC	Present value of costs
RC	Revealed competitiveness
RCA	Relative comparative advantage
RCEP	Regional Comprehensive Economic Partnership
RCT	Randomised control trial
RD	Regulatory distance
REX	Registered Exporter
RHS	Right-hand side
RI	Regulatory intensity
RMA	Relative import advantage
ROO	Rules of origin
ROW	Rest of the world
RPD	Relative profit differences
RTA	Relative trade advantage
RXA	Relative export advantage
SAFTA	South Asian Free Trade Area
SAARC	South Asian Association for Regional Cooperation
SCF	Standard conversion factor
SCL	Special Commodity Levy
S-C-P	Structure-conduct-performance
SDG	Sustainable Development Goal
SFER	Shadow foreign exchange rate
SITC	UN Standard International Trade Classification
SLC	Sri Lanka Customs
SLFP	Sri Lanka Freedom Party
SLPP	Sri Lanka People's Front
SMEs	Small and medium enterprises
SOE	State-owned enterprise
SP	Stated preference

SPS	Sanitary and phytosanitary
SSM	Special safeguard mechanism
STCS	Small tanks cascade system
TFA	Trade Facilitation Agreement
TFP	Total factor productivity
TPR	Trade Policy Review
TR	Total revenue
TRAINS	Trade Analysis Information System
TRIPS	Trade-Related Aspects of Intellectual Property
TRQ	Tariff-rate quotas
TVC	Total variable cost
UNCTAD	United Nations Conference on Trade and Development
UNP	United National Party
UPFA	United People's Freedom Alliance
US, USA	United States of America
VAR	Vector Autoregression
WCO	World Customs Organisation
WDI	World Development Indicators
WITS	World Integrated Trade Solution
WTA	Willingness to accept
WTO	World Trade Organisation
WTP	Willingness to pay

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Part I

Policy Analysis and the Policy Environment

Overview of Agricultural Policy

1

Jeevika Weerahewa

Abstract

The purpose of this chapter is to introduce the terminology used in the book, examine the need for well-informed agricultural policy-making, and provide an introduction on how a policy analysis is conducted. It describes and classifies various agricultural interventions by objective and instrument, identifies key elements in the policy process, describes the policy processes adopted by various government agencies, and justifies the need to perform agricultural policy analysis. In elaborating, it uses examples from the agriculture sectors of developing countries in general and Sri Lanka in particular.

Keywords

Public policy · Policy formulation · Agriculture · Sri Lanka

1.1 Why Do Governments Intervene in Agricultural Markets?

Policy-makers in both developing and developed countries treat agricultural markets as strategic sectors requiring close government attention to achieve their broader development objectives. Accordingly, government interventions in agricultural markets have been predominant in many countries.

Sadoulet and De Janvry (1995) highlight two implicit objectives behind such interventions: efficiency-oriented and non-efficiency-oriented objectives. Efficiency objectives aim to restore resource use efficiency in agricultural markets and thereby

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achieve economic growth objectives. Measures within this category include the provision of public goods; internalising externalities in production and consumption; addressing economies of scale enjoyed by certain groups of producers; restoring efficiency of the markets by regulating monopolists and monopsonists; minimising transaction costs; and, addressing asymmetric information. The non-efficiency objectives focus on various social and environmental issues: alleviating poverty and other vulnerabilities; addressing sustainability and inter-generational issues; contributing towards greater equality and equity; building participatory governance and social stability; sustainability in resource use; and food and other security aspects.

1.2 How Do Governments Intervene in Agricultural Markets?

Governments adopt various measures to intervene in agricultural markets. They include output and input price policies (farm subsidies through price support programmes, price ceilings and floors, price stabilisation measures, etc.); trade policies (import and export taxes, licensing requirements, bans, etc.); food policies (food stocks and variable levies, consumer food subsidies through cheap food policies, fair price shops, and food stamps); direct production subsidies to credit and fertilisers; monopolistic control of markets through parastatal agencies; regulation of competition in agricultural markets; direct income (decoupling) transfers; asset transfers (e.g. land reform); public investment in agriculture, such as infrastructure and irrigation; research; and extension. Interventions can occur outside of the sector as well, including broad macroeconomic policies; monetary and exchange rate policies; interventions in microfinance; and, policies aimed at poverty reduction, economic growth, and development. The Trade Policy Review (TPR) reports of the World Trade Organisation (WTO) provide a good overview of policy instruments adopted by governments to regulate economic activities. The most recent TPR for Sri Lanka issued in 2016 lists the following policy instruments: special commodity levy, export cess, subsidies (notably the fertiliser subsidy), and tariffs (World Trade Organisation 2016). State enterprises or marketing boards (such as the Paddy Marketing Board) that operate in the sector mainly for distribution and marketing are also cited in the TPR (World Trade Organisation 2016).

In addition, the legal framework for operations and regulation of production and marketing activities in agriculture is shaped by various acts and ordinances. Some examples from the Sri Lankan context include the Soil Conservation Act of No. 25 of 1951, Plant Protection Ordinance No. 10 of 1924, Seed Act No. 22 of 2003, Control of Pesticides (Amendment) Act No. 6 of 1994, and Regulation of Fertiliser Act No. 68 of 1988.

The Sri Lankan government is known in the global policy arena for frequent changes made to the type and/or level of policy instruments. Such changes are well documented by the Central Bank of Sri Lanka in its Annual Reports. Table 1.1 provides an account of policy instruments adopted by the government (Central Bank of Sri Lanka 2018).

Table 1.1 Some recent changes made to economic policy instruments adopted by the government of Sri Lanka

Date announced	Policy instrument
1 January 2018	An ad valorem cess rate of 2.5 per cent of the Colombo Tea Auction average price was introduced on the importation of tea, flavoured or unflavoured, as an alternative levy to the specific cess of LKR 10 per kg and cess levied on whichever is higher
	Special Commodity Levy (SCL) of LKR 0.25 per kg on the importation of husked brown rice, semi-milled, or wholly milled raw rice (Kekulu), Naadu rice (red or white), Samba rice (red or white), and broken rice was extended up to 31 March 2018
19 January 2018	SCL on the importation of Maldive fish, black gram, chillies, seeds of coriander, turmeric, black gram flour, and canned fish was extended for a period of 6 months. SCL of LKR 200 per kg was imposed on the importation of grated or powdered cheese of all kinds for a period of 6 months
8 May 2018	SCL on the importation of fresh, frozen, or chilled fish, excluding fish fillets and other fish meat (other than mackerel, sailfish, marlin, and thora fish), green gram (moong), mangosteen (fresh and dried), oranges (dried), pears, cherries, plums and sloes, kiwifruit, sprats, and dried fish was extended for a period of 6 months
12 October 2018	The maximum retail prices on white sugar were imposed as follows: white sugar (unpacketed), LKR 100 per kg; white sugar (packeted), LKR 105 per kg
19 September 2018	Customs duty waiver on milk powder was decreased to LKR 175 per kg from LKR 223 per kg. Hence, the applicable duty rate was LKR 50 per kg
2 November 2018	Customs duty waiver on the importation of wheat grain was increased to LKR 9 per kg from LKR 6 per kg. Hence, the applicable duty rate is LKR 3 per kg
6 March 2019	Cess on dried fruits, fresh, or dried nuts and used or reconditioned refrigerators and freezers was reduced

Source: Central Bank of Sri Lanka (2018)

1.3 How Are Policy Decisions Conveyed to the Public?

Various official documentation provides information related to the state's policy objectives, policy directions, policy instruments, and policy levels to different degrees. The following section provides brief descriptions of such documents with some examples from the Sri Lankan context.

Vision of the government: This is generally stated in the economic policy documents of the country. For example, in Sri Lanka, the previous national policy document, *Vision 2025*, stated: "Our vision is to make Sri Lanka a rich country by 2025. We will do so by transforming Sri Lanka into the hub of the Indian Ocean, with a knowledge-based, highly competitive, social-market economy. The current national policy document, titled National Policy Framework: Vistas of Prosperity and Splendour (NPF), presents a national vision of 'a productive citizen, a happy family, a disciplined society and a prosperous nation'" (Ministry of Finance 2020).

Sectoral policies: These are formulated by the Ministry with purview of the sector in collaboration with all stakeholders. Once approved by the cabinet, they become the guiding documents with respect to interventions in the relevant sector. In Sri Lanka, a number of national policies govern interventions in the agriculture sector. They include the National Agriculture Policy (2007), National Policy for Primary Industries (2018), National Livestock Policy, and National Fisheries Policy. The objective of the National Policy for Primary Industries (NPPI) says, “The NPPI is intended to promote the export of primary products relating to agriculture and fisheries through value addition and the application of innovative business models” (Ministry of Primary Industries and Food and Agriculture Organisation, 2018).

Strategic and action plans: Ministries develop medium-term strategic plans covering approximately a five-year period and annual action plans. The latter may identify financial allocations for different programmes and actions and the agencies responsible for implementing activities.

Acts and ordinances: Acts and ordinances provide the needed legal framework to implement a policy. They are approved by the parliament and a government agency is made responsible to implement an act or ordinance. For example, the Export Development Board (EDB) has been established to implement the Sri Lanka Export Development Act of No. 40 in 1972. The EDB has issued cesses under the same act in http://www.srilankabusiness.com/pdf/cesses_new.pdf.

Gazette notifications: Amendments to acts and ordinances are issued as gazette notifications. They are approved by the parliament. For example, the export cess on tea was changed to LKR 10 per kg by a gazette issued on July 24, 2018, with the following preamble:

> *By virtue of the powers vested in me by Sect. 14(1) of the Sri Lanka Export Development Act, No. 40 of 1979, I, Malik Samarawickrama, Minister of Development Strategies and International Trade with the concurrence of the Minister of Finance and Mass Media, do by this Order amend the rate of Cess specified in the corresponding entry in Column IV in the Schedule to the Extraordinary Gazette No. 1941/32 dated 20.11.2015, in respect of the article specified under the H. S. Heading 09.02 as specified in the Schedule hereto, with effect from 25.07.2018.*
>
> *MALIK SAMARAWICKRAMA, Minister of Development Strategies and International Trade (Ministry of Finance 2019),*

Cabinet papers: National policies are amended through cabinet papers approved by the cabinet.

Budget: The Minister of Finance reads the budget in parliament, and once approved, it becomes a guiding document for the treasury to disburse allocations.

Circulars: Circulars are issued by the Secretaries to Ministries.

Programmes: Programmes are designed by ministries and implemented by various national and provincial departments in Sri Lanka. For example, the Ministry of Agriculture implements a Food Production National Programme, and one of its activities is increasing the production and productivity of supplementary food crops including paddy. The objective is stated thus:

> *This programme is implemented with the objectives of make the country self-sufficient in traditional local food and to ensure the availability of high-quality food items through adopting environmental friendly food production methods and to increase productivity and to increase the production and productivity of additional food crops and to ensure the food security by proper management of the available food stocks. Under this, programmes for improving crop production productivity of paddy, maize, chili, big onion, soya and green gram is implemented.*

(Ministry of Agriculture 2018–2019)

One of the strategies of this programme is to "Generate new varieties that produce high yield through research and development to increase production and productivity of paddy and other crops, provide high-quality seeds and encourage new technological cultivation methods and achieve self-sufficient through this process" (Ministry of Agriculture 2018–2019).

Projects: Projects have a lifespan and funded generally by an external donor agency. The Agriculture Sector Modernisation Project (ASMP) is a good example (Ministry of Agriculture 2018–2019). A description is given below.

> *To support the Government of Sri Lanka in the modernisation of the agriculture sector, the World Bank through a Credit from the International Development Association (IDA) is supporting the ASMP. The development objective of the ASMP is to increase agriculture productivity, improve market access, and enhance value addition of smallholder farmers and agribusiness in the project areas. The project focuses on the demonstration of agriculture diversification and technology improvement for production and post-harvest value addition, value-chain development for higher value-added production and better market linkages, and income generation from agriculture. The project also seeks to ensure that the agriculture modernisation and diversification agenda is inclusive and poor farmers, including women, are enabled to benefit from investments into value addition, new skills and technology improvements, sustainable crop management, and new financing and marketing arrangements.*

(Ministry of Agriculture 2018–2019)

1.4 What Process Is Followed in Policy Formulation and Policy Decision-Making?

The policy process is normally conceptualised as sequential parts or stages: (1) problem identification, (2) policy analysis, (3) strategy and policy development, (3) policy enactment, and (5) policy implementation.

Problem identification: Determine the root cause of a policy problem.

Policy analysis: Identifying possible policy options and picking the most appropriate option.

Strategy and policy development: Planning how to develop, draft, and enact the policy.

Policy enactment: Following official procedures to get the policy authorised.

Policy implementation: Planning for successful policy implementation and achieving the desired outcomes.

The policy process is highly context-specific and can differ across countries, institutions, and sub-sectors, as well as over time.

Given the importance of understanding a national policy process, Resnick et al. (2015) introduced an applied framework, named the kaleidoscope model, to analyse drivers of policy change in the food security arena. This model identifies slightly different stages in the policy cycle – agenda setting, design, adoption, implementation, and evaluation and reform – and key variables that define the necessary and sufficient conditions for policy change to occur. The authors highlight the importance of conducting policy research to facilitate policy analysis. They explain how policy research has evolved over time and state the need for developing capacity in developing countries to do policy research and analysis to facilitate the policy process.

1.5 Scientific Evidence-Based Policy-Making

1.5.1 Policy Research and Policy Analysis

The "policy analysis" stage mentioned in the above section involves conducting of a scientific investigation to produce scientific evidence required for strategy and policy development. This activity is sometimes termed as *policy research* as well. Though these terms are often used interchangeably in academia, some view them as two distinct terms. Policy research is an analysis intended to bring clarity to the impacts of public policies, while policy analysis is an evaluation of policy options in order to make policy recommendations and inform impending decisions. Policy research seeks to understand and inform the policy-making process by carrying out primary research into specific policy issues and is usually the interest of groups of policy researchers or academics. Policy analysis, in contrast, is a more politically motivated exercise and seeks to have direct influence on actual policy outcomes by designing policies for government agencies. It is usually conducted by policy analysts attached to ministries, policy centres, and think-tanks. Policy research is issue-centric, while policy analysis is mostly client-centric. The results of policy research are mostly disseminated through journal articles and research reports in technical language, while policy briefs written in non-technical language communicate the results of policy analysis. There is a growing interest both in academia and among policy-makers to merge the two streams.

1.5.2 Ex Ante and Ex Post Methods

Ex ante analysis is "what if" analysis, while ex post analysis is "what happened" analysis. Ex ante analysis is a useful tool in policy design to evaluate options; ex post analysis may be conducted once a policy is implemented. Each method has its own advantages and disadvantages. Ex post analyses enjoy a richness in data but may be handicapped in terms of proposing solutions to present-day problems. The focus is on explaining what has already happened. Ex ante analyses can analyse proposed or newly designed policies.

Policy researchers and analysts must choose the appropriate method given the nature of the policy question to be answered. For example, an ex post analysis is the appropriate method to evaluate the effects of the paddy procurement scheme adopted by the Sri Lankan government between 1972 and 2019. This ex post analysis may be conducted mainly using historical data on paddy procurement by the Paddy Marketing Board (PMB). Ex ante analysis would be required if the policy question involved evaluating the economic effects of a proposed increase in the guaranteed price of paddy used by the PMB in procuring paddy. The researcher could conduct a series of interviews with paddy farmers and PMB officials to infer their potential behavioural changes due to an increase in the guaranteed price to obtain the requisite data for analysis or perform a forecasting exercise using an econometric model. Alternatively, a mix of ex post and ex ante methods may be adopted to reap the advantages of both methods. This requires reframing the policy question, perhaps thus: what would have been the situation in the paddy sector if a higher guaranteed price was adopted by the PMB during 2000–2019? This will allow the researcher to develop a model using historical data that then can be used to assess the effects of a hypothetical policy shock.

1.5.3 Generic Steps Involved in Conducting Policy Analysis

Getting cause-and-effect right is extremely important in designing or redesigning a development policy and has become a central focus of research in development. The scientific method of policy analysis runs through the following stages:

- Identification of an appropriate model, taking into account that all models are constructed subjected to a set of assumptions
- Construction of the model, e.g. $Y = Y(X, Z)$, where Y is a vector of policy objectives, X is a vector of uncontrollable exogenous variables, and Z is a set of policy instruments
- Running of the base model
- Validation with existing levels for X and Z
- Simulations using Z and sensitivity analysis

In the above example of assessing the paddy procurement scheme, Y would be purchases of PMB, Z is guaranteed price, and X can be a vector of characteristics of paddy farmers.

The policy effect denoted by Y can include measures to denote various dimensions of development, including economic growth, poverty, malnutrition, income distribution, food safety standards, and environmental pollution.

1.5.4 Qualitative and Quantitative Approaches

The *Y*, *X*, and *Z* cited above could be either qualitative or quantitative. The nature of a policy question determines whether a qualitative or quantitative approach is chosen. A quantitative approach is ideal for answering questions of *how much*, while a qualitative approach is more tailored to answer questions of *why*, *what*, and *how*.

1.5.5 Interdisciplinary and Multidisciplinary Approaches

Policy recommendations based on scientific investigations should ideally aim to change the underlying causes, rather than the symptoms, of problems by utilising new opportunities provided by modern science and technology, including molecular biology and digital technology, as well as new knowledge in the social sciences, and opportunities offered by globalisation. Accordingly, inputs from multi- and interdisciplinary teams are required for better policy analysis and responses. While agricultural economists have a predominant role, the contributions of other social scientists and natural scientists are indispensable.

1.5.6 Why Is Agricultural Policy Research and Analysis Mostly Carried out by Agricultural Economists?

Economic theory has much to offer in providing guidelines to help conceptualise and design policy reforms. In policy reform, the question that must be answered is: when does a policy work and when does it not and why? Economic theory is rich and flexible enough to justify many different policies, depending on the constraints and opportunities defined by the context.

With the growing interest in addressing varying types of development problems, economists further broaden and deepen the scope of analysis into the areas of institutions, governance, and politics. They increasingly acknowledge the importance of institutions – the rules of the game in a society – and the nature of politics and power struggles that lie behind them and apply their empirical and conceptual tools to analyse those deeper determinants.

Agricultural economics is a field that covers the economics of every aspect in a food system ranging from food consumption and nutrition to various delicate issues in land use and its implications on environment. It provides tool kits to address issues at household level, sectoral level, national level, and global level. Therefore, agricultural economists possess the theory and context-specific knowledge required to perform agricultural policy analysis in comparison with other professionals.

1.6 Assignments

1. List down the key policy documents issued by three selected government agencies over the past 2 years. Identify the title of the policy document and the committee/person who issued the document.
2. Classify the policies by the objective of the policy and policy instrument.
3. Document the policy process adopted by the two agencies in arriving at one of the policy decisions listed in (1) above. State the number and nature of the meetings conducted, highlighting the composition and chairing.
4. State what additional information would have helped in reaching the above policy decision.

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Public Policy: An Overview

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Abstract

Understanding the role of the government in a market economy is important for proper dialogue between citizens and policymakers in a democratic governance system. Even though the topic is not novel, the management of economies in developing nations shows that basic economic principles are sometimes ignored. In this context, revisiting the subject of public policy, particularly the role of the government in a market economy, is pertinent. This chapter defines and describes what public policy is and policy instruments available to a government; summarises the theory and empirical evidence on markets' ability to allocate resources efficiently and improve social welfare; and, describes the government's role, within principles of minimum intervention, in creating inclusive economic institutions, maintaining equitable distribution of income, correcting market failures, and ensuring macroeconomic stability.

Keywords

Market economy · Role of government · Market efficiency · Market failures · Economic institutions

2.1 What Is Public Policy?

Policy can be defined in many ways, and there is no single definition that encompasses all the relevant elements of a public policy. A broad definition is that policy is a "purposive course of actions that an individual or a group consistently follows in dealing with a problem". This definition emphasises the *purpose* of the

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policy to address a problem. But it is vague in the sense that it doesn't elaborate on the types of problems, objectives of solving problems, or who carries out the course of actions.

Public policy is defined as "declared state objectives relating to health, morals and wellbeing of the citizenry". This definition reduces the vagueness of the first one by specifying that government undertakes the course of actions. The notion that government should play a major role in maintaining the moral values of a society is archaic: while governments enforce legally relevant morals, like preventing criminal activities through law enforcement, the belief that the state should ensure the entire spectrum of moral values became less relevant as societies evolved into modern democracies. This discussion will focus on the role of public policy in ensuring the well-being of citizens.

Public policy is also defined as "a purposive and consistent course of action produced as a response to a perceived problem of a constituency". This introduces the political perspective of public policy. Citizens will have a list of priority issues which they call upon the government to resolve. In campaigning for elections, a political party's manifesto will lay out certain policies or courses of action; and people elect a government they believe will best address their problems through policy. Despite gaps between what is promised and what is actually accomplished, the process provides opportunity for people to express their desire to have perceived problems resolved through public policy.

Another closely related term is economic policy, which can be defined as "a course of action that is intended to influence or control the behaviour of the economy to maximise social welfare".[1] Public policy and economic policy both concern the well-being of the citizens. In economics, well-being/welfare refers to contentment with one's standard of living, including financial status and material consumption. Economic policy is more precise as it intends to maximise well-being.

There are many different ways to categorise policy instruments; one very broad way is to consider regulation (stick), economic means (carrot), and information (sermon) as the main instruments. Regulatory measures such as use of a catalytic converter to control vehicular pollution are associated with a fine when violated, whereas a tax concession for investors is an incentive (carrot) to promote investments. Daily information about the number of cases of COVID-19 and their geographic distribution alters the behaviour of the public and potentially reduces the spread of the disease. This minimalist typology, on the one hand, emphasises the compulsory nature of the government in its solution strategies. On the other hand, it refers to the resources available to the government.

Also, public policy instruments may be classified by the degree of government intrusion into the market: regulation, expenditure, public property, self-regulation, and exhortation. Regulations are implemented by various government ministries, departments, or agencies to carry out the intent of legislation enacted by the parliament. Expenditure refers to the fact that governments spend tax revenue for

[1] https://www.cliffsnotes.com/study-guides/economics/introduction/economic-policy

public purposes as stipulated in public policies. Regarding property, a government owns various properties such as lands, building, etc. In a broader sense, this property also includes the government's financial resources. The way a government manages public property will have significant economic implications. In the most basic sense, self-regulation involves controlling government behaviour in exercising its powers in achieving its long-term goals. For example, governments generally have powers to acquire private land for public purposes. Self-regulation requires application of this power only when it is absolutely necessary (e.g. when building a road), accompanied by reasonable compensation. Exhortation is persuasive and powerful communication: for example, the state exhorts the public against drug use or to refrain from dumping garbage in public places. The degree of intrusion is highest with regulation and gradually declines towards self-regulation and exhortation.

Direct controls applied to avoid undesirable behaviour or actions are another policy instrument available to a government. According to this explanation, direct controls can be applied to enforce certain desirable behaviours by the public too. Banning some pesticides (Dichlorodiphenyltrichloroethane, commonly known as DDT) and narcotics (like heroin) and prescribing certain mandatory technologies (such as the use of energy-saving bulbs in all the government building) are examples of direct controls. Economic regulations, such as maintaining desirable interest rates, promoting economic growth by various means, imposing taxes and duties, providing subsidies for selected sectors, and setting or removing tariffs to promote exports or to control imports, form a major part of public policy.

Governments implement development projects, such as roads, power plants, irrigation, water supply, etc. Contracting is a policy instrument available to the government in selecting the best companies or organisations to carry out civil works. When a government owns assets like forests, oil fields, or mineral deposits, it provides concessions to individuals or companies via an agreement granting rights to develop and use these resources. Public services such as water supply may also be operated as a concession.

Direct loans, loan guarantees, and public insurance are another set of policy instruments frequently used by the Sri Lankan government. The supply of certain goods and services through government corporations, such as Sri Lankan Airline, Ceylon Electricity Board, and the Port Authority, are also commonly used public policy instruments. Fees (for various government services such as issuing passports), charges (for water pollution), various legal obligations, and public information are also frequently used policy instruments by the government.

The above list is not complete but should provide a broad understanding about the various instruments available to the government to implement its policies.

2.2 The Market and Its Efficiency

Understanding the role of markets is a prerequisite to understanding the role of the government as a policymaker. Consequently, it is essential to examine the concept of a free market economy.

The free market economy is one in which decisions regarding investment, production, and distribution are mainly based on supply and demand which are themselves based on the decisions of individuals. Prices of goods and services are determined by the interaction of supply and demand. Supply represents the cost aspects of the economy; demand, consumer preference or the value (benefits) consumers assign to various goods and services. Market equilibrium balances the costs and benefits and provides equilibrium prices. Prices or price changes dictate the best allocation of resources, ensuring economic efficiency, which ensures the highest level of social welfare.

The word "free" means that market forces, supply and demand, are allowed to function without intervention by the government. There is always *some* intervention by the government; at the very least, it has to collect taxes and spend tax money on national defence, health, and education, as well as provide some level of regulation of markets, like setting standards for health and safety and facilitating the exchange function. Therefore, there is no absolutely free market anywhere in the world. Markets are subjected to government interventions at various degrees, and the "free market economy" is a relative term and that implies minimum government interventions.

The interest in free market economies is based on its well-known ability to improve the well-being of citizens. Adam Smith, the father of economics, first asserted the markets' ability to improve social welfare. He explains in *The Wealth of Nations* (Smith 1776) that the motivation to maximise profits drives a free market economy. Individuals, acting in their self-interest, generate demand or supply, compelling others to buy or sell goods or services. In return, s/he either receives or pays compensation and one party makes a profit. In this process of exchange in a free market economy, resources are allocated in the most efficient manner. Smith uses the term "invisible hand" to describe the market process, distinguishing the government's role as the "visible hand".

The invisible hand theory basically states that without any intervention, if all individuals in an economy act in their best self-interest, the result is automatically in the best interests of the economy and always better than in a centrally planned and regulated economy. If each consumer is allowed to choose what and how much to buy, they will allocate their limited income to maximize their well-being. Similarly, when each producer is free to choose their production quantity, technique, and prices, producers would use an efficient method of production to cut costs and charge low prices to maximise revenue. Consumers would buy from sellers who offer the lowest prices. Also, investors would invest in industries that maximise their return. All this would take place automatically if the economy is set free from government intervention.

Every individual would endeavour as much as s/he can both to employ their capital in support of economic activities like industry or agriculture that produce the greatest value. Here, individuals *neither know nor intend* to promote the public interest. By supporting such economic activities, s/he intends only their own security. Similarly, by engaging in the economy in such a manner as to produce the greatest value, individuals intend only their own well-being. By pursuing her/his own self-interest, individuals frequently promote society's best interests more effectively than if s/he actually intends to promote socially desirable outcomes. In fact, Smith claims that he has never known those who endeavour to effect socially desirable ends to do much good (Smith 1776).

Economic literature in the post-Adam Smith period looks at the welfare impacts of markets in various ways. In particular, trade theory further extended the role of markets by demonstrating that free trade improves the welfare of all trading partners. The culmination of this process was Nobel laureate Kenneth Arrow mathematically proving that free market equilibrium maximises social welfare. The ability of markets to improve standards of living is formally described by the first fundamental theorem of welfare (FFTW): free market economic equilibrium is Pareto efficient. Pareto efficiency means that the economy has removed all inefficiencies in investments, production, and consumption and no additional efficiency gains are possible; i.e. one person's welfare cannot be improved without harm to others. Simply, the economy is at the best state in terms of the aggregate welfare of its people, given the resource endowments, technology, and peoples' preferences.

The above is the most powerful theory in economics: it heavily influences economic policies throughout the world. How has this powerful economic theory performed in the real world? There is ample empirical and historical evidence of the markets' ability to take societies towards prosperity. The post-Second World War economic prosperity of nations belonging to the Organisation for Economic Co-operation and Development (OECD) is mainly due to their reliance on the market economy. While some countries regulated markets (e.g. European countries) more than others (such as the USA), all these countries followed a free market economic policy. Economic assets, particularly the physical infrastructure of European countries, were very badly damaged by the war. The USA helped these countries to rebuild their damaged infrastructure through the Marshall Plan, and, following rehabilitation, these countries followed a free market policy. Within about 20 years, they became rich countries again. Many factors contributed to this development but the free markets played the main role.

Opposite to the free market economy is the centrally planned economy. Today, only North Korea seems to have a centrally planned economy. The largest centrally planned economy, the Soviet Union, collapsed in December 1991 in the middle of a huge economic crisis. Vietnam, China, Lao PDR, and Cuba were all once centrally planned economies; they now claim to be socialist countries, but use market economic principles to a large extent in managing their economies. Up to about the 1960s, the centrally planned economies showed better progress in addressing issues of employment, housing, universal access to education, and universal access to health. By the late 1980s, these countries were far behind market economies like OECD countries. The abandonment of the centrally planned economic model by many countries during the 1980s and 1990s signals that the free market system is better than central planning as a method of organising an economic system.

What caused the failure of centrally planned economies? There were several reasons, including complex world politics. However, it would be fair to state that the failure was largely due to the absence of market forces that provide signals and incentives on what, how much, at what quality, and at what cost to produce: an efficient link between producers and consumers. This identifies a fundamental problem with centrally planned economies. No planning body, over time, can match the efficiency of markets in connecting producers and consumers. Other problems such as guaranteed incomes that minimise the incentives for hard work and innovation, thereby undermining technological progress in meeting consumer demands, have also contributed to the failure of centrally planned economies.

The superiority of free market economies can also be explained using the two main strategies followed by market and centrally planned economies: export promotion versus import substitution. Many developing countries adopted import substitution policies as a developmental strategy during the initial phase of post-independent history. For instance, between 1970 and 1977 Sri Lanka pursued import substitution, switching to open market policies in 1978. During 1970–1977 period Sri Lanka recorded a very low economic growth owing mainly to import substitution policy though the unfavourable external factors such as food crisis and higher oil prices also contributed to the poor performance. The Sri Lankan economy grew fast as a result of adopting free market policy after 1977. But the Civil War changed the development trajectory of the country, and Sri Lanka could neither complete the necessary free market reforms nor realise the full benefits of a free market economy.

India adopted import substitution policies for much longer than Sri Lanka, initiating reforms to liberalise its economy around 1991, leading to fast growth. The Asian tigers (South Korea, Singapore, Hong Kong, and Taiwan) did not pursue import substitution, instead choosing a path of export promotion. These countries became the first set of developing Asian countries, along with Japan, to become rich. More recently, the rest of Asia has shown economic growth and increasing prosperity simultaneously with moving towards more free market, export-oriented economic policy stances.

China's development experience perhaps provides the best example of how a free market economy improves social welfare. Like other fully socialist countries, the Chinese economy was managed via state ownership and central planning. From 1950 to 1973, Chinese real Gross Domestic Product (GDP) per capita grew at a rate of 2.9 per cent per year on average, while neighbouring countries such as Japan, South Korea, and Taiwan were growing at much faster rates. Starting from 1970, the Chinese economy entered into a period of stagnation and, after the death of Mao Zedong, the Communist Party leadership turned to market-oriented reforms to salvage the failing economy. Communist Party authorities carried out market reforms first on an experimental basis and then in two stages. An initial experiment of private farming in one province showed remarkable growth in agriculture. The first stage of reforms, in the late 1970s and early 1980s, involved the de-collectivisation of agriculture, opening up of the country to foreign investment, and permission for entrepreneurs to start businesses. However, most industries remained state-owned. The second stage of reform, in the late 1980s and 1990s, involved privatisation, contracting out of many state-owned industries, and lifting of price controls, protectionist policies, and regulations, although state monopolies in sectors such as banking and petroleum remained. The private sector grew remarkably, accounting for as much as 70 per cent of China's gross domestic product by 2005. From 1978 until 2013, an unprecedented growth of 9.5 per cent per year occurred. This growth has had major development impacts; average wages rose sixfold between 1978 and 2005, while absolute poverty declined from 41 per cent of the population to 5 per cent from 1978 to 2001. By 2015, China had become the world's second-largest economy, next to the USA (US Congressional Research Service 2019).

2.3 Role of the Government in a Market Economy

If the markets do such a good job of allocating resources and improving welfare, what is the role of the government in a free market economy? First and foremost is the inaction; one of the most important principles of public policy is that the government governs best that governs least. In other words, the government should allow the market to function without managing the day-to-day functioning of the economy. In particular, the government should not supply goods and services which can be supplied by the private sector. Instead, the government should provide oversight of the economy's overall functioning.

The outcome of market processes depends on the economic institutions or working rules ("rules of the game") created by the government. Establishing economic institutions that enforce property rights, create a level playing field, maintain competitive pressure among firms, and encourage investments in new technologies is fundamentally a part of the government's role in a market economy. In the early economic literature, this role is referred to as the first-order engagement of the government in the economy. Adam Smith (1776) described the importance of the government establishing proper economic institutions. He not only identified it as one of the fundamental roles of the government but also highlighted how economic institutions affect the distribution of the economic outcomes of a nation:

> According to the system of natural liberty, the sovereign (government) has only three duties to attend to;. . . . The third duty is erecting and maintaining certain public institutions which it can never be for the interest of any individual, or a small number of individuals. (Smith 1776)

In addition, governments have three very important roles commonly known as the second-order engagement. One aspect relates to the inability of markets to distribute economic outcomes equitably. The bulk of the returns in an economy may be earned by a few rich people. For example, in the majority of Asian economies, about 30 per cent of the income is earned by the 10 per cent of richest households. Ensuring some form of equity, as desired by society, is government's responsibility. Another aspect is that market processes fail to achieve efficiency when there are market failures, such as externalities (pollution problems, nature conservation, etc.); public goods (national defence, health, and education); natural monopolies (public utilities such as power transmission lines); and information failures. Government should intervene to correct these market failures using direct provision, standards, rules, taxes, subsidies, and other policy instruments. Finally, governments should ensure sound macroeconomic management by spending the collected taxes on productive areas, ensuring healthy balance of payments, exchange rates, and interest rates. Market economies encounter business cycles, and, during slow growth periods, public investments should help to lift the economy out of recession.

2.4 Economic Institutions

What are economic institutions? They are the conventions, rules, and entitlements that define the domains of choice for economic agents. From an institutional economics perspective, an economy is a set of ordered relations among self-interested agents. The essential problem of economic organisation is to design a set of signalling devices which will guide these self-interested agents to act in the interest of the larger community: what individuals must or must not do (duties); what they may do without interference from other individuals (privileges); what they can do with the aid of collective power (rights); and, what they cannot expect collective power to do in their behalf (incapacity or exposure).

Institutions consist of the rule of law, a level playing field for individuals to participate in the economy which fosters competition and economic growth. Establishing the rule of law, including national defence, protection of human rights, maintenance of law and order, and establishing secure property rights, is of paramount importance for the markets to play their role in the economy.

Well-defined property rights play a vital role in market development and provide correct incentives for individuals to participate in and benefit from their economic activities. Such rights should be universally understood by economic agents and should exclude others from enjoying the benefits of an individual's economic activity. In addition to universality and excludability, rights should be transferable in order for economic exchanges to take place. The many economic exchanges taking place every second in an economy are actually transferring various rights. For instance, a customer purchasing a loaf of bread for LKR 100 exchanges their right to LKR 100 for the right to that bread. Government restrictions on exchange of rights curtails the development of markets. Also, there should be a mechanism to resolve disputes arising in exchanges.

A level playing field means that competition among economic agents should be ensured, and there should be no entry or exit barriers. In the absence of competition, private entities retain a high market share and influence the price mechanism. For instance, in Sri Lanka, the higher prices for rice during the December–January period and lower prices of unmilled rice at harvesting times are due to the concentration of market power among a few rice millers. Furthermore, there are numerous entry and exist barriers in the Sri Lankan economy. Among numerous examples, three-wheeler drivers do not allow cheaper and safer Uber and other taxi services in many parts of the country.

Quality institutional systems reduce transaction costs in the economy. Transaction costs refer to the cost of obtaining information, negotiating contracts, and enforcing contracts. Even in the information technology era, barriers to obtaining information remain in Sri Lanka. Negotiating contracts is still very informal and the costs of enforcing contracts very high in terms of long delays in dispute resolution. A well-functioning legal system that supports the economy should have clear lines of authority and division of responsibility among governmental units; clarity and precision in legal rules; mechanisms and processes for the protection of property rights; procedures that offer stability and predictability; a sense of fairness in litigation processes; and, accessibility of the legal system to the public.

The existence of laws is necessary but not sufficient for ensuring a well-functioning market economy. As stated in the World Bank's World Development Report (2017), laws may be used to empower change-actors or reinforce existing power; to provide order and certainty or create conflict and exacerbate confusion; to build or undermine legitimacy; and, to enhance competition or undermine it. Like many countries in Asia, Sri Lanka should strengthen the rule of law in promoting, enforcing, and institutionalising a culture of fair competition. Mechanisms that help give less powerful, diffused interest groups a bigger voice in the policy and governance arena could help balance the influence of more powerful, narrow interest groups. However, participatory mechanisms in regulatory institutions are still relatively uncommon in Sri Lanka.

Conventions, beliefs, and culture constitute an important segment of institutions. In Sri Lanka, there is a mistrust of markets which often leads to an economic policy based on unwarranted controls and regulatory measures. For example, reluctance to seriously reform or privatise state-owned enterprises (SOEs) may be due to mistrust of the markets. Except for the state-owned banks, all SOEs run at huge losses: the tax revenue which should be spent on long-term investment in physical infrastructure, health, and education are instead diverted to maintain SOEs, undermining economic development.

Sri Lanka graduated to lower middle-income country status in 2019. Many countries get stuck at this level of income for a long period of time: a phenomenon known as the middle-income trap. Lower middle-income countries should transform their economies to knowledge-based economies to compete with advanced countries and avoid the middle-income trap. Related to this, the World Bank identifies four incentive pillars of economic institutions of a knowledge-based economy: effectiveness of legislation influencing entrepreneurship; effectiveness of juridical system in keeping transaction costs low and supporting effectiveness of market mechanism; and, competitive pressure and effectiveness of labour markets (Robertson 2008).

Total factor productivity (TFP) measures the quality of institutions in an economy. As shown in Fig. 2.1, Sri Lankan GDP growth fluctuated throughout the post-independence period. Initially, it was thought that this erratic behaviour was mainly due to the war, but this pattern continued after the war highlighting fundamental problems in the economy. Figure 2.2 shows that TFP and GDP growth follow a very close pattern. Also, the figure reveals that growth of TFP has stagnated. Generally, in any country with sustained growth for a long period, TFP is an upward sloping

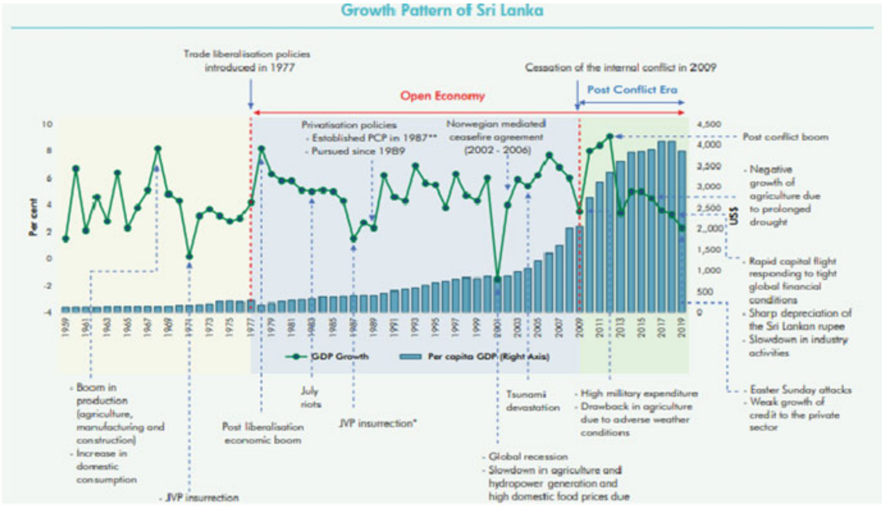

Fig. 2.1 Growth of GDP in Sri Lanka between 1960 and 2014. Source: Adopted from Asian Development Bank (2017)

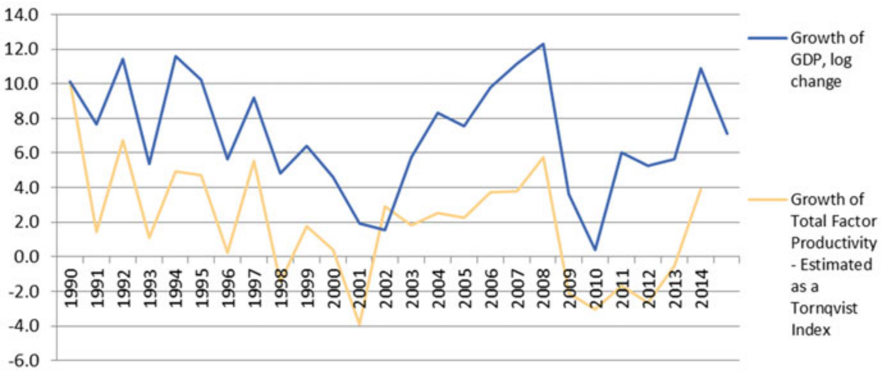

Fig. 2.2 Sri Lanka's GDP and TFP growth between 1990 and 2015. Source: Global Productivity database (2020)

curve. These two graphs clearly indicate that Sri Lanka's economic institutions are of poor quality.

Acemoglu and Robinson (2012) in *Why Nations Fail* assert that extractive economic institutions are the main reason for underdevelopment and poverty: "Inclusive economic institutions that enforce property rights create a level playing field and encourage investments in new technologies and skills are more conducive to economic growth than extractive economic institutions that are structured to extract resources from the many by a few and that fail to protect property rights or provide incentives for economic activity" (p. 430). They further point out that while inclusive economic institutions are supported by and support inclusive political institutions, extractive economic institutions perpetuate extractive political institutions. Inclusive political institutions distribute political power widely in a pluralistic manner and achieve some amount of political centralisation required to establish law and order which is the foundation of secure property rights and an inclusive market economy.

2.5 Ensuring Equity

As observed in many Asian countries, market economies may produce high-income inequality. The market economy inherently favours capital over labour, skilled over unskilled labour. Moreover, it tends to support growth in coastal and urban centres rather than inland and rural centres. Coupled with unequal access to education and health facilities, job opportunities, capital, and land, this results in large income disparities. Income inequality can create disparities that transmit to future generations. For example, the Asian Development Bank (2012) reported that in two decades (1990 and 2000), Asia witnessed rising inequality in 11 economies (including the People's Republic of China, India, and Indonesia) comprising 80 per cent of Asia's population.

Access to quality education and spatial difference are two important determinants of inequality in many Asian countries. This is compounded by the ageing population as disparities accumulate over time with age (Deaton and Paxson 1994). Inequality excludes talented people from the labour force, creates social disharmony, and eventually leads to political instability. Therefore, government programmes should promote equity through use of tax revenues for a variety of social welfare programmes. Improving equity with minimum disturbances to the market process is a challenging task for any government.

In previous decades, Sri Lanka enjoyed low income inequality and good social indicators, backed by social welfare spending on universal food subsidies, free education, and free health care. But since the 1970s income inequality measured by Gini coefficient significantly increased from 0.32 in 1970 to 0.43 in 1980. This has been attributed mainly to the policy of economic liberalisation in the late 1970s. Income inequality, measured by Gini coefficient, has since ranged between 0.43 and 0.49. Sri Lanka's ethnic conflict is eventually an equity issue as well, and the war has created further inequality between southern and northern populations. The main causes of the two insurrections in 1971 and 1989 are youth unemployment and inequity. Given this history, Sri Lanka has to make every effort to ensure further growth does not widen income disparities.

Historically, Sri Lanka has had lower spatial inequality because of various government policies that supported rural populations. This has been changing and, as of 2015, 41 per cent of national GDP is accounted for by the Western Province (Asian Development Bank 2017). This underscores the importance of a balanced approach for regional development and inclusive economic growth.

As explained earlier, access to education and health are important determinants of inequality. In the early 1970s, social welfare expenditure comprised over 40 per cent of government expenditure, equivalent to over 12 per cent of GDP (Asian Development Bank 2017). Today, the country's health and education spending remain among the lowest regionally and globally due to declining tax/GDP ratio. Given the public sector's dominance in health and education, this low public expenditure on health and education is a cause for concern.

There is a trade-off in reducing inequality. Many measures to reduce inequality and redistribution of income require higher taxes, and taxes reduce economic growth. Therefore, efforts on reducing inequality should be carefully selected to avoid unnecessary slowdown of the economy. Avoiding inequality in terms of "unequal access to market opportunities and public services" provides opportunities to reduce inequality without undermining the growth prospects of a nation. Therefore, an efficient fiscal policy, interventions to support lagging regions, and more employment-friendly growth should be the focus in helping bring Sri Lanka's growth trajectory to a more inclusive one.

2.6 Correcting Market Failures

Market failures – monopolies, externalities, public goods, and information failures – are reasons for direct intervention by the government in a market economy. Monopolies (i.e. only one firm produces the good or service) produce less than optimal quantities of goods and services for sale at prices that are higher than in a competitive market price, thereby reducing social welfare. It is the government's duty to promote competition by avoiding monopolies or oligopolies (few firms in the market). The absence of a sound competition policy is a major deficiency in Sri Lanka for the free markets to deliver good economic outcomes.

There are some industries, like water supply, sanitation, and energy, which behave like monopolies because of their technical nature. For example, having several firms lay pipes for water transmission in an area would be wasteful. These industries have very high initial costs and ever-declining average cost curves which prevent them behaving like the usual competitive market firms.

This type of firms is known as natural monopolies, and the government should provide such natural monopoly goods and services or properly regulate the private sector provision of them. Most physical infrastructure belongs to this category. This a rare occasion that justifies the direct supply of goods and services by the government.

The government should not be involved in direct provision of goods and services that can be profitably produced by the private sector without reducing social welfare. Government agencies may not be as efficient as private enterprises in delivering goods and services due to structural constraints (such as the structure of incentives for employees and relationships with the political leadership) and rules of engagement with the public.

In Sri Lanka, based on the above, SOEs like the Petroleum Corporation, Ceylon Electricity Board, Sri Lankan Airlines, State Timber Corporation, etc., may be considered as social welfare reducing initiatives. It is evident that regulatory mechanisms for SOEs in Sri Lanka are not robust enough and lack resources and independence from political interference which undermine their effectiveness. To move forward, the functions assigned to SOEs must be efficiently carried out without colossal losses. This may require that some SOEs are maintained at least as cost recovering SOEs and others privatised or operated through public-private partnership models.

Externalities such as pollution, decreasing biodiversity, and destruction of ecosystems create a diversion between social and private costs undermining economic efficiency. The economy cannot sustain growth unless these environmental problems are solved. Climate change has become the most challenging environmental problem with threats to the very survival of the human race. Sri Lanka is extremely vulnerable in this regard. It is the responsibility of the government to correct such externalities through strict controls, taxes, subsidies, permits, and other policy instruments to reduce pollution and protect finite natural resources.

Public goods occur when exclusion is not possible in consumption: one individual's consumption does not prevent others from consuming it. The protection I get from national security does not prevent others from enjoying it. This results in free-riding which undermines the capacity of the private sector to supply optimal quantities of such goods. In such situations, government provision of goods like national defence is necessary. Education and health are quasi-public goods: this justifies the public provision of health and education with a carefully designed role assigned to the private sector. Regulating, rather than prohibiting, the private sector in the health and education sectors is an important government function.

2.7 Ensure Macroeconomic Stability

Though allowing the markets to play a dominant role in the economy, government assumes the responsibility to help the economy achieve goals of growth, full employment, and price stability. Justification for macroeconomic management by the government has its origin in the Great Depression in the 1930s. Prior to the Great Depression, the thinking was that cyclical swings in employment and economic growth would be modest and self-adjusting. A reduction in aggregate demand in the economy will result in the decline of prices and wages. A lower price level, including low interest rates and wages, would induce employers to make capital investments and employ more people, stimulating employment and restoring economic growth. The depth and severity of the Great Depression, however, severely tested this hypothesis and showed that the self-adjustment process didn't work.

Keynes showed that during recessions structural rigidities and certain characteristics of market economies would exacerbate economic weakness and cause aggregate demand to plunge, further prolonging the recessions. In order to come out of the great depression, Keynes advocated a countercyclical fiscal policy.

He asserted that during periods of economic slump, the government should expand public investment in areas like infrastructure to make up for the decline in investment and boost consumer spending in order to augment aggregate demand and investor confidence (Sarwat et al. 2014). Over time, the role of government in macroeconomic management evolved to be in two major areas: fiscal policy and monetary policy.

Through fiscal policy the government uses its power to collect taxes and to spend them on infrastructure development, national defence, health, education, and so on. Fiscal policy is a frequently used tool for reducing inequality too. Both taxation and government spending can be used to reduce or increase the total supply of money in the economy – the total amount, in other words, that businesses and consumers have to spend. When the country is in a recession, the appropriate policy is to increase spending, reduce taxes, or both. Such expansionary actions will encourage businesses to expand and consumers to buy more goods and services. When the economy is experiencing inflation, the opposite policy is adopted: the government will decrease spending, or increase taxes, or both. Such contractionary measures reduce spending by businesses and consumers in order to push inflation down.

Through monetary policy, the government uses its power to control the money supply and level of interest rates. Monetary policy is exercised by the Central Bank which is empowered to take various actions that decrease or increase the money supply and raise or lower short-term interest rates, making it harder or easier to borrow money. When the Central Bank notices that inflation is rising, it will use contractionary monetary policy to raise interest rates which will eventually decrease the money supply in the economy. When interest rates are higher, borrowers have to pay more for the money they borrow, and banks are more selective in making loans. Because money is "tighter" – more expensive to borrow – demand for goods and services and prices will fall. To counter a recession, the Central Bank uses expansionary monetary policy to increase the money supply and reduce interest rates. In practice, it may take a short or long period to respond to monetary policies, depending on the characteristics of the economy.

In addition, the government also takes steps to maintain a stable exchange rate for the local currency. When there is excessive depreciation of the currency, government may intervene in currency markets to stabilise exchange rates as a short-term measure. In the longer term, measures such as export promotion and tourism expansion are taken to stabilise exchange rates. Managing budget deficits, domestic and international debts, and balance of payments are some of the other areas of macroeconomic management by the government.

2.8 Conclusion

In understanding the role of the government or the purpose of public policy, the first step is to comprehend the fact the markets are efficient and maximise aggregate social welfare. But markets should be facilitated by the government by erecting inclusive economic institutions. When good-quality institutions are not in place, economic outcomes are not optimal. Most of the time, such failures are misunderstood as failures of the market. Once the enabling economic institutions are established, the government should follow a hands-off approach, allowing the markets to work freely.

This minimal intervention approach works only when markets are doing a good job. But the market has its weaknesses in some sectors of the economy which mandate government intervention. There are three types of failures. Firstly, the market outcome does not guarantee equitable distribution of incomes: here the government has to intervene for redistribution of incomes as desired by society. Secondly, there are market failures, such as monopolies, natural monopolies, externalities, public goods, and information failures. The government should either directly supply goods and services when the market fails or regulate the relevant markets to ensure optimal outcomes by private-sector provision. Finally, the government should ensure macroeconomic stability and work proactively to sustain economic growth and prevent economies from falling into recessions.

The above description of the role of the government in a market economy provides a sound framework for discussing the economic problems of Sri Lanka today.

To relate this discussion to Sri Lanka, the reader may use this framework to evaluate some of the government policies, such as maintaining a 1.4 million and increasing public-sector workforce (Japan with 140 million population has 850,000 public servants), maintaining many loss-making businesses such as airlines, electricity utility, Petroleum Corporation, sugar factories, etc., and direct provision and heavily subsidized provision goods and services.

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Agriculture and Economic Development

3

D. V. Pahan Prasada

Abstract

The evolution of agriculture from the days of the Lewisian two-sector model to today's context has involved many changes and developments, but the backwardness of the agriculture sector has persisted. Low-income countries have experimented with different policy orientations for agriculture. The modern linkage connecting agriculture to the rest of the economy is best described as a series of innovations in value addition through different types of processing and by linking the supply chains to niche markets. However, the occasional successes in value addition hardly match up to the systemic inefficiencies in low-income agriculture. For instance, there is evidence of countries where more than 34 per cent of the population is undernourished, while agriculture represents 30 per cent of GDP. Agriculture also faces significant environmental and climate challenges. While using 85 per cent of the developing world's freshwater withdrawals and 40 per cent of land, the sector accounts for up to 30 per cent of greenhouse gas emissions. The solutions to these challenges lie in multiple places: appropriate technologies, informed policy, transparent institutions, and, above all, efficient markets.

Keywords

Growth models · Role of agriculture · Sectoral impacts · Macroeconomic impacts

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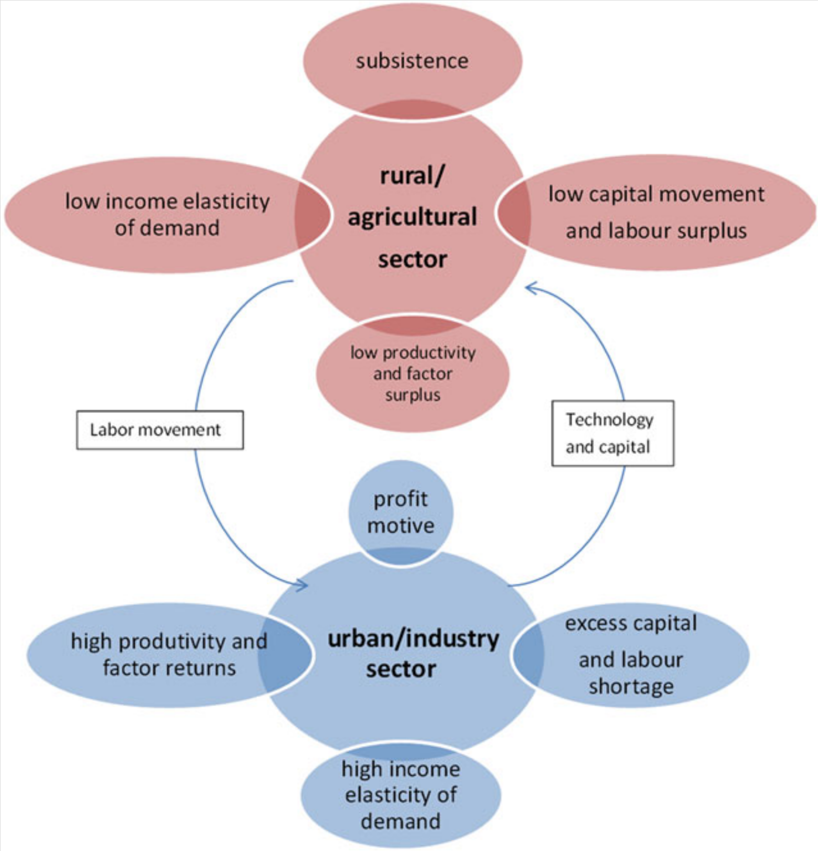
3.1 Role of Agriculture in Economic Development

3.1.1 Linking Agricultural Transformation to Economic Growth

Agriculture's contribution to economic development forms an integral component of the literature on development policy. Among the many contributors to the literature on agriculture and economic development, Arthur Lewis, Yujiro Hayami, Vernon Ruttan, John Mellor, Theodore Schultz, and Gustav Ranis stand out for making enduring contributions highlighting the agriculture sector's relations to economic growth. This genre of literature was essentially a response to the Malthusian warning that population growth would surpass the rate of increase in food supply. It also attempts to explain the economic and social transformations conditioned by global events, such as the industrial revolution, colonisation and imperialism, and the world wars of the twentieth century. Each of the aforesaid global events had its own element of shock and transformation to the global food supply. At the same time, episodes such as the Green Revolution marked a technology-driven process of gradual intensification of agriculture, necessitating a holistic understanding of agriculture's role.

The postcolonial world contained a multitude of low-income economies ideally suited for experimenting with economic restructuring. A pervasive traditional sector and tiny pockets of industrialisation were characteristics of many countries emerging from colonialism. In the context of two sector models (see Box 3.1), the role of agriculture was unambiguously outlined by many theorists as a facilitator to a future era of industrialisation.

Box 3.1 Two-Sector Model of Economic Growth. Lewis Model, 1954 (as visualised by the author)



In general, the structure of western economies was the model to be emulated. Mellor (1968) articulates the fivefold role of agriculture as follows: (a) meet a rapidly growing demand for agricultural products associated with economic development; (b) increase foreign exchange earnings by expanding agricultural exports; (c) supply labour to the non-agricultural sector; (d) supply capital, particularly for its own growth, for overheads and for secondary industry; and, (e) serve as a market for industrial output. The role of agriculture, as conceived above, is necessarily a subordinate role, a precondition to industrial transition, and the basis of prioritisation of self-sufficiency in staples and exports of agricultural raw materials. Thus, one could argue that the two-sector model was the origin of backwardness that many agricultural economies still grapple with.

A third strategy of agricultural growth was in making large investments in rural infrastructure. This complements the export-driven model by making local supply chains logistically efficient. Thus, public investments in agriculture form a historically important and still relevant component in the growth equation. The development literature provides much evidence of high and significant values of social rate of returns to large investments in irrigation, dams, and land consolidation projects, to name a few.

The evolution of agriculture from the days of Lewisian two-sector model to today's context has involved many changes and developments, but the backwardness of the agriculture sector has persisted. Such developments delivered hope but fell short of tangible outcomes. For instance, the high-yielding varieties in staples made self-sufficiency possible but failed to generate adequate profit margins to the cultivator. Export agriculture initiatives opened agricultural economies to the world but delivered neither stable prices nor sustainable business linkages. Marketing boards made supply chains stable but failed to coordinate production to avoid seasonal gluts and shortages. Farm subsidies helped continuity of staples but made farming systems less diverse. Technology helped farmers to be efficient but not optimal.

The modern linkage extending from agriculture to the rest of the economy is best described as a series of innovations in value addition through different types of processing of the raw product and matching the supply chains to niche markets. This process necessitates higher standards and quality to enable agricultural produce to be positioned in the mind of the consumer as products with respectability similar to industrial products. In other words, agriculture is transforming into an industry. As value addition and productivity increases, the excess labour is shed and production channels are streamlined in terms of efficiency and reliability.

Formulation of the agricultural sector's role in broader economic growth will vary based on the nature of development trajectories that a country faces. As a country undergoes a process of structural transformation, there are four broad responsibilities for the agriculture sector (Myint 1977). These include (1) food security, associated with annual per capita production of food (rice and other field crops); (2) labour mobility, releasing agricultural labour force to other sectors (manufacturing and services); (3) capital formation, through domestic savings from this sector; and, (4) agricultural trade, foreign exchange by exporting agricultural products. Each of the above has direct contributions to the national output.

3.1.1.1 Sri Lanka's Experience of Agricultural Transformation and Growth

Economic growth during the postcolonial period in Sri Lanka has been driven almost entirely by agricultural production and processing. The statistics reveal that, in addition to the dominant agricultural sector that accounted for nearly 50 per cent of national output, the agricultural processing sector constituted nearly 7 per cent of the manufacturing sector in the early post-independence years. The classical two-sector basis was observable even within the agricultural sector in the form of a subsistence sector and a plantation sector.

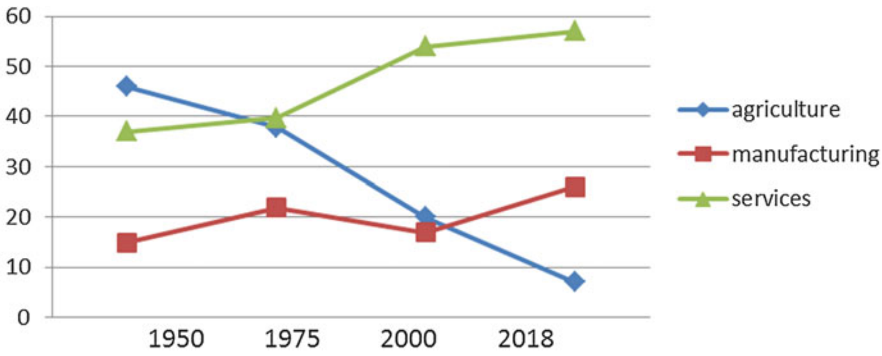


Fig. 3.1 Declining contribution (%) from agriculture to national output. Source: Department of Census and Statistics and Central Bank of Sri Lanka, 1975–2019

However, Sri Lanka's growth story deviates from a textbook two-sector model. According to Jogaratnam (1964), the local peasant agriculture sector failed to release surplus labour to the more productive sectors (namely, the plantation sector) due to a host of structural reasons. Thus, a classic two-sector model, as visualised by Arthur Lewis (1954), did not materialise. On the other hand, the plantation labour did not seem to have benefited in any way from the rapid expansion and rising levels of productivity within the plantation industry. Thus, both sectors failed to generate welfare to the respective local participants.

After independence from British rule, the subsistence sector received a boost in the form of irrigation, land reallocation, and colonisation programmes. Staples were locally grown under state patronage. The Green Revolution had a significant impact on local staples in terms of factor productivity. These rural sector transformations helped release excess labour from the subsistence agricultural sector. The rise in factor productivities resulted in wage growth, but real prices of agricultural produce continued to decline under global supply conditions. The net result was a drastic decline of the agricultural sector's contribution to national output (see Fig. 3.1).

In the 1970s and afterwards, after realising the shortfalls of Lewisian-style growth, low-income countries adopted a regime of economic expansion in the form of export-led growth. The agriculture sector was given the promise of niche markets for efforts in diversification and partial value addition. Classically, agricultural exports carried the dual benefit of increasing farmer incomes and foreign exchange earnings of the country simultaneously. However, an individual country that caters to a small fraction of world exports of an agricultural product faces an elastic demand at the world market. In order to reduce the overexposure of exports to price shocks and to make export revenues less sensitive to price variations, the efforts to increase exports either within the product category or through diversification made sense. The downside of simultaneous efforts to expand exports of an agricultural commodity by a number of countries is the risk of substantial price declines, especially when the relevant price and income elasticities are low. The Sri Lankan experience in agricultural exports was similar to many other countries of

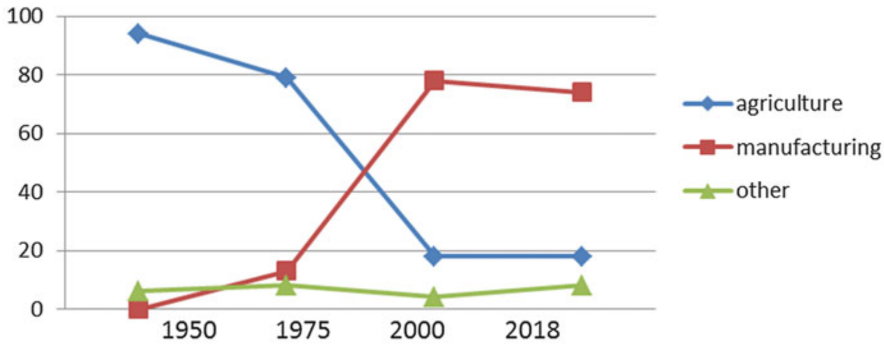


Fig. 3.2 Agricultural exports as a percentage of total exports. Source: Department of Census and Statistics and Central Bank of Sri Lanka, 1975–2019

similar development status. While many programmes were carried out to diversify agriculture beyond plantation crops into spices, horticultural products, growth media, etc., substantive evidence of agricultural export-led growth was not observed (see Fig. 3.2).

Sri Lanka's agriculture sector today is a mix of several strategies that were discussed earlier. For instance, it is largely export-oriented in horticultural produce, spices, and tea but pursues import substitution in staples, and other field crops. The livestock sector remains underutilised overall with a growing poultry sector that meets the domestic demand. While the elements of export-led growth and import substitution are both observed in isolated pockets, the overall agriculture sector does not display an exclusive growth orientation today.

3.1.2 Poverty Alleviation

There is substantial cross-country evidence to support the argument that agriculture sector growth is important in reducing poverty. Wiggins (2003) outlines three channels of impact of agricultural growth on poverty alleviation. First, there is the direct impact of agricultural growth on farm incomes which accounts for a large share of total income in poor economies. Second, there are numerous rural economy linkages. Growth in the incomes of farmers and farm labourers creates demand for non-farm products and services in rural areas. These are often provided locally using local labour. Third, agricultural growth leads to reduced prices for food and raw materials and thus raises the real incomes of the urban poor. Agricultural growth may also generate savings that lead to greater farm and non-farm investments. In addition, large public investment projects in agriculture, such as irrigation, reservoir, and river basin development, bestow high payoffs to growth and poverty reduction. In particular, returns to agricultural research and extension (Alston et al. 2002) have been highlighted for having direct impacts on rural poverty reduction. Datt and Ravallion (1998) report that the price and wage effects of agriculture are more important in reducing rural poverty in the long run than short-run direct effects on farm income. For example, during the Green Revolution in Asia, total factor productivity rose faster resulting in rising agriculture sector wages. This change took place more rapidly than the rate of decline in food prices (Lipton 2005), generating net welfare gains in the agricultural sector.

Food price volatility is a key poverty implication of agriculture. Given the relatively high share of household expenditure on food in low-income households, price shocks can aggravate poverty statistics at short notice. For instance, the 2008 food price spike is estimated to have moved approximately 130–155 million of the global population into poverty (World Bank 2007).

3.1.2.1 Sri Lanka's Experience of the Agriculture-Poverty Nexus

While the incidence of poverty nationwide has been reduced over the last 20 years, pockets of poverty persist. In 2016, with the official poverty line at LKR 4166 per person per month, the poverty headcount was 1.9 per cent in urban areas; 4.3 per cent in rural areas; and, 8.8 per cent in the estate sector (Department of Census and Statistics 2017a). In 2018, the mean household monthly income for urban areas was reported to be LKR 88,692, while the values for the rural and estate sectors were LKR 58,137 and LKR 34,804, respectively (Department of Census and Statistics 2018). The global Multidimensional Poverty Index (MPI) incorporates other dimensions of poverty into the headcount indices and ranks countries based on 10 indicators, namely, nutrition, child mortality, years of education, school attendance, electricity, sanitation, drinking water, cooking fuel, floor, and assets. The MPI for Sri Lanka (reported for 2016) indicates that 37.5 per cent of people are deprived when the weighted average of all indicators is considered (Department of Census and Statistics 2019).

A blind spot in Sri Lanka's achievements in poverty alleviation is the area of gender parity. National poverty statistics, while displaying significant improvement, mask the gender wage gaps that are ingrained in the traditional economic units in the rural agricultural and estate sectors. For instance, the estimated earned income per capita per month for women is LKR 5379, and the estimated earned income per capita per month for men is LKR 17,275 (Food and Agriculture Organisation 2018), a disparity indicative of both unequal compensation and unequal opportunity.

Poverty in the agricultural sector in general (and particularly in the plantation sector) is due to a number of direct and indirect factors rooted in historic economic structures. Income poverty in agriculture can be explained in terms of falling real prices for agricultural goods and falling productivity in the rural sector. The presence of a vicious cycle of poverty is especially evident in the agriculture sector where incomes are seasonal and credit-bound relationships create pressure on farm incomes even after a good harvest. On the other hand, poverty strengthens out-migration of skilled workers, intensifying the deprivation within the sector. Statistics in 2017 show that, except for the professionals, the agriculture sector carries the highest percentage of workers in the age cohort of 45–60 years in Sri Lanka (Department of Census and Statistics 2017b).

3.1.3 Food Security and Livelihood Development

Food security is framed conventionally as a collective of four aspects: availability, access, utilisation, and stability. Food availability is ensured through local production and imports. Access is assured through affordable relative prices of foods and lower transaction costs along the food supply chain. Food processing, storage, and marketing are key aspects of utilisation. Stability of food supply is ensured via long-term planning that will determine both quantity and prices. Food security and quality of livelihoods within the sector are closely interlinked. A dominant rural sector having access to cultivable land and other inputs ensures a steady flow of food to the rest of the economy. Given the large land footprint of agriculture, land and resource policies directly affect the supply side of food. Factors such as drought, floods, pests, and diseases cause volatility in food production. In addition, high production costs, low profitability, post-harvest losses, inappropriate land use, shortage of water in some parts of the world, and declining soil productivity also have detrimental impacts on food security.

A host of factors determines food supply but food demand is easily conceptualised. The annual rate of increase in demand for food is a function of the rate of growth of population and that of per capita income. The access to food depends on the income elasticity of demand and, therefore, has a dampening effect on the demand expansion due to per capita income growth. Food access, on the other hand, is a function of mainly the per capita income. The level of value addition and reduction of waste, both of which are factors influenced by consumer education and technologies of food supply and processing, directly influence food utilisation.

Statistics show that undernourishment has fallen when food production has risen, at least in the early stages of growth. Per capita food production grew by only 1.4 per cent per annum in countries where the number of undernourished increased substantially (Food and Agriculture Organisation 2003). But it grew by 3.3 per cent per annum in countries where there was a significant fall in the number of undernourished people (Food and Agriculture Organisation 2003). In general, throughout low-income countries, agriculture accounts for around 9 per cent of GDP and more than half of total employment. Paradoxically, in countries where more than 34 per cent of the population is undernourished, agriculture represents 30 per cent of GDP, and nearly 70 per cent of the people rely on agriculture for their livelihoods (Food and Agriculture Organisation 2003).

3.1.3.1 Sri Lanka's Experience in Food and Livelihood Security

Sri Lanka focused the greater part of her agricultural policy on food security during the post-colonial period. Thus, large-scale irrigation plans with concurrent colonisation programmes were scaled out into major river basins. State land was parcelled and allocated to the landless in the form of long-term user deeds in order to expand the cultivation of staple foods. Reservoirs and irrigation canals were restored to ensure a continuous supply of water. These efforts did meet with considerable success as observed in food availability in the island. While food access and food usage remain important concerns, Sri Lanka recorded a very high Household Food

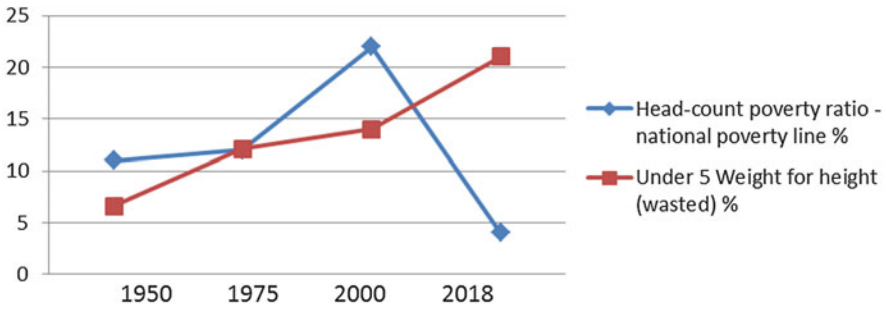


Fig. 3.3 Are poverty and nutrition statistics diverging? Source: Department of Census and Statistics, 1975–2019

Insecurity Access Scale Score (HFIAS), implying 90 per cent food secure households, placing Sri Lanka as the most food-secure nation in South Asia (Department of Census and Statistics 2017a). However, severe food insecurity is observed for 3 per cent of the households in the same measure.

In contrast to the above food security statistics, the Global Hunger Index indicates that the average level of calorie deficit in Sri Lanka in 2014–2016 was the highest in South Asia. The evidence suggests that access to food does not correlate with nutritional security in Sri Lanka. For instance, the Medical Research Institute of the Ministry of Health reports that almost one in three (31.8 per cent) pregnant women is anaemic. Stunting in children under 5 years increased during the period 2007–2016 in seven districts (see Fig. 3.3).

3.1.4 Natural Resource Conservation

Pressure on natural resources arising from the agricultural sector is threefold. First, it is agriculture's direct dependence on natural resources. For example, water use in agriculture may create pressure on the alternative uses of water resources. Similar impacts may be observable on fertile land. Open access grasslands, forests, and fisheries typify the "tragedy of the commons". Second, there is the pollution element and the depletion of the quality of the resource due to use. For instance, water is polluted by agrochemicals and soil by heavy metals found in fertilisers. Carbon emissions also fall under pollution. Thirdly, there are indirect impacts, such as the destruction of habitats of flora and fauna and reduction of biodiversity due to monocultures.

Such impacts emerging from agriculture pose serious unresolved problems to the quality of the environment and farming ecosystems. Indirectly, habitat destruction and ecological transformations such as monocultures have brought about pest and disease outbreaks, wild animal intrusion to farmlands, and reductions of biodiversity. Nevertheless, given the key role of providing sustenance in terms of provision of food and feed, agriculture has a custodial role to the earth's natural resources, especially with regard to the natural resources in human habitats.

Ecology-friendly agriculture remains an ideal that is paid lip service in mainstream farming models. This, however, should not underestimate the role of alternative agricultural practices such as organic farming that are increasingly being promoted in response to consumer demand for environment-friendly produce.

Statistically, agriculture is a major user of scarce natural resources. Approximately, 85 per cent of the developing world's fresh water withdrawal and 40 per cent of land are in agriculture. It is also a leading contributing factor to underground water depletion, agrochemical pollution, loss of biodiversity through deforestation, and to global climate change, accounting for up to 30 per cent of greenhouse gas emissions (United Nations Framework Convention on Climate Change 2015).

The gravity of the sector's impact on the environment and natural resources has long been a part of human knowledge and widely addressed in literature since the famed work of Rachael Carson. In response, academic and policy interest has focused on ecosystem-based approaches to agriculture. But widespread adoption of more sustainable approaches has often been hindered by inappropriate policies that encourage overexploitation and misuse of resources. Strengthening property rights and providing long-term incentives for natural resources management with off-farm benefits are necessary in both intensive and extensive farming areas to manage externalities. For instance, there is growing interest in payments for ecosystem services to help overcome market failures in managing environmental externalities (Food and Agriculture Organisation 2007). Among other corrective measures, environmental certification of products and farms enables consumers to pay for sustainable environmental management. Carbon trading schemes, especially if they provide finance for avoided deforestation and soil carbon sequestration, offer significant potential to reduce emissions from agricultural land uses.

3.1.4.1 Agriculture's Impact on Sri Lanka's Environment

While research has been carried out into elements of pollution of water, air, and soils, the environmental footprint of agriculture in Sri Lanka has not been studied extensively. Numerous studies have highlighted the overuse of water in agriculture: Fig. 3.4 shows the relative size of agriculture in water withdrawals. The fate of

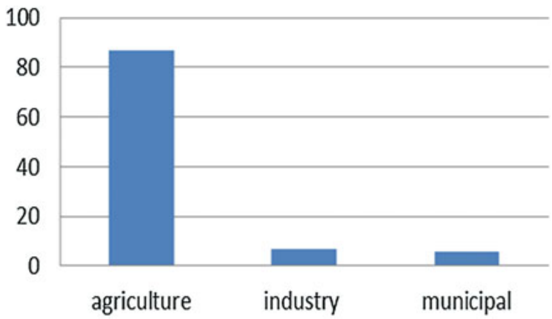


Fig. 3.4 Water footprint of agriculture (percentage water withdrawals). Source: Food and Agriculture Organisation (Aquastat database)

water quality under agriculture has been a serious concern. Soil application of fertilisers beyond the recommended levels has affected the water quality (Rajakaruna et al. 2005). According to Henegama et al. (2013), in key vegetable cultivation areas, the fertiliser application rates exceeded the recommended rates by large margins. Amounts of potassium, phosphorus, and nitrogen were reported to be higher by at least 217 per cent, 12 per cent, and 55 per cent, respectively. The soil carbon content and microbial habitats have been depleted by the intensive use of agrochemicals. Cultivation on sloping terrain has led to removal of the topsoils. Soil erosion and surface runoff from agricultural lands have resulted in siltation of tanks and reservoirs (Dayawansa 2006).

Over a period of 70 years, land-use maps indicate the expansion of agricultural land. While land productivity has increased in several crops such as tea and rice over the same period, land productivity has declined overall indicating that there may be land abandonment from agriculture due to declining soil fertility. Conservative estimates indicate that nearly 44 per cent of agricultural lands in Sri Lanka have been subject to land degradation. This value is higher in sloping terrain where tea is cultivated.

3.2 Drivers of Agriculture Development

The push factors and pull factors affecting agriculture are numerous and dynamic in nature. Analytical clarity is best served in treating the supply side and demand side differently. The supply side is predominantly driven by the policy framework, material input availability, and cost structure, and labour availability. The demand side is much simpler to understand but varied in composition. The consumer demand for food, feed, and fibre both locally and globally is coordinated by a market price mechanism.

3.2.1 Global Trends

The agricultural sector in every country adjusts to global trends and shocks. Global food value chains have integrated vertically to minimise transaction costs. While such developments ensure efficiency in the value chain, smallholders must adjust significantly to fit into these novel economic structures. With global supply chains integrated, diversification from primary exports to processed exports is necessary to maintain local competitiveness. The global trends of market integration can pose challenges to local agricultural value addition in the absence of frontier technologies. This vacuum is partially filled through the introduction of forward contract models and public-private partnerships which have introduced modern technologies into the agricultural value chain.

Among the less wholesome global trends, a recent threat to food sector stability is high fuel prices which have prompted many countries to look for alternatives, such as ethanol made from carbohydrates. Thus, crops such as maize, cassava, sorghum,

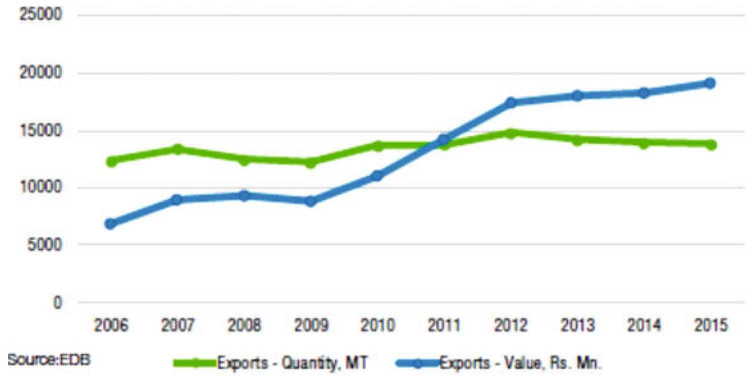


Fig. 3.5 Cinnamon exports: quantities and values. Source: Export Development Board and Institute of Policy Studies, 2016

etc. are now cultivated for the purpose of fuel. While this is a significant driver of agricultural expansion, the obvious pressures on food and feed have not been resolved.

Thirdly, the world food demand is moving to nature-based, herbal, and locally procured produce. Global initiatives of standardising food supply chains free of heavy metal traces and emission-reducing production processes have restructured agricultural supply chains significantly. In mainstream agriculture also, it is possible to introduce green or organic variants (e.g. organic spices in Matale District and pesticide-free rice in Badulla District). Globalisation of specialised export crops with comparative advantage, such as cinnamon, pepper, and cardamom, appear to consolidate the local value chains. Area cultivated under such crops has risen under global preferences for Sri Lankan cultivars of these products and the careful matching of supply to niche markets. Real prices of these niche commodities have risen in world markets, resulting in significant value gains (see Fig. 3.5).

The changing global retail food marketplace is also an important driver of local agricultural development. Supermarkets and electronic markets have replaced conventional platforms for retailing. Reardon et al. (2012) claim that in emerging Asia at least 37 per cent of the market share is captured by supermarkets. The statistics for countries such as Hong Kong and Singapore report that nearly 60 per cent of the share of fresh fruits and vegetable sales are with supermarkets and other modern retailers (Reardon et al. 2012). Evidence from Sri Lanka also highlights the penetration of supermarket chains in fresh fruit and vegetable supply.

3.2.2 Macroeconomic Drivers

Macro sector shocks affect the agricultural sector through traded produce. Agricultural goods are traded through different channels and different institutional linkages. Starting from bilateral trade agreements to open market trading, agricultural output

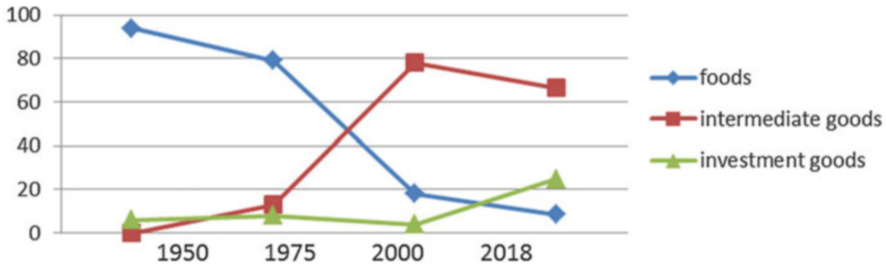


Fig. 3.6 Food imports percentage of total imports. Source: Central Bank of Sri Lanka, 1975–2019

crosses borders every day and becomes important determinants of agricultural price level domestically.

Trade liberalisation is the single most important macroeconomic driver of local agricultural sector transformation in the modern era. Essentially, Sri Lanka moved from a high nominal rate of assistance to agriculture to a more liberal trade regime over the years. With a significant trade dependence, the agricultural and food sectors were directly affected by exchange rate shocks. For the greater part of the last 50 years, Sri Lanka operated a fixed exchange rate regime with currency overvaluations. However, Yamaguchi and Sarma (2006) conclude that this regime helped to reduce the real food imports and increase the agricultural exports, implying that the export depressing impact of an overvalued local currency did not materialise in the agricultural sector. Trade-dependent subsidies, such as for fertilisers, create pressure on the balance of payments under a fixed exchange rate regime. With the General Agreement on Tariffs and Trade (GATT) commitments on reducing tariff protections and floating regime, the vulnerability of local production increased significantly in the area of spices and plantation crops. Empirical studies do not find large-magnitude benefits to agricultural exports under a regime of floating exchange rates and lowered nominal rates of assistance. Statistics indicate that the imports of food have declined drastically in relation to non-food imports (see Fig. 3.6).

The third macroeconomic driver of agricultural sector development is inflation. The inflationary impact of a given percentage increase in food prices is much more severe in a low-income country than in a high-income economy. This is a simple consequence of the dominant position of food as a wage good in lower-income countries, where 50 to 60 per cent of total consumption expenditure is devoted to food compared with 20 per cent in developed economies.

3.2.3 Environment Pressures

Climate change impacts loom large in future projections of changes in the food supply. While technology provides solutions to mitigate and adapt to climate shocks on agriculture output at a given production setting, the impact of climate change on heterogeneous farmlands remains unaddressed. For instance, in the Sri Lankan agro-

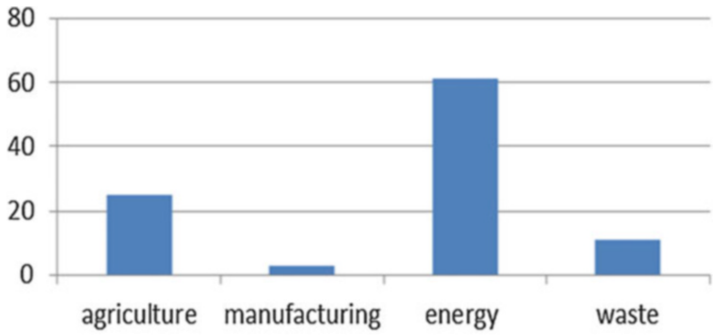


Fig. 3.7 Percentage contribution of agriculture to GHG emissions in Sri Lanka. Source: United Nations Framework Convention on Climate Change 2015

climatology, with the wet zone becoming drier and dry zone becoming wetter, there will be challenges of altering the farming systems in order to match the topology and soil environment to climate variations.

The paradigm of carbon trading also places pressures on agriculture as the opportunity cost of allocating land for cropping and livestock may be high in the presence of better prices of carbon stocks. While the valuation of ecosystem services and carbon will make the use of natural resources efficient at the global level, the local impacts may not be unambiguous. Shrestha et al. (2013) estimate that by introducing a carbon tax starting at USD 15 per metric ton, Sri Lanka's cumulative Greenhouse gas (GHG) emissions may drop by nearly 22 per cent by the year 2030. While agriculture is just one sector contributing to GHG emissions, such stylistic calculations will have impacts on land-use decisions in agriculture.

Agriculture is a dominant contributor to GHG emissions in the Sri Lankan context. Figure 3.7 shows the relative sectoral contribution to GHG emissions in Sri Lanka. Within the agriculture sector the relative burden of emissions is shared by the rice sub-sector and dairy sub-sector (Fig. 3.8). With stringent international commitments on carbon emission reduction, there is pressure to modify the conventional agricultural production practices into more sustainable ones.

Sri Lanka's agriculture currently records a contribution below the average value (i.e. 35 per cent) for a "non-annex 1" country under the United Nations Framework Convention on Climate Change classification. As the Food and Agriculture Organisation (2017) points out, the potential for reducing emissions from the agriculture sector is available, especially in the livestock sector. Greenhouse gas emissions and the resulting climate change impacts will be a key driver of the agricultural sector of Sri Lanka in the years to come.

3.2.4 Technology

Agricultural intensification is taken seriously in land-locked and resource-poor countries. The supply chains are directed towards input factor productivity and

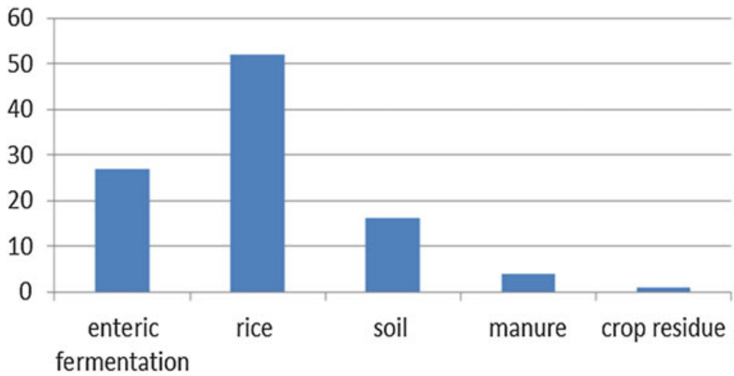


Fig. 3.8 Percentage breakdown of relative contribution of activities within agriculture to GHG emissions. Source: United Nations Framework Convention on Climate Change 2015

reduction of transaction costs. At the national scale in Sri Lanka, the impact of technology in agriculture shows mixed outcomes. While the increased private sector participation in protected agriculture and niche product developments has benefited from external know-how and technology, the para-statals and smallholder sector have not shown significant adoption of new technology. The only clear adoptions have been at land preparation and harvesting of staples (which remain at nearly 100 per cent locally). New policy developments such as public-private partnerships are necessary to introduce capital-intensive technologies at other stages of the agricultural supply chain. The historical evidence is symptomatic of a rise of input productivities in some sub-sectors while clear lags are visible in others. In general, tea and rice cultivations show increasing returns to land while coconut and rubber do not (Fig. 3.9).

The level of penetration of technology is varied even in cases where there are substantive increases in land productivity. For instance, in local rice production, the land preparation, harvesting, and threshing stages use mechanisation to a level above 98 per cent of the farmers (Gamlath et al. 2018). But, the rate of mechanisation of seedbed preparation is at 29.73 per cent, rice transplanting at 3 per cent, weeding at 3 per cent, and power spraying at 9 per cent. The time trade-offs for manual implementation of tasks such as transplanting are more than 10 times the labour hours used with mechanisation.

Other technological drivers of agriculture include Information and Communication Technologies (ICT), especially as part of agricultural extension provision. This development is a result of near 100 per cent penetration of mobile telephony into the rural sector. A recent study finds that mobile agricultural extension users are 2.2 times more likely to decrease fertiliser and pesticide use than non-users (Palmer and Darabian 2017). Users of mobile phone-based agricultural extension were also significantly more likely to report changes to their planting habits (3.3 times) and their harvesting and storage practices (2.2 times) than a matched group of non-users (Palmer and Darabian 2017).

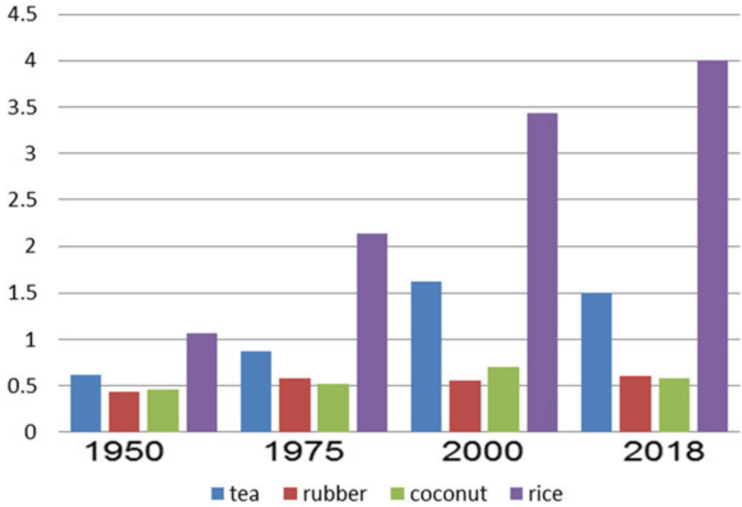


Fig. 3.9 Evidence of land productivity changes in plantation crops and rice. Note: Comparison across crops per given year is not intended due to difference in units. Display of changes across years by crop is the intended purpose of the figure. Source: Central Bank of Sri Lanka and Department of Census and Statistics, 1975–2019

3.2.5 Institutions and Policies

Institutions and policies are a key aspect of agriculture in almost all countries. In many low-income and middle-income countries with a significant rural sector, agricultural institutions and policies are politically impactful. As the economies of these developing countries gradually open to world trade, the frictions arise mainly in agricultural institutions and policy structures. The classic development question for many decades and perhaps still to date is why agricultural policy is still so difficult to reform. Is it due to inefficiency in policy structures that are politically appealing? Is it inability to coordinate across vast numbers of rural-smallholder producers? Is it the issue of inadequate land title ownership among smallholders? Or is it the essential perishability of agricultural produce, making harmonising agricultural value chains difficult? There may be other possibilities.

Local experience with respect to agricultural sector policies starting from the colonial period is worth revisiting for the lessons one can draw from history. According to Jogaratnam (1972), the development strategy for Sri Lanka in the early twentieth century was concerned with the provision of credit which was considered to be the critical factor that limits sustained increases in agricultural production. Thus, agricultural policy was mainly concerned with the establishment of rural cooperative credit societies. After failing to reap the expected outcomes, the policy interest shifted to irrigation, land development, and settlement in the 1940s. It was recognised that the farm units were too small to be economically viable and that new land had to be opened up or existing land consolidated. The focus on agricultural expansion was accompanied by a scheme of incentive prices which guaranteed the farmer a price for rice and input subsidies (particularly for fertilisers). A third era of policy materialised in the 1960s with rural development programmes, influenced mainly by Arthur Mosher's work. The logic was to adopt an integrated approach to agricultural development focusing on five essential elements (markets, technology, local input supplies, production incentives, and transportation) and five accelerators (education, production credit, group action by farmers, land improvement, and national planning). The integrated development focus temporally overlapped with the introduction of Green Revolution technologies. The domestic rice sector saw rising productivity of inputs and livelihood conditions. Perhaps, at this point, in the later 1970s to 1980s, the labour releasing role of agriculture actually occurred. Adoption of an open economy structure to the country helped pull labour out of agriculture into urban vocations in manufacturing.

Even though investing in agricultural research and development has generated very high internal rates of returns historically, most recent agricultural policy commitments have taken the form of channelling funds toward subsidising private goods (like fertiliser and credit). Researchers have argued that spending on private goods provision, such as through subsidies, is less productive than investments in public goods (López and Galinato 2006).

Many countries display a policy bias favouring the agricultural sector viz-à-viz other sectors of the economy. Literature reports the impact of subsidies as a 30 per cent decline in the relative price of agricultural products with respect to a non-agricultural price (Krueger et al. 1991). This policy bias is worsened by overvalued exchange rates, high tariffs, and taxes on agricultural exports (Anderson 2008). Macroeconomic restructuring is usually recommended as a measure to correct such historical biases towards agriculture. However, the outcomes are mixed. There is evidence to suggest that while macroeconomic initiatives have increased the competitiveness of agriculture, these gains may be offset by trade policies (of high-income countries) which reduce world market prices for agricultural produce (World Bank 2007).

Looking at the multinational agricultural development agenda, one observes that the share of agriculture in official development assistance has declined sharply in the period up to the 2008 food price crisis: the share varies from 18 per cent in 1980 to around 3 per cent in 2005 (World Bank 2007). However, the food price crisis refocused attention on newer problems of agricultural development, such as price volatility and the fungibility of cash subsidies. This renewed attention resulted in drawing capital in the form of private-public partnerships, and the novel institutional structures promised a greater likelihood of returns to public spending globally.

Modern agriculture policy has moved away from the classic material subsidies and land tenure restrictions even within South Asia. Key examples in this regard include water markets in Bangladesh, electronic (online) vending platforms in India, and electronic finance in Pakistan, all acting to widen the policy frontier in agriculture. Simultaneously, the organisational structures of agriculture are fast evolving to capture the benefits of global capital stocks and private venture capital. For instance, in all South Asian countries, private-public partnerships are promoted actively by the state as a solution to the capital shortage in agriculture. Sri Lanka has actively adopted a Public-Private-Producer model of agricultural investments since 2015, in ventures ranging from standard crop and animal production to peripheral areas such as seaweed culture and apiculture (Prasada 2019).

3.3 Assignments

1. Agriculture's contribution to growth rate diminishes in the long term, but there may be short-term contributions that surpass the other sectors. Using cross-country data from 1950 onwards, test if the above claim holds. Use World Bank open data for data series extraction.
2. Using time series data on agricultural GDP and an agricultural price index, test if the following major policy episodes had any impacts on output or prices. Use World Bank open data and CBSL annual reports for data series extraction.
   Accelerated Mahaweli project (1978–1984)
   Fertiliser subsidy removal (1990–1994)
   Land reform (1972–1975)
   Trade liberalisation (1978 onwards)

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Part II

Concepts, Approaches, and Measures for Policy Analysis

The International Trading System

4

Emalene Marcus-Burnett

Abstract

This chapter provides an overview of the multilateral trading system and the key organisations with oversight of international trade rules. Particular emphasis is placed on the World Trade Organisation (WTO) and the discussions on agriculture. Regional and bilateral trade agreements are also briefly examined given their potential for trade diversion or trade creation. Some practical application is included aimed at providing a greater understanding of some of the trade issues and their potential impact on domestic policies.

Keywords

International trade · WTO · WITS

4.1 An Overview of the Chapter

> *Each word, each comma that we negotiate here has a direct and measurable impact on public policies and business realities — and consequently, on people's lives.*

Roberto Azevedo, former Director-General, World Trade Organisation (WTO 2020b)

Mrs. Marcus-Burnet has been following multilateral trade negotiations for more than 15 years and has served as WTO Chair of the Committee on Agriculture (Regular Session).

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No nation exists in isolation. Nations are connected through various arrangements covering areas, such as merchandise trade, tourism, migration and remittances, and investments. Some of these arrangements are formal with limited membership and various commitments which members are required to fulfil. Some arrangements permit membership based on geography (e.g. the South Asian Free Trade Area or SAFTA) or a specific characteristic (e.g. Organisation of the Petroleum Exporting Countries or OPEC), while others involve members from all over the world (e.g. the World Trade Organisation or WTO).

In international trade, formal agreements are now widespread. Trade agreements boost trade by helping to reduce barriers, open new markets, and increase the predictability and transparency of trade. Trade agreements can help a country to boost exports but also expose uncompetitive domestic industries to increased imports. Trade agreements have an impact on the growth and development of countries and, as highlighted by the WTO Director General in his farewell speech, on people's lives.

Only a few trade agreements, associated with the General Agreement on Tariffs and Trade (GATT) and the WTO, have shaped the international trading environment. Typically, trade agreements do not determine the development policy aims and objectives of the national governments of member countries. Rather, they influence the country's choice of trade policy instruments (i.e. whether to use an import tariff or domestic subsidy; whether to apply a specific import tariff or ad-valorem tariff) and policy levels (e.g. 10 per cent or 25 per cent).

In this context, the international trading system and the main organisations/ arrangements governing international trade must be considered in the design and reform of domestic agricultural trade policy. An understanding of the international trading environment will assist policymakers in crafting domestic programmes that meet local policy objectives which are consistent with international trade obligations.

This chapter will examine the key institutions governing and facilitating international trade in agriculture. The main focus will be on the WTO and its agreements affecting agriculture production or trade. More specifically this chapter (i) describes the multilateral trading system, with particular emphasis on the World Trade Organisation, the United Nations Conference on Trade and Development (UNCTAD), and the Food and Agriculture Organisation of the United Nations (FAO); (ii) describes the key Regional Trade Agreements (RTAs) and bilateral agreements to which Sri Lanka, or its trading partners, is party; (iii) explains how international trade interacts with and impacts upon other arrangements (RTAs, bilaterals) and domestic policy; (iv) presents some of the tools for assessing international trade; and (v) presents an application to further explore trade data.

4.2 Theories on International Trade Versus Actual Trade Performance

International trade theories seek to explain international trade flows, why countries trade, and why countries may specialise in certain sectors. According to Diaz-Bonilla and Ron (2010), the benefits of trade include the reduced variability in supplies at the domestic level (when compared to reliance on domestic production only) and reduced price volatility due to increased supply. Early proponents of trade and development theory include Adam Smith, David Ricardo (theory of comparative advantage), and W. Arthur Lewis (dual-sector theory/industrialisation by invitation in small economies).

The Ricardian theory of comparative advantage, using a two-country, two-product, two-factor model, concludes that global welfare and economic growth increase when countries specialise in production of the good for which they have a comparative advantage (i.e. use relatively less resources to produce) and trade (import) that in which they are the less efficient producer. Later theories, such as the Heckscher-Ohlin model, better mirrored international trade by expanding the number of countries and factors of production to show that there could be winners and losers from trade and that the results of trade liberalisation can be disproportionate, even among similarly situated developing countries. Modern theorists, such as Joseph Stiglitz and Jagdish Bhagwati, have highlighted the limitation of traditional models and postulated alternative trade theories that take into account the asymmetry in information, production, and supply lags inherent in agricultural production and other market imperfections experienced by developing countries.

Available data largely confirm, consistent with international trade theories, that generally open economies – economies that participate in the international trading system – experience greater economic growth and consumer welfare than closed economies. The 1930s were the most vivid representation of such theories. The use of beggar-thy-neighbour policies during the 1930s confirmed trade theories as increased nationalism resulted in reduced world output and prolonged the Great Depression. Beggar-thy-neighbour policies (the term coined by Adam Smith) describe a country's use of tariffs and other barriers to protect the domestic market which worsen economic problems in its trading partners and, in the absence of an international rules-based trading environment, encourage retaliation, with negative effects on demand, purchasing power, and growth. Indeed, this experience galvanised support for the 1944 Bretton Woods Conference that gave birth to the International Monetary Fund (IMF) and the International Bank for Reconstruction and Development (IBRD) and set the framework for the eventual establishment of the WTO. The WTO itself is premised on the belief that a free and market-oriented trade system increases global welfare.

However, the reality is that protectionist policies still exist. One study (Tokarick 2003) concluded that substantial protectionism remains in the agricultural sector in developing countries. The reality is that country policies aimed at the agricultural sector can be complex and, at times, contradictory in light of the multifunctional nature of the sector. This multifunctional nature means that policymakers are aware that agriculture has an important role in contributing meaningfully to food security, rural employment, improved livelihoods, poverty reduction, economic development, and supplying raw materials for expanding industrial and bioenergy sectors, while being a source of foreign exchange earnings. This means that often policymakers are simultaneously trying to safeguard sensitive domestic production and seeking increased external market access for products of export interest; policy objectives can be protectionist or liberal depending on the product under scrutiny. For example, where a staple plays an important part in poverty alleviation and rural development, a country is likely to seek to safeguard domestic production and the domestic market, notwithstanding the fact that it may be cheaper to import. This policy may coexist with actions seeking to expand export markets for another commodity produced in the country. Morrison and Sarris (2007) argue that some import protection may be warranted where countries are now developing their agricultural sectors, and that for countries with relatively low tariffs, further liberalisation that reduces such tariffs may be counterproductive.

4.3 Product Classification in International Trade

As more countries gained independence in the first half of the twentieth century, and international trade expanded, there was need for a common system to facilitate international trade and provide a common basis upon which trade data could be collected, exchanged, and analysed. Today, the two primary systems of international product classification are the UN Standard International Trade Classification (SITC) and the Harmonised Commodity Description and Coding System (HS). There are other product classifications, such as the Combined Nomenclature used within the European Union and the Mercosul Common Nomenclature (MCN) used by the MERCOSUR bloc for intra-regional trade. MERCOSUR is the South American regional trading bloc comprising Argentina, Brazil, Uruguay, Paraguay, and Venezuela.

4.3.1 The United Nations Standard International Trade Classification

The UN SITC was created in 1950 by the United Nations Statistical Office as a means of facilitating easier comparability of merchandise trade among nations (United Nations 2020). All UN member governments were urged to make use of the SITC. However, the SITC has been overtaken in importance by the HS classification which the UN Statistical Commission itself eventually endorsed in 1993. Nonetheless, given its widespread availability, the SITC remains popular for analyses of trade and economic data. Given the existence of the two parallel product classification systems, the UN Statistical Office intermittently undertakes a reconciliation of the SITC and HS classifications, and this has accompanied revisions to the SITC, the last of which is Revision 4.

4.3.2 The Harmonised System

The HS system provides a detailed classification system to compile trade statistics. It was created by the European Customs Cooperation Council as a tariff nomenclature to group products according to their class and stage of production (raw, intermediary, or processed). The Convention on Nomenclature for the classification of Goods in Customs Tariffs entered into force on 1 July 1955 and the International Convention on the Harmonised Commodity Description and Coding System (Convention on the HS system) entered into force on 1 January 1988.

The HS system is used by over 170 countries and is maintained by the World Customs Organisation (WCO) (www.wcoomd.org) and updated every 4–6 years to take into account changes in trade patterns and new products. The latest revision to the HS system became effective in January 2017, and the seventh edition, HS2022, is scheduled to become effective from 1 January 2022 and will include guidance on classification for new or newly traded products, such as e-waste, novel tobacco, and nicotine-based products, as well as a specific sub-heading for the classification of smartphones.

4.3.3 Deconstructing the HS Code

The HS system is divided into XXI sections covering 97 chapters, and over 5000 tariff lines. The first chapter is Live Animals (Chap. 01), which falls within Sect. I, Animals and Animal Products, and ends with Works of Art, Collectors' Pieces and Antiques (Chap. 97). HS classifications are uniform to the six-digit level with flexibility for country-specific descriptions at the eight- and ten-digit levels. For example, the six-digit HS Tariff code 020725 identifies poultry meat not cut in pieces and that is frozen. The first two digits (02) identify Meat and Edible Meat Offal (Chap. 02). The next two digits (07) identify that the meat is from poultry of heading 0105, fresh, chilled, or frozen, and the last two digits (25) that it is "of turkeys, not cut in pieces, frozen". This is the method of breaking down a tariff code and, at the six-digit level, is the identical product descriptor in all countries using the HS system.

Tariff codes beyond the six-digit level may differ across countries. For example, the eight-digit code 02072540 in the USA represents Meat and Edible Offal (02), of poultry (07), not cut in pieces but frozen (25), and valued at 88 cents or more per kg (40), the latter a sub-description being unique to the USA.

Data comparisons at the four- and six-digit levels are more reliable given the comparability across countries. Thus, the use of more detailed tariff classification, such as the eight-digit level, may increase product specificity at the expense of trade comparability across countries. As such, many trade databases, such as the World Integrated Trade Solution (WITS), use the six-digit level of trade.

Access to the Harmonised System Database operated by the WCO is only available with a paid subscription. However, many national customs and trade divisions provide access to data free of charge. For example, data on HS tariff lines can be accessed through the US International Trade Commission site (www.hts.usitc.gov).

4.4 Institutions Governing and Facilitating Global Trade

4.4.1 World Trade Organisation

4.4.1.1 The Origins of the Multilateral Trade Organisation

The 1944 Bretton Woods Conference set the framework for discussions on the establishment of the International Trade Organisation (ITO), which was intended to be the global organisation to oversee trade. Despite the inability to agree on the establishment of the ITO at the subsequent 1947 UN Conference on Trade and Employment, there was agreement on the provisional application of the then-concluded General Agreement on Tariffs and Trade (GATT), pending the conclusion of negotiations on the establishment of the ITO.

4.4.1.2 The GATT Negotiations

Over eight rounds of GATT negotiations, GATT Contracting Parties sought to achieve binding agreement on international trade modalities and the establishment of the ITO. The GATT negotiations resulted in continuous tariff reductions among GATT Contracting Parties. Of particular note were the Kennedy Round (1964–1967), which established the anti-dumping framework and introduced the concept of non-reciprocity of concessions by developing countries, and the Tokyo Round (1973–1979), which set the groundwork on non-tariff measures and framework agreements in specific commodity areas. The Uruguay Round (1986–1994) was the longest and most ambitious as it included more countries, as well as discussions on agriculture which was a contentious area and had been omitted from previous negotiations. The Uruguay Round culminated in the Marrakesh Agreement which established the WTO with effect from 1 January 1995.

4.4.1.3 Overview of the WTO

The WTO is headquartered in Geneva, Switzerland, on the same premises that housed the GATT Secretariat. As of November 2020, there were 164 members covering 98 per cent of world trade, with a further 23 developing, or Least Developed Countries (LDC), in the accessions process.

The WTO legal texts (WTO 2020a) are comprised of:

- The Marrakesh Agreement establishing the WTO.
- Four annexes containing the various individual agreements. Annex 1 contains the multilateral agreements (Annex 1A: Trade in Goods; Annex 1B: Services; and, Annex 1C: Intellectual Property); Annex 2 outlines the Understanding on Rules and Procedures Governing the Settlement of Disputes; Annex 3 the Trade Policy Review Mechanism; and Annex 4, the plurilateral agreements in force at that time.

- 23 Ministerial decisions and declarations adopted in December 1993.
- A further four decisions adopted by Ministers at the Marrakesh Ministerial meeting.
- The Understanding on Commitments in Financial Services.
- The complete text of the GATT 1947 agreement (including the various amendments agreed during the GATT negotiations).

The main functions of the WTO are to (i) administer trade agreements; (ii) serve as a forum for trade negotiations; (iii) settle trade disputes; (iv) review members' trade policies; (v) assist developing countries with trade policy issues through technical assistance and training programmes; and, (vi) cooperate with other international organisations.

The core principles of the WTO are Most Favoured Nation (MFN) treatment and national treatment/non-discrimination. MFN treatment means that the most favourable conditions granted to one country in a trade agreement (e.g. a lower tariff rate for one imported product) are extended to all WTO members. National treatment means that in the application of tax and other internal measures, countries should not institute measures that favour local production. The operation of the national treatment principle is exemplified in the panel report on one of the earliest WTO disputes – Japan; Alcoholic Beverages (WT/DS8/R, 1996) – a dispute that centred on Japan's tax and distribution regime for imported alcoholic beverages. The panel held that, in requiring special distribution systems and applying different taxes, Japan was in violation of the national treatment principle (GATT Article III) in that its system treated imported vodka (a directly substitutable product to local shochu) differently. If a country institutes a measure that de facto benefits its local production even if de jure it appears to be neutral, such a country could be in violation of the national treatment principle. Such was the case in Chile – Alcoholic Beverages (WT/DS87/R, 1999) – since the measure was designed in such a way that, de facto, Chilean products enjoyed the lower tax rate while almost all the imported products attracted the higher tax.

Transparency and special and differential treatment for developing countries are important elements in WTO agreements and negotiations. Transparency, in the form of members' notification of measures and the implementation of commitments, helps to ensure the smooth operation of and confidence in the multilateral trading system. Special and Differential Treatment for developing countries was included in the WTO Agreements and remains an element in ongoing negotiations. Special and differential treatment provisions include lower tariff reductions and longer implementation periods for developing countries: agricultural tariffs in developed countries were to be reduced by 36 per cent of the base tariff over 6 years, while developing countries had to reduce tariffs by 24 per cent over 10 years and LDCs were not required to undertake any reductions.

4.4.1.4 Constituent Bodies

The Ministerial Conference is the highest decision-making body. In the period between Ministerial Conferences, decisions are taken by the General Council.

Fourteen Regular Committees, which report to the General Council, monitor the implementation of existing commitments largely through the review of members' notifications and questions on their domestic programmes. These regular bodies include the Committee on Agriculture, the Committee on Market Access, the Committee on Sanitary and Phytosanitary Measures, and the Committee on State Trading Enterprises.

Special Session Committees discuss negotiation modalities based on the parameters agreed by the Ministerial Conference.

4.4.1.5 Decision-Making in the WTO

Decisions are made by consensus, defined as the absence of a formal objection at the meeting at which the decision is taken. Unlike institutions with weighted voting, such as the IMF, each WTO member from the smallest to the most powerful nation has one vote. While the Ministerial Conference is supposed to meet every 2 years, the membership may decide, in the interest of the Organisation, to defer a Ministerial Conference. For example, the Sixth Ministerial Conference was held in December 2005, but the next Ministerial Conference was not held until December 2009. Further, the next scheduled Ministerial Conference, MC12, was originally to be held in June 2020 in Nur-Sultan, Kazakhstan, but in light of global events has been deferred to 2021.

4.4.1.6 The State of Play in the Trade Negotiations

Of the WTO Agreements, only the Agreement on Agriculture (in Article 20) and the General Agreement on Trade in Services (in Article XIX) contained built-in negotiation mandates.

The WTO Ministerial Declaration adopted at the fourth WTO Ministerial Conference held in Doha, Qatar, in 2001 provided the official mandate under which negotiations in the various areas were to be conducted. Similar to GATT practice where the negotiating round was named after the city in which it was launched, this first (and yet to be concluded) round of multilateral trade negotiations launched by the WTO is known as the Doha Round or, alternatively, in recognition of the centrality of development, the Doha Development Round.

Two decades later, the optimism and ambition that characterised the early stages of the negotiations have all but vanished. Although countries reiterate their commitment to, and the importance of, the multilateral trading system, the continuing divergence in positions, the protracted nature of the discussion, and the slim prospect of achieving meaningful agreement have resulted in countries re-directing their efforts to bilateral and regional trade discussions. The COVID-19 pandemic and ensuing disruption in global supply chains have also increased bilateral and regional trade discussions. It remains to be seen whether the first female Director-General of the WTO will be able to galvanise the membership into making much-needed progress.

The negotiating discussions on goods (agriculture and non-agriculture), services, Trade-Related Aspects of Intellectual Property (TRIPS), WTO rules, and Dispute Settlement Understanding (DSU) are the core areas and attract the greatest attention.

However, the Doha Ministerial Declaration Work Programme contained over 15 areas and also included implementation issues, trade and investment, trade and competition policy, trade and environment, trade and transfer of technology, transparency in government procurement, trade facilitation, and electronic commerce. Notwithstanding the impasse in the core negotiations, progress has been achieved in other areas of the Work Programme. For example, WTO members successfully concluded negotiations on the Trade Facilitation Agreement (TFA) in 2013, and it entered into force on 22 February 2017. Members continue to support the moratorium on the application of customs duties on electronic transmissions; it is expected that the moratorium will continue. Indeed, the pandemic in 2020 has resulted in a more focused discussion on the online delivery of services. Progress was also made on issues of importance to LDCs as the membership agreed on the preferential treatment of services and services supplies from LDCs. This departure from the MFN principle in favour of LDCs is covered by a WTO waiver until 2030.

4.4.1.7 The Agriculture Negotiations

Article 20 of the Agreement on Agriculture (AoA) contains a built-in agenda for negotiations. The work that began in 2000 under this agenda was recognised in the Doha Work Programme. The mandate in paragraph 13 was for "comprehensive negotiations aimed at: substantial improvements in market access; reductions of, with a view to phasing out, all forms of export subsidies; and substantial reductions in trade-distorting domestic support. We agree that special and differential treatment for developing countries shall be an integral part of all elements of the negotiations and shall be embodied in the schedules of concessions and commitments and as appropriate in the rules and disciplines to be negotiated, so as to be operationally effective and to enable developing countries to effectively take account of their development needs, including food security and rural development" (World Trade Organisation 2001). It is now historical fact that the various deadlines for the completion of modalities were missed.

- It was only in 2015, in the WTO Ministerial Decision on Export Competition (World Trade Organisation 2015), that members were able to agree on disciplines on export subsidies. This was, however, one of the less contentious areas in the agriculture discussions since WTO notifications revealed a downward trend in the use of export subsidies, and rising agricultural prices obviated the need for such subsidies. Optimism remains that members can build upon the success of the Decision on Export Competition to have agreed modalities on other export competition elements, including export restrictions, food aid programmes, and the operation of any public stockholding programme.
- WTO notifications reveal an upward trend in the provision of domestic support, in particular, the "Green Box" which encompasses programmes considered non-trade distorting and have no monetary limit on their application. At the launch of the current negotiations, members had advocated for strong disciplines in and cuts to the levels of domestic support. There has been a lessening of the level of ambition as discussions now centre on a possible cap and cut approach to

domestic support. In a March 2020 update, then Chair of the Committee on Agriculture (Special Session), Ambassador John Ford noted that divergences remained on domestic support. Members remain divided on the approach and level of cuts. Based on members' views, an agreement on enhanced transparency measures seems possible by the 12th WTO Ministerial Conference in 2021.

- Market Access remains the area in which significant differences persist, not along a North-South divide, but along trade lines. Groups like the Cairns Group (a coalition of agricultural exporters, including Argentina, Brazil, Chile, Indonesia, South Africa, Australia, Canada, and New Zealand) advocate for significant tariff cuts and reform in the area of special agricultural safeguards. Indonesia is also the coordinator of the Group of 33 which advocates for a Special Safeguard Mechanism (SSM) for developing countries and flexibilities for public stockholding programmes. The membership remains as divided on the SSM as it was a decade ago. The likelihood of agreement on this area, within the current circumstances and without any fundamental changes in the WTO, is slim. As with the discussions on domestic support, the area of greatest possible convergence is that of transparency in, inter alia, the administration of Tariff Rate Quotas and reporting on ad valorem equivalents.
- Cotton remains one of the core agricultural issues under discussion. Cotton is discussed in the WTO on two tracks: (1) the trade reforms needed to address subsidies and high trade barriers for cotton and (2) the assistance provided to the cotton sector in developing countries. A large part of the membership supports an outcome on cotton. The need for comprehensive modalities to address cotton is championed by four African countries known as the Cotton 4 or the C4 Group: Benin, Burkina Faso, Chad, and Mali.
- After two decades, and with negotiating positions seemingly entrenched, new approaches may be needed to ensure progress in the agriculture negotiations. The Ottawa Group, formed in 2018 and comprising 13 WTO members keen to see a revitalised WTO, has been holding informal discussions on possible progress that can be made in the agriculture discussions. The focus on enhanced transparency and more stringent criteria for support programmes may be one way forward. The focus on areas likely to achieve consensus is also a way forward. However, this could disproportionately affect some and result in issues of interest to some countries not being addressed. Out of necessity, in 2020, due to the disruption in the transportation and distribution of food supplies, some countries implemented measures that facilitated agricultural trade. Building on these would provide a resolution on some agriculture negotiating issues, such as public stockholding programmes.
- One of the most effective and controversial suggestions to resolve the agriculture negotiations has been greater differentiation and reliance on proportionality. There is concern among some WTO members that over 2/3 of the membership is eligible for special and differential treatment, which means that the burden is on a few countries. Of greater concern is that some large developing countries are eligible for differential treatment accorded to developing countries and, using data on their agricultural trade performance, are not in need of such flexibilities.

The idea of graduation is attractive to some developed countries as it would result in some countries being ineligible for developing country flexibilities, a prospect that makes concessions to developing countries more politically palatable. Members have resisted an open-ended discussion on this contentious area given its divisive impact on developing countries. The impasse in the selection of Appellate Body members and the present inability to hear appeals has further placed the WTO at a crossroads. Until these larger issues are resolved, it is likely that a comprehensive agreement on agriculture will remain elusive.

4.4.2 Key WTO Agreements of Importance to the Agricultural Sector

4.4.2.1 The Agreement on Agriculture

The WTO Agreement on Agriculture was the first comprehensive multilateral agreement on agriculture covering tariffs (market access) and support (domestic support and export competition) measures. The Agreement comprises a preamble and 13 Parts encompassing 21 Articles and 5 Annexes. The preamble recognises the importance of agriculture to food and livelihood security, environmental concerns, and the special position of developing countries, while seeking "to establish a fair and market-oriented agricultural trading system" (World Trade Organisation 2016). The product coverage for agriculture in the WTO is defined in Annex 1 as chaps. 1–24 of the World Customs Organisation Harmonised System of tariff classification, excluding fish and fish products. This definition encompasses both basic agricultural products, as well as the value-added/manufactured product.

Of note is article 21.1 which gives primacy to the provisions of the AoA by making the provisions of GATT 1994 and other agreements in Annex 1 to the WTO Agreement applicable "subject to the provisions" of the AoA. Such an exemption for agriculture was necessary since some provisions, such as the Tariff Quotas and the Special Safeguard Provision, allow a member to disregard the MFN and National Treatment rules contained in GATT Articles I and III. Article 21.1 of the AoA, therefore, immunises a country from challenges to measures applied in conformity with the AoA but which may be in contravention of other WTO and GATT rules.

Article 20 contains an in-built agenda for the continuation of the reform process with Members' Schedule of Commitments as the basis for further reductions. Under the 2001 Doha Declaration, modalities were to be concluded by 2005. However, a comprehensive agreement on agriculture is yet to be achieved. Agreement on the reform has been difficult, in part, due to disappointment in developing countries with the results of the Uruguay Round. The promised gains have been illusory or less than expected in some cases, and developing countries have found that the existing rules severely hamper their policy options. The use of non-tariff barriers and regulations, often by major markets of export interest, has also placed many developing country exports at a disadvantage.

Market Access

These modalities are outlined in Part III. Article 4 allows the incorporation of Members' Schedules of Commitments to be included as an integral part of the Agreement. The AoA itself contains little elaboration and details on commitments for tariff reductions. As per Article 4, concessions are contained in Schedules of Commitments of the individual member states. The illustrative list of measures that are prohibited is provided as footnote 1 to Article 4.2. These prohibited measures include quantitative import restrictions, variable import levies, and discretionary import licensing.

The major activity under Market Access was commitments to tariff reductions by member states as a means to promote freer international trade. As provided for in the AoA, tariff reduction commitments by member states were based on the bound tariff rates in the Uruguay Agreement. Recall that the AoA emerged out of the Uruguay Round, which itself represented a continuation of the tariff reductions begun under GATT 1947. As such, where there were bound tariffs, these were the base rates used for reduction purposes. In general, developing countries were required to reduce tariffs by 24 per cent over 10 years, with minimum tariff line cuts of 10 per cent. Developed countries were required to reduce tariffs by 36 per cent over 6 years, with minimum tariff cuts of 15 per cent for any product. LDCs were required to bind tariffs only, with no reduction obligations. Thus, all countries were required to have bound tariffs for all agricultural products. Tariffication allowed countries to have access to Special Safeguards (SSG) for agriculture. As provided for in Article 5 of the AoA, SSGs allowed countries, faced with a surge in imports or depressed import prices that threatened the domestic market to apply additional tariffs on imports beyond a certain level. The trade-off for access to the SSG was the implementation of Tariff-Rate Quotas (TRQs); that is, the commitment to import a certain minimum amount at a lower than prevailing tariff level. The minimum level began at 3 per cent of domestic consumption of the product averaged over the 1986–1988 period, increasing to 5 per cent by end of the implementation period (2000 for developed countries and 2004 for developing countries). These tariff-rate quotas were required to be at more favourable rates than prevailing tariffs. One of the drawbacks of this was that for products with declining consumption or declining import patterns (maybe due to better local quality), the use of the 1986–1988 base period resulted in proportionally greater market access. However, a member's obligation was only to open the TRQ, and there was no obligation to fill the quota. Members with low fill rates could, however, expect questions from other members on the reason(s) for the low fill rate.

Domestic Support

These modalities are outlined in Part IV of the AoA. The domestic support commitments set out the rules relating to how members should provide support to the agricultural sector. The Agreement has two broad categories of domestic support: measures that are not subject to reduction commitments (Green Box) and the Total Aggregate Measure of Support included in a member's Schedule of Commitments.

This latter category comprises product-specific and non-product-specific domestic support (Amber Box) and market price support (Blue Box).

Green Box policies are those deemed to not have a major effect on production and trade (i.e. non or minimally trade-distorting subsidies). These are listed in Annex 2 of the AoA. Green Box policies cover many government service programmes, including general services; environmental protection and regional development programmes; public stockholding programmes for food security purposes and domestic food aid; and, direct payments to producers that are not linked to production decisions. Support which fits into the Green Box is generally available to all producers (i.e. not limited to specific sectors) and is funded by government (whether through central government or via a designated agency), not through price support or higher process to consumers. As these subsidies are deemed to have no or minimally trade-distorting impacts, the AoA provided no ceiling on their provision. There is no limit to the amount that a country can spend on Green Box policies, as long as the policies meet the general and specific criteria in Annex 2 (see paragraphs 2, 3, and 4). The implementation experience has revealed that, for some countries with the budgetary means, the overall level of domestic support remained stable as countries adopted creative approaches to craft WTO-consistent measures in support of their agricultural sector.

Amber Box measures are subsidies that are deemed to be trade-distorting and encompass support provided to specific domestic commodities or producers and also non-specific product support. Amber Box policies are best described by what is not in it. It excludes all domestic support that meets the criteria contained in Annex 2 (Green Box policies) and support provided under Articles 6.2 and 6.5 of the Agreement on Agriculture (Blue Box policies). Non-specific product support includes, for example, concessional loans to the sector for debt restructuring, drought recovery, and preparedness activities, or a grant programme to support food manufacturing businesses in accessing new or higher value-added markets. Product-specific support includes, for example, the cost of subsidised or free crop insurance guarantee schemes available only to producers of a specific commodity or the value of the free storage provided to grain producers.

While the specific support measures in the Amber Box are not listed, there is a methodology for calculating the overall level of such support (Aggregate Measure of Support, or AMS) in Annex 3 of the AOA. The AMS is a single figure that captures the level of non-specific and specific product support provided by a country. Members were required to cap and reduce such subsidies. Developed countries were required to reduce Amber Box support by 20 per cent over 6 years and developing countries 2/3 of this (13.3 per cent) over 10 years. Only 32 members have Amber Box commitments. Countries with no scheduled AMS commitments could still provide support utilising the de minimis (minimal support allowed) provisions under Article 6.4 (10 per cent for developing countries). Developing countries could also provide support under Article 6.2 to support low-income and resource-poor farmers. One group of WTO members has calculated that, while it has decreased, product-specific support still accounts for the majority of notified support. The European Union, the USA, Japan, China, and Switzerland were the top five providers of product-specific support. Nonetheless, concern has been expressed at the increasing use of product-specific support falling within the de minimis level. Cereals, dairy, pork, and beef are among the products that receive the largest amount of product-specific support.

Blue Box modalities are outlined in Annex 4 of the Agreement which provides the modalities for the calculation of the Equivalent Measure of Support. Blue Box measures are deemed to be trade-distorting support but for which, as per Article 1 of Annex 4, calculation of the market price support was not practicable. As stated by the WTO, "any support that would normally be in the amber box, is placed in the blue box if the support also requires farmers to limit production (details set out in paragraph 5 of Article 6 of the AoA)". These have been described as "Amber Box support with conditions" and represented a compromise position during the Uruguay Round negotiations to take into account the concerns of the European Union (Orden et al. 2011). Domestic Support notifications reveal that, indeed, the EU is the primary user of such measures.

Export Competition

Measures to support exports – such as, direct cash subsidies, lower transport costs or rebate schemes for transport costs, or the provision of subsidised export credit – can distort trade as they artificially lower export prices and enhance the competitiveness of exported products. In the WTO, export competition components in agriculture are export subsidies and the provision of in-kind food aid. Within the Doha Development negotiations, proposals were made on the provision of food aid in monetary terms rather than in-kind support.

Export subsidy modalities are contained in Part V of the AoA. Article 9 outlines the export subsidies subject to reduction commitments, with some concessions allowed for developing countries providing support to underwrite the cost of marketing, internal transport, and freight charges (Article 9.4). During the implementation period, scheduled export subsidies were to be reduced by 21 per cent in volume terms and 36 per cent in value terms for developed countries and by 14 per cent in volume terms and 24 per cent in value terms for developing countries.

One of the successes of the tenth WTO Ministerial Conference held in Nairobi, Kenya, in 2015 was the Ministerial Decision on Export Competition which provided for the elimination of all forms of scheduled export subsidies, as well as export credits, export credit guarantees, and export credit insurance schemes. Members' notifications will reveal whether there is a genuine reduction in support or if the overall level of support remains the same through increases in allowable support measures, such as Green Box subsidies.

4.4.2.2 The Agreement on the Application of Sanitary and Phytosanitary Measures

Negotiations on agriculture recognised the need for food safety and health standards in the sector. Similar to other WTO Agreements, some important principles in the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) are non-discrimination, equivalence, and special and differential treatment for developing country members. Sanitary and phytosanitary (SPS) measures are closely associated with agricultural products, even though the SPS Agreement itself contains no provision limiting its application to agricultural products. This may be because some food products, notably fish and fish products, fall outside the scope of the WTO definition of agriculture. Indeed, footnote 4 to Annex A of the SPS Agreement specifies that for the definition of SPS measures, fish is included as an "animal".

The SPS Agreement consists of a preamble, 14 articles, and three annexes. The agreement applies to all SPS measures that directly or indirectly affect international trade (Article 1, SPS Agreement). The agreement seeks to balance members' need to protect human, animal, or plant health and life without such measures being barriers to trade. Measures implemented by members must be scientific-based and, as per Article 3, grounded in international standards, guidelines, and recommendations where such exist. Article 3, which addresses harmonisation, specifically recognises three international treaties ("the three sisters"), namely, the Codex Alimentarius Commission, the International Office of Epizootics (OIE), and the International Plant Protection Convention (IPPC). These three bodies are observers to the work of the SPS Committee, sharing with the Committee any developments in their respective areas since the SPS Committee has been tasked with monitoring the process towards harmonisation undertaken in these organisations. As observers only, these bodies are not called upon to pronounce upon the consistency of the measures adopted by members.

With the entry into force of the WTO, there is increased attention on the SPS measures instituted by members. One difficulty is to distinguish when SPS measures are instituted as disguised barriers to trade as opposed to when they are instituted to guard against trade that increases the risk of importation of pests and diseases that pose threats to human, animal, or plant health and life. Developing countries, as a result of limited resources, face challenges of constrained participation in the formulation of standards and limited laboratories and testing facilities to achieve the requisite scientific rigour required to implement SPS measures. In recognition of members' challenges, especially developing country members, the SPS Agreement includes provisions for technical assistance (Article 9) and special and differential treatment for developing and least developed countries (Article 10).

4.4.2.3 The Agreement on Technical Barriers to Trade

Technical standards, like SPS measures, can be used as barriers to trade in the absence of international coherence. Technical standards can be barriers as they potentially increase costs when producers have to satisfy varying requirements. For example, labelling requirements can be a barrier where non-conventional sizes and fonts are specified and the market share does not compensate for the increased production cost. While provision is made in the Agreement on Technical Barriers to Trade (TBT Agreement) for members to be provided with a reasonable time to conform to new measures, the lack of specificity on what constitutes a reasonable time may hamper timely conformity and impact a firm's market share and bottom line.

The TBT Agreement consists of a preamble, 15 articles, and three annexes. Article 1 of the TBT Agreement specifies that all goods, industrial and agricultural, are subject to the provisions of the Agreement. However, measures affecting goods produced for governmental bodies are exempt. The preamble recognises that countries should be able to implement measures aimed at, inter alia, quality assurance and prevention of deceptive practices. The TBT Agreement details the process for preparation, adoption, and application of standards. As with the SPS Agreement, transparency is stressed. Members are required to publish draft measures, provide early notice of measures contemplated, and allow sufficient time for comments. Under Article 11, members are required, if requested, to advise on the preparation of technical regulations and provide technical assistance, especially to developing countries. This is in addition to the Special and Differential Treatment to developing countries outlined in Article 12.

4.4.2.4 The Agreement on Trade-Related Aspects of Intellectual Property Rights

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) is contained in Annex 1C of the WTO Legal Texts. The TRIPS Agreement is comprehensive and comprises a preamble and 73 Articles. The areas covered include copyright and related rights (i.e., the rights of performers, producers of sound recordings, and broadcasting organisations); trademarks including service marks; geographical indications including appellations of origin; industrial designs; patents including the protection of new varieties of plants; the layout-designs of integrated circuits; and, undisclosed information including trade secrets and test data.

There are three main features of the TRIPS Agreement: standards, enforcement, and dispute settlement.

Standards: The TRIPS Agreement is a minimum standards agreement which allows members to provide more extensive protection of intellectual property if they so wish. Members are left free to determine the appropriate method of implementing the provisions of the Agreement consistent with their domestic legal system and practices.

Enforcement: The second main set of provisions deals with domestic procedures and remedies for the enforcement of intellectual property rights.

Dispute settlement: It follows the WTO's dispute settlement procedures.

Developing countries, in general, did not pay sufficient attention to the negotiations on TRIPS, and the linkage between TRIPS (intellectual property) and agriculture is only being deeply explored in the post-WTO era. As such, many developing countries are now catching up with respect to the intellectual protection and exploitation of their world-recognised indigenous products. One key provision is Article 27 on patentable subject matter. Article 27(3) (b) excludes from patentability "plants and animals. . . .and essentially biological processes for the production of plants or animals. . .". However, there is allowance for the protection of plant varieties. The review of this provision as part of the Doha Development Agenda has polarised countries, resulting in no agreement on the way forward as countries seek an extension of protection for more than wines and spirits.

4.4.3 Dispute Settlement in the WTO

One distinguishing feature of the WTO has been its Dispute Settlement modalities, which is contained in the *Understanding on Rules and Procedures Governing the Settlement of Disputes* (DSU). The dispute settlement provisions allow for members' commitments to be legally enforceable, avoiding the diplomatic route often favoured for the resolution of inter-country disputes. Breach of the WTO rules can result in a panel authorising retaliation if the measures under dispute are not brought into conformity with a member's WTO commitments within the agreed timeframe. Such retaliation usually entails additional tariffs, up to a panel-approved level, on the violating country's exports to the complaining country. As such, the WTO Dispute Settlement process can result in real economic costs to countries that breach WTO rules. There also is an arbitration option provided for under Article 25 of the DSU. This can be of use in situations when time is of the essence and the complaining state may be concerned about the cost to pursue a dispute.

The DSU applies to the Agreement Establishing the WTO; all WTO Multilateral Trade Agreements, that is, agreements on the trade in goods (Annex 1A), trade in services (1B) and the TRIPS Agreement (Annex 1C); the DSU itself; and where the participants to such agreements so agree, Plurilateral Agreements. Unlike the GATT system, the WTO dispute settlement process is faster and panel reports easier to adopt since Dispute Settlement Body decisions are adopted by negative consensus; that is, if an appeal has not been lodged, the panel report is adopted unless all members agree that the report should not be adopted. As such, although GATT panels may last years, the indicative timeframe for the WTO dispute settlement process is less than 18 months.

Once a dispute has been initiated, parties provide written submissions outlining the legal and factual bases of their position. Oral presentations are then made to the panel. Panel deliberations are not open to the general membership, although the panel report is circulated to the membership 10 days after being delivered to the parties to the dispute. Like the criminal and civil judicial system, there is the possibility of an appeal on points of law and issues of legal interpretation (Article 16.4). Table 4.1 summarises the timeframe for the various steps in the WTO dispute process.

The DSU is contained in Annex 2 of the WTO Legal Texts. The Agreement contains 27 Articles and 4 appendices. Issues and panel reports are considered by the Dispute Settlement Body (DSB). Panels comprise three panellists unless the parties to the dispute agree to a panel of five panellists (Article 8.5). Panellists serve in their individual capacity rather than as representatives of their country. The WTO Secretariat maintains an indicative list of panellists, who are qualified individuals nominated by WTO members or are respected professionals in trade law. Provision is also made for the establishment of a seven-member Appellate Body, of which

Table 4.1 Timeframe for the various steps in the WTO dispute process

Activity	Timeframe
1. *Consultations on measure(s) in question* This is a mandatory step prior to requesting that a panel be established to adjudicate on the measure(s) in question	At least 60 days
2. *Establishment of panel and appointment of panellists* The parties to the dispute have some input into the selection of panellists. Where parties cannot agree on the composition of a panel, the Director-General is then tasked with using his good offices to appoint panellists	45 days
3. *Final panel report to parties*	6 months
4. *Final panel report to WTO members*	3 weeks
5. *Adoption of report by Dispute Settlement Body* (DSB) (where no appeal is lodged)	60 days
6. *If there is an appeal*	
7. *Report of the Appellate Body*	60–90 days
8. *DSB adopts Appellate Body report*	30 days
9. *Member indicates to the DSB how it intends to bring its measures into conformity*	Within 30 days of report's adoption
10. *Where a measure is found to be inconsistent with WTO commitments, and there is no agreement on compensation, the complaining member may seek permission through the DSB to retaliate*	20 days unless parties agree other (extended) timeframe

three serve on any one appeal of a panel decision (Article 17.1). There are no provisions for the appeal of an Appellate Body report, and these reports are adopted by negative consensus (Article 17.14).

Retaliation measures to compensate for loss resulting from breaches should be in the same sector that was affected by the inconsistent measures, since the aim is to place the aggrieved member in the economic position it would have been but for the inconsistent measure. Where retaliation in the same sector provides insufficient compensation, retaliation may be allowed in other sectors. For example, after its successful claims regarding the consistency of the US measures on online gambling, Antigua and Barbuda was authorised to undertake retaliatory measures in other areas, such as intellectual property.

The inability to agree on the selection of persons to the Appellate Body has affected the Dispute Settlement system. The USA has blocked the appointment of Appellate Body members, and so, without the US' cooperation, members' terms have expired and the membership has been unable to replace them. The Appellate Body currently only has one person whose term is set to expire in November 2020. As such there are insufficient Appellate Body members to adjudicate on appeals; Dispute Settlement system is stymied at the appeal level but the panel stage remains unaffected.

The USA has expressed concern that the Appellate Body is extending its remit and, instead of adjudicating on WTO law, is making WTO law extending principles and measures such that they are now beyond the intent and agreement of members. The USA maintains that it is the members that agree on modalities, not the Appellate Body. Although only formally raised by the USA, the concern about the Appellate Body extending its functions to rulemaking, rather than mere clarification, is shared by other members. Although there is no system of precedent, Appellate Body panels only exceptionally differ from previous findings on issues of legal interpretation; panels often adopt the Appellate Body's reasoning from previous decisions. As such, the USA's concerns are valid. Members, as part of the negotiating process, had submitted proposals on the reform of the Dispute Settlement, but these discussions have yielded no fruit, likely contributing to the USA's frustration and its decision to block the appointment of Appellate Body members.

The WTO has had a very active dispute settlement system with some countries, such as the USA and China, frequently being parties to WTO disputes. In contrast, some, such as Antigua and Barbuda, were a complainant in only one case. Sri Lanka has been a complainant in one dispute settlement case – against Brazil involving desiccated coconut – and has been a third party in four dispute cases involving measures by Brazil, India, the European Communities (as the EU was then known in the WTO), and the USA.

Below are summaries of two dispute settlement cases. The first case concerned Brazil's imposition of countervailing duties on desiccated coconut (Box 4.1). The Philippines raised this concern with Brazil in late 1995. Sri Lanka also, in February 1996, submitted a request for consultation on the measure (see WTO document WT/DS30) but did not proceed to the stage of requesting the establishment of a panel on the measure. The second case concerned China's Domestic Support Measures applicable to corn, rice, and wheat (Box 4.2). The dispute on China's measure showed the complexity in calculating market price support where processed or some processed products are involved. In addition to accounting for the volume losses in the processing process, another issue was what constituted a basic agricultural product and the relevant price to be used. While the definition of a basic agricultural product in Article 1(b) of the Agreement on Agriculture references a member's Schedule of Commitments, Paragraph 7 of Annex 3 on the calculation of the level of support refers only to the "point of first sale of the basic agricultural product concerned".

Box 4.1 Case 1: Brazil – Measures Affecting Desiccated Coconut
Complaint by the Philippines

In a communication dated 27 November 1995, the Philippines submitted to Brazil a request for consultation on Brazil's countervailing duties on desiccated coconut as contained in Brazilian Inter-ministerial Ordinance No. 11 of 18 August 1995. The Ordinance resulted in a countervailing duty of 121.5% being imposed on desiccated coconut imported from the Philippines and, in the view of the Philippines, impaired its exports and was

(continued)

Box 4.1 (continued)
inconsistent with Brazil's obligations under Article 13 of the Agreement on Agriculture and the understanding on the imposition of countervailing duties (GATT Article VI).

Process

In a communication dated 17 January 1996 (51 days after its request for consultations), the Philippines requested the establishment of a panel to examine the dispute. A subsequent request was submitted on 5 February 1996, this latter date ensuring that, as per Article 4.7, the 60-day timeline was respected. A panel to adjudicate on the dispute was established on 5 March 1996. Among countries indicating third party interests was Sri Lanka.

Under the DSU, panels are required to submit their reports normally within 6 months. Any delays must be explained. The panel made such a submission on 18 September 1996, since under normal DSU procedures, the panel should have submitted its report by 5 September 1996. The Panel Report was circulated on 17 October 1996. On 16 December 1996, the Philippines appealed the decision. The Appellate Body findings of 21 February 1997 upheld the panel's findings that the measures were not inconsistent with commitments. The Appellate Body report WT/DS22/11/Rev2 was adopted by the membership on 20 March 1997.

This dispute was adjudicated within 11 months (to panel stage) and, including appeal, was disposed within 16 months.

Findings on Brazil's Measure

The complaint was dismissed. The Appellate Body upheld the panel's findings. Brazil's use of and reliance on the provisions of the Agreement on Subsidies and Countervailing Measures (SCM Agreement) were not inconsistent with its obligations. The Appellate Body concluded, in paragraph 294 of its report, that neither the provisions of the Agreement on Agriculture cited nor article VI of GATT (countervailing measures) constituted applicable law for the purposes of the Philippines's claims. This dispute underscores the fact that a measure, taken in isolation, may appear to be inconsistent with a specific Agreement but that the WTO Agreements must be examined holistically. Brazil's countervailing duty measure could not be examined in isolation using only the countervailing provisions (GATT Article VI) and disregarding the exception under Article 32.3 of the SCM Agreement.

Box 4.2 Case 2: China – Domestic Support for Agricultural Producers

Complaint by the USA

On 13 September 2016, the USA requested consultations on China's domestic support measures that favoured certain producers of corn, rice, and

(continued)

Box 4.2 (continued)

wheat, contrary to the Agreement on Agriculture. The USA examined China's Domestic Support notification which included a nil figure for Market Price Support and claimed that China applied market price support for producers of wheat, rice, and corn over the period 2012–2015 that was in excess of its de minimis commitment of 8.5%. China, as per its accessions commitments, is allowed a de minimis level of 8.5% (compared to 10% for developing countries included in the Agreement on Agriculture). Countries are allowed to record a nil figure for trade-distorting (Amber Box) subsidies where such support does not exceed the de minimis level.

Process

A panel was established on 25 January 2017. The panel report was circulated on 28 February 2019 and adopted by the Dispute Settlement Body on 26 April 2019. China did not appeal the panel's findings. China and the USA agreed on a reasonable time for China to implement the DSB recommendations and so bring its measures into conformity with its obligations. However, while the panel process is concluded, the issue is not fully resolved. Disagreement persists between China and the USA on whether China's amendments satisfy the panel ruling and are in accordance with Article 21.5 of the DSU. China also objects to the level of concessions proposed by the USA as compensation for the breach of obligations. In a communication dated 5 August 2020, China has requested the establishment of a panel to adjudicate on whether it has complied with the panel rulings.

From the written request for consultation, until the adoption of the report by the DSB, the dispute took 32 months. However, part of the delay arose due to the almost year of consultations, after the submission of the written request, in an effort by the parties to amicably resolve the dispute.

Findings on China's Measure

Given that the policy measure for corn expired prior to the USA's challenge, China successfully argued, citing the Appellate Body report on US-Certain EC Products, that a panel cannot make a recommendation on an expired measure. The panel thus declined to adjudicate on the support to corn and only considered the measure's impact on the support provided to wheat and rice (specifically the Indica and Japonica rice varieties).

The panel held that China exceeded its allowable commitment level of "nil" as contained in Sect. I, Part IV of its Schedule of Concessions on Goods. China was not in conformity with its obligations under Article 3.2 and 6.3 of the Agreement on Agriculture.

On the de minimis allowance, China argued that the 10 per cent de minimis level specified in Article 6.4(b) of the Agreement on Agriculture is available to China as it is a developing country and built a link of consistency between this 10 per cent allowance and China's AMS levels. Under Article 6.3 of the Agreement on

Agriculture, countries with no domestic support commitments (such as China), where the market price support does not exceed the de minimis threshold, the level of product distorting domestic support can be recorded as "nil". However, relying on China's Accession Protocol and the provisions of paragraph 342 of China's Working Party Report, the panel held that China's de minimis level was limited to "8.5 percent of the total value of production of a basic agricultural product during the relevant year". One principle of treaty interpretation is that in general, unless otherwise indicated, the provisions of later treaties supersede those of earlier treaties. As such, the limit in China's 2001 Accession Protocol was given precedence over the limit in the earlier concluded Agreement on Agriculture.

In its assessment on the market price support levels, the panel examined the elements used to calculate the Market Price Support (MPS): the Applied Administered Price (AAP); the Fixed External Reference Price (FERP); and, the Eligible Quantity of Production. Paragraph 8 of Annex 3 of the Agreement on Agriculture outlines the method for calculation of MPS as follows:

$$\text{MPS} = (\text{AAP} - \text{FERP}) \times \text{Eligible Quantity of Production}$$

On the applied administered price (AAP), the USA argued (in para 7.174 of the report) that, using the ordinary principles of interpretation, the AAP is the price provided to the product. The panel held that the AAP was the minimum procurement price as legally defined in China's Annual Notices for the products in question.

On the FERP, the USA argued for the use of the average import price during the period 1986–1988 (as contained in para 9 of Annex 3). China, in contrast, supported use of the 1996–1998 period which was the base period used in calculating domestic support commitments during its accessions process. China argued that there must be consistency in the calculations of Base Total Aggregate Measurement of Support (AMS) and current total AMS levels.

This element was of importance since use of the 1986–1988 period would have resulted in a larger price differential and so a higher market price support level. China successfully argued that the 1986–1988 period was not applicable since all acceding countries with MPS commitments used a base period other than the 1986–1988 period. The Panel concluded that while the reference period for original WTO members was the average import price during 1986–1988 as per the Agreement on Agriculture, China's use of the 1996–1998 period was reasonable.

There was also disagreement on the adjustment in the FERP on rice to take into account volume loss from the milling process. The panel rejected China's submission and used an adjustment rate of 70 per cent to reflect the level of unmilled rice lost in the milling process.

With respect to the Eligible Quantity of production, the USA claimed that where there were no limits, the entirety of the production is eligible and that, conversely, if a limit such as on the geographic scope or a regulatory maximum is applied, that limit should be accounted for when determining the volume eligible to receive the applied administered price (AAP) (para 7.279 of the report).

China contended that in the absence of any specific guidance in para 8 of Annex 3 of the Agreement on Agriculture, countries could choose a methodology that accords with "a holistic and harmonious interpretation of the Agreement on

Agriculture". China's approach resulted in a lower quantity (and thus a lower calculated market price support), while the approach favoured by the USA resulted in a higher quantity of eligible production and so a higher market price support.

The panel relied on the text of para 8 of Annex 3 that uses the words, "eligible to receive the applied administered price" and the ordinary meaning of the terms. Reference was also made to the Appellate Body interpretation of the quantity of eligible production in the report on Korea – Various Measures on Beef. The Panel held at para 7.315 of the report that the relevant parameter is the entire production in the specified regions for the year under consideration, excluding the volume of out of grade grains.

Having examined the individual elements, the panel calculated the MPS and concluded that, in the years under question (2012–2015), China's support for wheat (MPS/total value of production) amounted to 12.14 per cent, 18.17 per cent, 21.72 per cent, and 22.39 per cent, all in excess of China's 8.5 per cent de minimis level. The support provided to rice was also deemed in excess of China's 8.5 per cent de minimis level.

The 1960s were characterised by increasing change and greater independence of and participation by developing countries in the UN system. In 1964, the first United Nations Conference on Trade and Development (UNCTAD) was held in Geneva, Switzerland. Arising out of the advocacy of developing countries, in December 1964, UNCTAD was institutionalised as a permanent inter-governmental body through UN General Assembly Resolution 1995 (XIX) with the aim of facilitating discussion and research on the trade and development issues affecting developing countries. It was the intention that UNCTAD would be the primary forum to facilitate north-south dialogue on the global economic agenda and developing countries' integration and better participation in the new international economic order. One of the initial successes of UNCTAD was the Generalised System of Preferences (GSP) Scheme developed in 1971 and endorsed by UN resolution 21 (II) under which developed countries that were GATT contracting parties granted temporary preferential tariff rates on selected products originating from developing countries. The temporary GSP scheme was made permanent through a GATT Enabling Clause waiver in 1979. UNCTAD was also instrumental in developing the category of Least Developed Countries to whom particular attention and assistance are given.

UNCTAD has observer status to all regular WTO bodies as well as three negotiating groups established under the WTO Trade Negotiations Committee – the Committee on Agriculture (Special Session), the Council for Trade in Services (Special Session), and the Committee on Trade and Environment (Special Session). UNCTAD was also granted ad hoc observer status in the negotiations on the WTO Agreement on Trade Facilitation.

UNCTAD's trade and development focus is wide, encompassing areas, such as sustainable development, fiscal stability, and commodity programmes (like the integrated programme for commodities established in 1976). As GATT negotiations intensified and the eighth round of GATT negotiations progressed, the focus of UNCTAD shifted from negotiating on trade elements to increased focus on research, policy analysis, and technical assistance to foster development in developing countries. As trade evolved and became more integrated, UNCTAD's focus expanded to account for new areas, such as foreign direct investment (e.g. the annual publication of the World Investment Report), technology, and sustainable production methods.

UNCTAD XV was originally scheduled to be held in Barbados in October 2020 but was rescheduled due to the global health crisis.

4.4.4 Food and Agriculture Organisation of the United Nations

Given its wide remit, the FAO is another useful organisation to be considered when examining the institutions facilitating international trade in agriculture. The FAO was one of the first specialised agencies created after the formation of the United Nations in 1945. With an initial focus on addressing hunger, the FAO seeks to address the challenges relating to the production, supply, and availability of food. The FAO was instrumental in the creation of the International Plant Protection Convention (IPPC) in 1952 and the Codex Alimentarius Commission in 1963, two of the three "sisters" (the third being the OIE) explicitly recognised in the WTO Agreement on Sanitary and Phytosanitary Measures. The FAO has observer status to some of the WTO bodies, including the Committee on Agriculture, the SPS Committee, and the TBT Committees.

The FAO provides a number of resources that are useful to trade analysis and negotiations. FAO's technical cooperation programme assists members to assess the effects of trade liberalisation on their agricultural sector. The FAO has undertaken many developing country studies of the WTO implementation experience, published analyses on policies and programmes of key OECD countries, and provided technical assistance to enhance the capacity of developing country trade officials to analyse the impact of liberalisation on their domestic sectors. The FAO website (http://www.fao.org/trade/en/) provides the gateway to an extensive collection of FAO research on trade and agriculture. The FAOSTAT database (http://www.fao.org/faostat/en/#home) is an invaluable free resource for accessing data on trade and agriculture production.

The 2001 International Treaty on Plant Genetic Resources for Food and Agriculture is a good complementary resource to the WTO TRIPS Agreement.

4.5 Tariffs and the WTO Tariffication Process

A tariff is a border duty or tax levied on imported or exported product(s). Tariffs raise the price of imported products and theoretically dampen domestic demand for such products. (The noted exception is Veblen goods which are quality products for which demand increases as prices increase). Tariffs on exported products raise the cost of the item to foreigners and may be implemented by governments with the primary aim of discouraging exportation of what may be a domestically sensitive product or as an avenue to collect revenue. Tariffs can be ad valorem (i.e. the tax is levied as a percentage of the CIF or FOB price per unit), specific (i.e. the tax is levied as a dollar amount on each unit and is independent of the CIF or FOB import price), or a combination of the two (e.g. for each kilogramme, a flat charge of USD 1 plus 10 per cent of the CIF price).

The Agreement on Agriculture required all WTO members to convert their trade barriers into tariffs or tariff equivalents since tariffs were to be the only form of border protection. The guidelines for the calculation of tariff equivalents are attached to Annex 5 of the Agreement. The trade barriers to be converted into tariff or tariff equivalents included quotas, quantitative restrictions, and discretionary import licensing requirements. The base period of 1986–1988 was used for the calculation of tariff equivalents. Tariff equivalents were to be primarily established at the four-digit level of the HS code unless the six-digit level was more appropriate. External prices were to be the actual CIF prices in the base period or, if not representative, the average CIF values in the base period in a near country.

Agriculture negotiations under the Doha Round included the proposal for tariff simplification: the conversion of all mixed, specific, and compound tariffs into their ad valorem equivalents. Most non-ad-valorem tariffs (e.g. specific and mixed tariffs) protect the domestic market from lower-priced imports. There were also proposals to address tariff escalation which negatively affected value-added efforts by many developing countries exporting agricultural products.

The publications of the WTO statistics division (data.wto.org) are an invaluable resource for the policy specialist. Publications include the annual World Tariff Profiles and World Tariff Profiles.

Consistent with WTO provisions, Sri Lanka has bound 100 per cent of its agricultural tariffs. Bound tariffs represent the ceiling or maximum tariff that a country cannot normally exceed. Sri Lanka has simplified its tariff structure, moving from a five-band tariff structure in 2009 to four bands and presently three tariff bands of 0 per cent, 15 per cent, and 30 per cent. The WTO Trade Policy Review of Sri Lanka (2016) reported that out of 6965 tariff lines at HS 8 digit level, 3922 attracted a rate of 0 per cent, 1324 the rate of 15 per cent, and 1457 the rate of 30 per cent. Further, 35 tariff lines (mainly tobacco and alcoholic beverages) exceeded the bound rates after the transition to the three-band system. Sri Lanka also applied "luxury tariffs" on sensitive domestic products. Sri Lanka's Special Commodity Levy is applied to 39 agricultural products, including palm oil, big onion, potato, lentils, sugar, milk, powder, sprats, and dhal.

4.6 Non-tariff Measures

Non-tariff measures, as the name implies, are measures other than tariffs that affect the importation or exportation of a good. These include SPS measures, TBT standards that may amount to technical barriers to trade, import licensing, and rules of origin requirements. Non-tariff measures may distort international trade. The extent of any trade distortion must be balanced against the objectives of safeguarding plant, animal, and human health and life. The terminology has evolved from that of Non-Tariff Barriers (NTBs) to the more widely used Non-Tariff Measures (NTMs), since not all non-tariff measures are necessarily barriers. For example, Sri Lanka has a requirement that imports of fresh fruit and vegetable be accompanied by a certificate attesting that the products have been in cold storage for at least 2 weeks. While Sri Lanka defends this measure as a means of safeguarding against the importation of invasive species (fruit fly), exporting countries have queried this measure as being more restrictive than necessary. This illustrates the difficulty in assessing NTMs as the perception of the measure depends on the perspective of the exporter or importing country.

There has been a rise in non-tariff measures with the advent of the tariff-only regime for agricultural products under the multilateral trading system (Cadot and Malouche 2012). This may reflect increased vigilance by countries to safeguard human, animal, and plant health and life or attempts to impose controls and, thus, disguised barriers to trade. Attempts to assess the quantitative impacts of NTMs on trade across countries have been difficult as different agencies use different criteria; it is difficult to determine the extent to which an NTM is a disguised barrier to trade and to compare measures. The WTO, the World Bank, and UNCTAD are among the institutions that have produced studies to better understand NTMs and their impact on trade. Nonetheless, given the diverse nature of such measures, studies have been more qualitative than quantitative and largely provide a summary of the number of NTMS across sectors.

4.7 Regional Trade Agreements

Regional Trade Agreements (RTAs), including bilateral agreements, are encouraged within the multilateral trading system as they facilitate deeper integration among countries and, theoretically, make negotiations at the multilateral level less cumbersome. According to a WTO report (WTO 2020c), “RTAs are taken to mean any reciprocal trade agreement between two or more partners, not necessarily belonging to the same region”. WTO Members may enter into RTAs if these agreements conform to rules relating to customs unions and free trade areas as per Article XXIV of the General Agreement on Tariffs and Trade 1994; entail regional or global arrangements between developing countries under the Enabling Clause or involve trade in services consistent with Article V of the General Agreement on Trade in Services. With the entry into force of the WTO, several RTAs (e.g. the USA operated Caribbean Basin Initiative and the ACP/EU preferential scheme) were granted waivers under GATT Article XXIV.

Members within an RTA agree to common benefits, such as lower tariff rates for intra-regional trade that are not available to non-member countries. RTAs may be beneficial as they result in deeper trade integration (one of the objectives of the WTO) and assist in enhancing welfare consistent with the theory of comparative advantage, economies of scale, and reduced duplication in processes.

RTAs can be counterproductive as they may entail varying rules of origin requirements and increased regulatory burden for participating countries (Bhagwati 1995). For non-participating RTA countries, one challenge is that an RTA can cause trade diversion (i.e. as a result of lower tariff rates in an RTA, trade diverts from previous non-RTA-participating countries to countries within the RTA). However, the extent to which such trade diversion is welfare-enhancing depends on the barriers and tariff wedge between RTA trade and external trade. The greater the barriers and tariff wedge, the less welfare-enhancing the arrangement as such barriers would make less efficient and more costly intra-RTA production more attractive. An examination of the RTAs is thus necessary to provide the holistic framework against which domestic agricultural policies should be measured.

The WTO reports that all members are parties to at least one RTA. RTAs have evolved from a simple focus on reduced tariff rates on goods of interest to include a range of issues, such as trade facilitation, trade in services, and investment promotion. The popularity of RTAs has led to the feature of overlapping membership and RTAs. For example, a country belongs to an RTA-A and also to RTA-B and RTA-C. The situation gets complicated as in reality all the members of RTA-A will not belong to RTA-B and RTA-C, and some of these countries will have membership in other RTAs, such as RTA-D and RTA-E. The complex web of these membership arrangements complicates issues such as rules of origin, standards, and regulatory consistency that must be met by importers and exporters and enforced by officials. Sri Lanka provides an example of the complex web of bilateral and regional trade agreements that countries could be a party to. Figure 4.1 depicts the overlapping RTA membership for South Asian countries. For example, Sri Lanka is a member of APTA, BIMSTEC, and SAFTA, in addition to the concluded bilateral agreements depicted by the solid lines and the agreements under discussion as depicted by the dashed lines. Table 4.2 provides some information on the RTAs of significance to Sri Lanka. These include the Asia-Pacific Economic Cooperation (APEC 2020), the Association of Southeast Asian Nations (ASEAN 2020), and the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC 2020).

4.7.1 Bilateral Agreements

4.7.1.1 India-Sri Lanka Bilateral Agreement

The India-Sri Lanka bilateral FTA came into force on 1 March 2000. It provides duty-free concessions on a wide range of products traded between the countries. This list was expanded such that Sri Lanka can export more than 4000 products to India since the end of March 2003. The export of some products has increased, while the export of spices, rubber, copper, etc. has reportedly declined. However, diversification of the export base was a positive aspect for Sri Lanka from the agreement. The major imports from India are vehicles, pharmaceuticals, sugar, yarn, textile, and oil. An Inter-Agency Committee was established in 2011 to discuss issues surrounding the implementation of the FTA and the possible deepening of the agreement to have

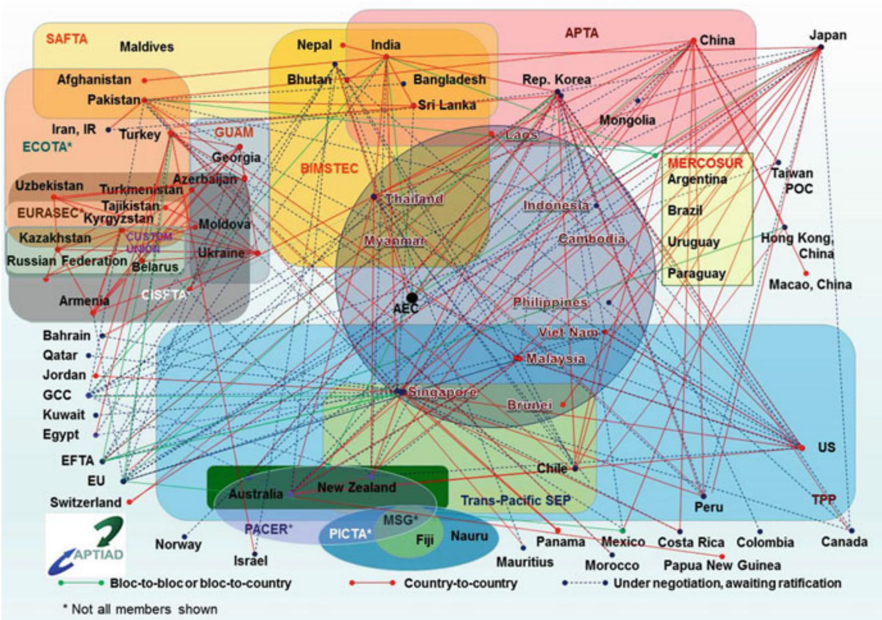

Fig. 4.1 South Asia Map of Bilateral and Regional Trade Agreements. Source: United Nations Economic and Social Commission for Asia and the Pacific (2018)

a comprehensive arrangement on market access commitment of both parties for goods, services, investment, and economic cooperation.

The Economic and Technology Co-operation Agreement (ETCA) is a proposed improvement to include trade in services and the service sector for the existing India-Sri Lanka FTA.

4.7.1.2 Pakistan-Sri Lanka Bilateral Agreement

The Pakistan-Sri Lanka bilateral agreement came into force on 12 June 2005. It aims to establish a free trade area consistent with WTO provisions. Its objectives are to promote harmonious economic relationships between the countries through trade expansion; to provide conditions for fair competition for trade; and, to contribute to the harmonious development and expansion of bilateral and world trade through the removal of barriers to trade. Pakistan and Sri Lanka completed their phasing-out commitment in March 2009 and November 2010, respectively. Sri Lanka obtained duty-free access for more than 4500 products and her export value has reportedly increased. The main exports are tea, betel leaves, coconuts, wood charcoal, and pepper. Penetration of a new product range was also observed in the Pakistan market.

4.7.1.3 Sri Lanka-Singapore Free Trade Agreement

The agreement between Sri Lanka and Singapore entered into force in 2018 and is the most recent bilateral agreement concluded by Sri Lanka. The agreement covers

Table 4.2 Some Key RTAs in the South Asia Region

RTA	Members	Type of RTA	Importance for agriculture
Asia-Pacific Economic Cooperation (APEC) (www.apec.org).	21 members, including Russia, China, Japan, Australia, the USA, and Canada. Sri Lanka is not a member	Economic and Trade. APEC operates as a "cooperative, multilateral economic and trade forum"	Trade facilitation has reduced the cost by 5 percent so far for all trade Harmonising regional standards for food safety Implementation of best practices and promoting sea food trade Technical cooperation via Agricultural Technical Cooperation Working Group (ATCWG) to improve the capacity of agriculture and its related industries and to share information and experiences in the areas of agriculture, biotechnology, and animal and biogenetic resource management
ASEAN Free Trade Area (AFTA) (www.asean.org)	10 members – Singapore, Indonesia, the Philippines, Thailand, Malaysia, Brunei Darussalam, Cambodia, Vietnam, Lao PDR, and Myanmar Sri Lanka is not a member ASEAN has signed FTAs with six countries (China Australia, New Zealand, India, Japan, and South Korea) and was in negotiations for a Regional	PTA covering trade in goods. There is no common external tariff but preferential tariff access to the ASEAN countries under the Common Effective Preferential Tariff scheme. Provision is made for the exclusion of sensitive products, such as rice and paddy from the scheme	Preferential access – 0 per cent to 5 per cent rate since 2003 compared to non-members which was around 10.9 per cent, excluding sensitive products such as rice and sugar. Sensitive products are required to allow preferential access by 2017. Products of ASEAN origin (40 per cent FOB value requirement is required) Joint promotion of twelve products

(continued)

Table 4.2 (continued)

RTA	Members	Type of RTA	Importance for agriculture
	Comprehensive Economic Partnership (RCEP) to include the six partner countries		(i) seaweed and seaweed-based products, (ii) cocoa, (iii) coconut, (iv) coffee, (v) forest products (timber and non-timber), (vi) palm oil, (vii) peas and beans, (viii) pepper, (ix) tapioca, (x) tea, (xi) tuna, and (xii) sericulture ASEAN standards for agricultural product
Asia Pacific Trade Agreement (APTA)	6 members – Bangladesh, China, India, Lao PDR, South Korea, and Sri Lanka	Evolved from a PTA to a Free Trade Area	5–50 per cent concessions (margin of preferences) Exports of tea, activated carbon, coconut coir moulded products, rubber products, titanium, and fish Imports of agricultural products are not prominent China and South Korea are main trading partners
South Asian Free Trade Area (SAFTA)	8 members – Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka	PTA in goods as well as the removal of barriers to trade, fair competition modalities. The aim is "to promote and enhance mutual trade and economic cooperation among the Contracting States, through exchanging concessions in accordance with this Agreement"	Tariff rates to reach (at several steps) 0–5 per cent except the negative list LDCs can have a longer list of sensitive products (http://www.doc.gov.lk/index.php?option=com_content&view=article&id=32&Itemid=157&lang=en) exempted from liberalization commitments than non-LDC signatories Sri Lanka has exported desiccated

(continued)

Table 4.2 (continued)

RTA	Members	Type of RTA	Importance for agriculture
			coconut and pepper and pepper light berries mainly to India Imports are not prominent
Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) (https://bimstec.org/?page_id=189)	7 members – Bangladesh, India, Sri Lanka, Myanmar, Thailand, Nepal, and Bhutan	Free Trade Agreement (FTA). However, modalities to achieve FTA remain to be concluded	Elimination of non-tariff and tariff barriers through government-to-government negotiations Provide corporations for improvement in fisheries and agriculture sector via releasing fund on research and development projects
Indian Ocean Rim Association for Regional Co-operation (IOR ARC)	22 members, including India, Mauritius, Singapore. 10 "dialogue partners" including China, Japan, the USA, and the UK	Key priority areas are maritime security, trade, and investment facilitation, fisheries management, disaster risk reduction, academic and scientific cooperation and tourism promotion and cultural exchanges	Reducing barriers to trade and promote Small and Medium Enterprises (SMEs) Management and Conservation fisheries resources Knowledge sharing, capacity building, and addressing strategic issues in the fisheries and aquaculture sectors

national treatment and trade in goods (Chap. 2); Trade Remedies (Chap. 3); and SPS and TBT (Chaps. 4 and 5). It also includes modalities on trade facilitation, government procurement, telecommunications, e-commerce, and dispute settlement. Sri Lanka has eliminated customs duties on 50 per cent of its tariff lines (including tariff lines already with zero duty) which will progressively increase this coverage to 80 per cent of tariff lines over 14 years. Sri Lanka will not reduce or eliminate duties on the remaining 20 per cent of tariff lines.

4.8 Unilateral Preferential Arrangements

Unilateral preferential arrangements seek to better integrate less developed countries into the world trade system. Such arrangements are premised on the fact that developing and least developed countries may be disadvantaged in their participation in the international trading system and require more favourable treatment to facilitate better growth and poverty reduction.

The Generalised System of Preferences (GSP) was championed by UNCTAD and launched in 1968. Australia was the first country to introduce preferential access for developing countries (UNCTAD 2018). Under the GSP schemes, for selected products, imports from qualifying developing countries are allowed more favourable treatment. Such schemes represented a derogation from the GATT principle of Most Favoured Nation. The temporary GATT waiver on the application of the MFN principle to allow for the operation of these schemes was made permanent in 1979 with the Enabling Clause which has also been “grandfathered” into the WTO through the adoption in the Marrakesh Agreement of the GATT 1994 agreement.

UNCTAD has published handbooks on 10 GSP schemes in operation. Below are three preferential trade agreements.

4.8.1 European Union: GSP, GSP+, EBA

The European Union (EU) operates a three-tier system: standard GSP for low- and lower-middle-income countries and available to all qualifying countries; GSP+ which provides enhanced access for vulnerable countries but is discretionary based on EU criteria and priorities; and the EBA for least developed countries (UNCTAD 2016a).

Since 1995, with the advent of the WTO tariff-only regime, quantitative barriers have been removed. The current scheme was initiated in 2014 and will last until 2023. The EU was the first to provide extensive coverage under its Everything But Arms (EBA) programme for least developed countries. EBA provides duty-free and quota-free access to all products, except arms and armaments, from LDCs. The scheme was implemented under EU Regulation 978/2012. In the South Asia region, Bhutan, Nepal, Myanmar, and Sri Lanka are participants in discussions on the regional agreement BIMSTEC and Least Developing Countries benefitting from the EU’s EBA. There would thus be implications for trade diversion or trade creation in any regional arrangements involving EBA beneficiary countries.

Sri Lanka regained the GSP+ privileges of the EU in May 2017. Sri Lanka agreed to implement the EU’s Registered Exporter (REX) system from 1 January 2018. This allows for certification of the origin of goods and the fast track of entry into the EU for approved exporters. The scheme provides full removal of duties for 66 per cent of all tariff lines, which includes textiles and fisheries. The scheme is conditional upon human and labour rights and working towards sustainable development.

4.8.2 The USA: GSP

Under the US GSP programme, Sri Lanka has duty-free access to the USA for up to 5000 tariff lines (excluding apparel products) (UNCTAD 2016b). In 2002, Sri Lanka signed a Trade and Investment Framework Agreement with the USA aimed at developing a framework for trade and investment. Discussions covered market access, GSP, trade promotion efforts, intellectual property rights, and sector-specific challenges to investments. Gender issues, investment policy, technical cooperation, and more exports of goods, such as machinery, optic and medical instruments, plastic, cereal, and wheat, were also included. The most recent discussions were held in June 2019.

4.8.3 Global System of Trade Preferences Among Developing Countries

The Global System of Trade Preferences among Developing Countries (GSTP) is a plurilateral partial scope agreement that came into force on 19 April 1989. Initial signatories were Bangladesh, Cuba, Ghana, India, Nigeria, Singapore, Sri Lanka, Tanzania, and Zimbabwe. Currently, there are 42 member countries covering the regions of Africa, East and West Asia, the Caribbean, West Asia, and the Americas (North America, Latin America, and Central America). The GSTP aims to promote intra-country trade among developing countries.

4.9 The World Integrated Trade Solution Model

As a policy analyst, researcher, or student with an interest in international trade, it is important to be able to access data that would allow assessment of, for instance, the impact of trade liberalisation. There are many quantitative trade models available to assist with policy analysis or research. In this section, we introduce the World Integrated Trade Solution (WITS) model (www.wits.worldbank.org). WITS is a freely available model that provides access to data on trade flows and provides facilities for analysing the impacts of changes in trade policy.

WITS (www.wits.worldbank.org) is a quantitative analytical tool used to analyse the effects of any tariff changes on international trade flows. It was developed by the World Bank in conjunction with the UN, UNCTAD, and the WTO. WITS is a collaborative, multilateral effort as the programme draws on tariff and trade information from databases maintained by the WTO, ITC, UNCTAD, and the UN Statistics Division. This allows for varying parameters to be included in any analysis, including tariff bindings, applied tariffs, and trade flows. The availability of several parameters allows for richer and more accurate analyses as focusing on only a few parameters (such as tariffs) in partial equilibrium models can overestimate the causative effect of that parameter.

Access to and activating an account with WITS is quick, easy, and free. A user manual is available on the WITS website for those wishing to learn about or re-familiarise themselves with the software. The user manual provides good guidance on how to use the software and run a simulation.

One of the shortcomings of the UN COMTRADE data set is that imports are recorded at CIF and exports at FOB values. Thus, value exports of Product A from

Table 4.3 Key functions in WITS

Tab	Functions
Utilities	Allows for the creation of user-defined product groupings. This allows for investigation of the entire product chain. For example, a WITS user can create a product group that covers the basic product, any intermediary, as well as the processed product, to examine the entire value chain of a product
Tariff and Trade Simulations	Allows the user to estimate the impact of tariff changes on a country. For example, if a country is contemplating a 24% tariff reduction, this option will allow the user to simulate the impact of such a reduction. Generating this data will aid the agricultural policy analyst in ascertaining whether the contemplated reduction would erode policy space in sensitive tariff lines or result in tariffs below the current levels. Such information assists trade negotiators in identifying possible trade-offs and red lines in negotiations
Quick Search	Allows a user to search for UN COMTRADE data, tariffs, non-tariff measures, or trade import data. QUICK SEARCH also allows for the search of a country's trade for one selected year or a quick view of the main export or import products of interest for the selected year with a partner country. This can then be used to conduct a more in-depth query using the ADVANCED QUERY option
Advances Query	Allows for more complex simulations, including uniquely defined analyses on trade flows, examination of a time period, or various partners or products. This function uses UN COMTRADE data which is the most comprehensive of the WITS databases as data goes back to 1962, and records include re-imports and re-exports. UNCOMTRADE data is recorded in SITC for years before 1988 and in HS for years after 1988. This is particularly important to note since the selection of the HS classification for years before 1988 may return a blank query result

country X to country Y will not necessarily mirror the value imports of Product A recorded by country Y from country X. Also, trade data for groupings vary with the membership. Insofar as the EU has undergone expansion (and with Brexit in 2020, contraction), it may be advisable for an analyst to manually create the country grouping to ensure consistency in membership across time periods (Table 4.3).

In using WITS, the following points should be noted:

- WITS allows users to ascertain the trade and protection data of a country or group of countries (such as developed countries or user-defined groupings). This flexibility allows users to analyse not only existing arrangements but the impact of potential regional trade agreements.
- One of the first parameters to be defined in the programme is the choice of tariff classification. There are a few options. The two primary options are the UN Standard International Trade Classification and the Harmonised Commodity Description and Coding System. HS Combined allows for the system to combine the various revisions of HS into a single nomenclature. In some instances, WITS offers product classification as per the International Standard Industrial Classification (ISIC), a database of industry classification maintained by the UN. While

these may offer greater detail than the HS, the coverage across countries is not as extensive.

- Another important step is to define the dataset to be retrieved. WITS data can be retrieved using either the SITC or HS formats. Generally, data for earlier periods may be only available in SITC format (the WITS database has data from as early as 1962). Similarly, with the predominant use of the HS classification, much of the more recent data is only available in this format. WTO agriculture commitments were scheduled using the HS classification system. As such, it is advisable to select the HS classification for queries.
- A blank result to a query is likely due to the unavailability of the data in the chosen format (i.e. depending on whether UN COMTRADE or WTO is selected).
- Where the trade data of a particular grouping is being analysed, it may be advisable to create country groupings.

Steps to undertake an advanced query in WITS:

- Log in to WITS with the email address and password used when registering.
- Click on the ADVANCED QUERY tab.
- Select TRADE DATA (UN COMTRADE).
- For a new query, designate a query name (maximum of 25 characters) and query description (maximum of 50 characters).
- Select the data source (UN COMTRADE).
- Select the reporters (country/countries being examined), the products of interest (2-digit, 4-digit level, or product groups), the partners (includes "world" as well as individual countries, pre-defined groupings, or custom designated country groupings), the years, and trade flows to be examined (exports, imports, re-exports, etc.).
- Click SUBMIT to generate the query.
- A dialogue box should appear asking whether you wish to check the query status. Click OK.
- Results should download in Microsoft Excel or Comma Separated Variable (CSV) format. Data table can be pivoted and sorted depending on the investigative query.

4.10 Assignments

Trade and the international trading system are dynamic. The Internet and websites of key organisations (www.wto.org, www.unctad.org, www.intracen.org) provide a good avenue to keep abreast of trade developments, access current trade data, and opportunities for technical assistance and e-learning resources.

1. Using the Internet or library resources, find at least one study and simulation undertaken on the effects of trade liberalisation. Compare to actual performance based on international/domestic indicators, such as contribution to GDP and earnings. Identify any reasons for the variance(s) between predictions and actual.
2. Using the WTO site (www.wto.org), examine the schedule of concessions for your country. Compare it to a partner country. Note the differences in the level of detail (SSG, TRQs, mixed tariffs) and any changes made after the initial submission.
3. Use the HS code to select a product at the 2-digit level. Starting with this 2-digit product code, how many products derive from this at the level of 4 digits, 6 digits, and 8 digits?
4. Chose a product of export interest to your country. Find the corresponding 4-digit HS code for that product. Using WITS (www.wits.woldbank.org) and the advanced query option, generate a Trade and Tariff Analysis query, for your country's exports to one developed, one developing, and one country grouping export markets of interest.
   - Having selected the product of export interest, using the TRAINS database, generate, for the most recent 5-year period for which data is available, the Trade and Tariff Analysis query of the MFN bound, MFN applied, Effectively Applied, and Preferential Tariffs for that product.
   - Examine the table generated. Are there any domestic or international tariff peaks? Are there any discernible trends in imports by the selected countries?
   - Using the SMART under Tariff and Trade Simulations, create two tariff reduction scenarios of a linear cut and a Swiss formula tariff cut.
   - For the product of export interest identified in 4 above, for the most recent year for which data is available, simulate the tariff effects of a Swiss formula and a linear cut based on WTO agricultural tariff descriptions. Identify the differences between the results of the two scenarios.
5. Zeta is a developing country with no scheduled domestic support commitments. It has an agricultural sector worth USD 300 million of which its major agricultural product, tea, is worth USD 80 million. Zeta desires to provide domestic support to its poor, vulnerable tea farmers. As a developing country, Zeta does not have unlimited budgetary resources and so is not in a position to provide unlimited support to the entire agricultural sector or support to tea farmers who are not poor and vulnerable. You are a policy analyst in Zeta and have been tasked with designing an appropriate domestic support policy.
   - Using the WTO Agreement on Agriculture and, in particular, Annex 2 as a guide, design a WTO consistent measure that Zeta can implement to achieve its objective.
   - Assuming you were instead a member of the Trade Ministry in a country with an interest in increasing its export of tea to Zeta, identify the possible shortcomings, if any, of the programme designed above.

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5 Economic Concepts for Agricultural Policy Analysis

Andrew Jacque

Abstract

We need to have some understanding of basic and essential theoretical aspects of agricultural policy analysis before we discuss analytical tools. This chapter outlines a methodology for conducting a policy analysis and then introduces concepts and models important to measuring the impact of trade and domestic policies that directly affect prices, quantities and societal welfare. The concepts of consumers' surplus and producers' surplus are introduced and developed from the viewpoint of measurement in a graphical analysis. The concept of Pareto optimality is introduced in the context of general equilibrium analysis and also to highlight the distinctions between first-best and second-best policy situations. The two fundamental models of economic analysis—the partial equilibrium model and the general equilibrium model—are introduced. These are at the heart of the analytical methods used in price policy analysis. We also introduce here the theory of second best, which provides some guidelines for choosing among alternative policies. The chapter concludes with the application of the concepts in partial equilibrium analysis of selected domestic and trade agricultural policies in small country and large country settings.

Keywords

Consumer surplus · Producer surplus · Pareto optimal · Partial equilibrium analysis · General equilibrium analysis

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5.1 Welfare Theoretic Approaches and Equilibrium Analysis

5.1.1 The Method of Economic Analysis

Economic analysis is conducted using models designed to apply theory to real-world scenarios in order to obtain insights into economic problems. Analysis may be conducted to understand the cause of a particular situation; to determine the likely impact of a specific policy or course of action; or to offer recommendations to obtain a particular outcome. In the strictest sense, only the final reason would classify as policy analysis since the product of policy analysis is advice.

Success in economic policy analysis is due (in part) to the choice of economic theory and to the appropriate "modelling" of the real-world situation: the model and the theory are interwoven conceptually and structurally. In other words, the decision-making processes and even the expression of the problem should be modelled to facilitate the application of the economic theory.

Economic models are *not* a recreation of the real world but rather a very simplified construction of reality, in this case economic reality. This simplified construction allows the analyst to focus on the bare essentials of the problem, its determinants, and the decision-making processes influencing the problem. A policy analysis basically involves three steps (refer to Fig. 5.1).

The first task is to determine the initial equilibrium that describes the situation before the analysis is conducted. This can include specifying the values of one or more of the relevant variables. Second, the analyses are conducted by varying one or more policy variables to determine changes to the initial equilibrium. Third, the outcome of the analysis, the end situation or the new equilibrium, is evaluated against the initial situation. It is important to focus on a few relevant variables. Too many variables would make it difficult to meaningfully analyse the problem and interpret the results of the analysis.

Economists use assumptions about the initial situation and the process being studied to simplify the real world and thereby obtain a model that is focussed and relevant to the problem. Assumptions play an important part in economic modelling. Whether explicitly stated or not, all economic models/frameworks/analyses have associated assumptions of which we need to be aware. This awareness would help in identifying the shortcomings of analyses conducted with the model.

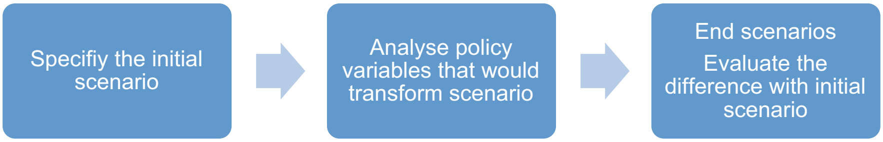


Fig. 5.1 Sequence of a policy analysis

Specific assumptions often associated with these models include the following:

1. Markets are competitive. This suggests that:
   (a) Markets comprise a large number of producers/sellers each with the objective of maximising profit. The number of producers/sellers is so large that an individual producer/seller cannot influence price.
   (b) Markets comprise a large number of buyers/consumers, each seeking to obtain maximum satisfaction from each rupee or dollar spent. The number of buyers/consumers is so large that individual buyers/consumers cannot influence price.
   (c) Prices are determined by the interaction of demand and supply forces.
2. The products being traded are homogeneous commodities; that is, there are no quality or other differences in the product no matter the origin of the item.
3. Consumer preferences are accepted as given (i.e. they are treated as exogenous in analyses).
4. Individuals and institutions make rational decisions.

The above assumptions can be regarded as fundamental to analyses within the framework of a competitive market. The assumption of competitive markets is often used in agricultural policy analysis because it closely approximates the scenario in the agricultural commodity markets of most countries. Agricultural commodity markets typically have a large number of buyers and sellers, with buyers seeking to obtain the lowest prices and producers seeking to obtain the highest prices.

The analyst can add or vary assumptions to appropriately model the process and situation that is being analysed. For instance, other forms of market organisations that may be relevant in some situations include the presence of a few sellers (oligopoly), a single seller (monopoly), a few buyers (oligopsony), and one buyer (monopsony). It is important to adopt the relevant models and assumptions for policy analysis in such markets.

There are two main types of models we use in policy analysis: General Equilibrium (GE) and Partial Equilibrium (PE). A GE model analyses a market considering the whole economy and interactions with other markets. A PE model considers a single market in isolation from the whole economy. Both of these approaches are useful depending on the scope of the analysis required.

5.1.2 The General Equilibrium Model and Economic Policy Analysis

GE models are more useful for assessing the impact of a price change that affects several commodity markets. GE analysis allows policy analysts to examine the impact of changes in price relationships on the production of various commodities, and also trade with other economies. In presenting the GE equilibrium in the following sections, we first consider a country in isolation (i.e., a closed economy) for convenience of understanding and then a country with an open economy.

5.1.3 General Equilibrium in a Closed Economy

A self-sufficient economy that does not trade is said to be in autarky equilibrium. Such an economy produces for domestic consumers. Therefore, domestic supply and demand are in equilibrium. To show this graphically, let's consider an economy that produces two goods (X and Y) using two factors of production (K and L). We consider that all the capital (K) and labour (L) are used in producing X and Y in this economy.

We use isoquants to represent different output levels for the goods X and Y which are produced using different combinations of K and L. An *isoquant* is the locus of all the combinations of two factors of production that yield the same level of output. For example, isoquants for good X are shown in the left panel of Fig. 5.2. Along an isoquant, such as X_0, the output level is constant. Isoquants shift rightwards, such as from X_0 to X_1, when output increases. Similarly, the isoquant map for good Y indicates a fixed level of output that can be produced using various combinations of inputs K and L.

An Edgeworth box can be used to represent this production relationship of the two goods and two inputs in the same diagram. Consider the upper panel of Fig. 5.3. From O_X to O_Y, the isoquants represent different levels of good X in the economy. Similarly, from O_Y to O_X, isoquants for good Y are shown. The tangent points of these isoquants show efficient production points for combinations of the two goods. In such production points, resources are efficiently allocated between the two goods, and it is not possible to reallocate the resources without compromising the present efficiency level. Therefore, these points are known as Pareto-efficient points.

The locus of these efficient points is called a *contract curve*. This diagram can be used to derive the Production Possibility Frontier (PPF) for the two goods' two inputs economy as seen in the lower panel of Fig. 5.3.

Each point along the PPF is efficient. Along the curve (PPF), the slope or the Marginal Rate of Transformation (MRT) increases. In other words, substitutability of one good for the other decreases. For example, the amount of good Y that has to be given up to produce one more unit of X increases along the PPF. We may say that

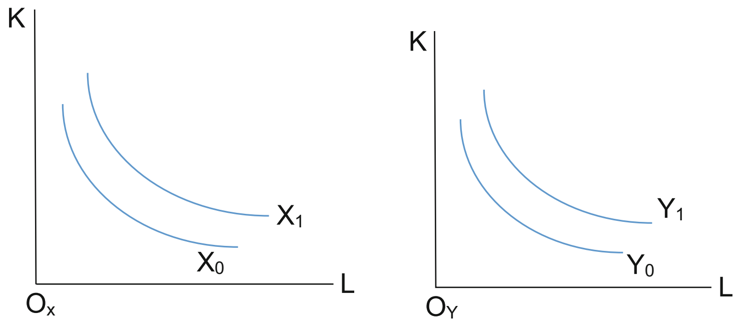
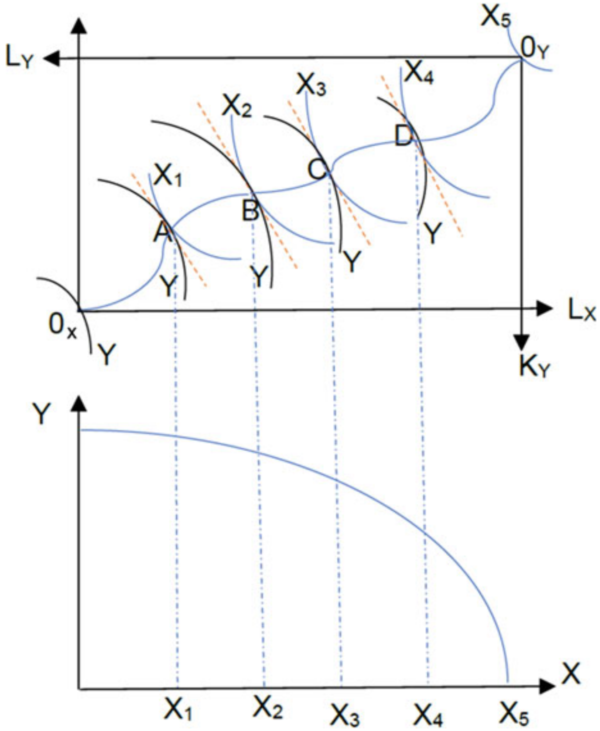


Fig. 5.2 Isoquant maps for goods X and Y

Fig. 5.3 Producer equilibrium



the opportunity cost of X increases along the PPF. The next question is, at which point on the PPF will production take place? Since we assume these industries are competitive, both industries face the same input prices. Therefore, the tangent point of the isoquants and the input price ratio is considered as the production point.

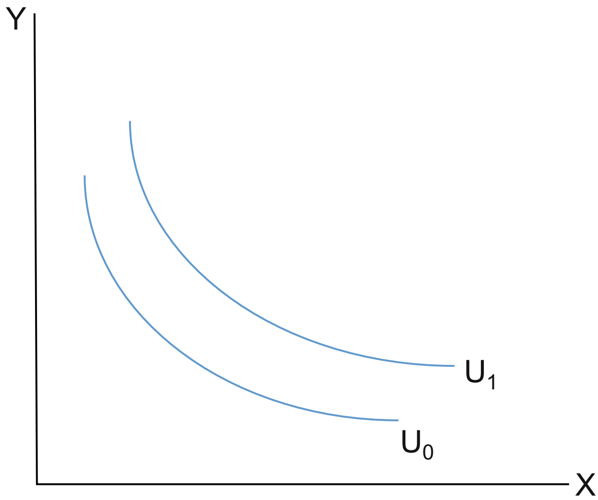
Take the consumption efficiency of the economy. Consumers buy the commodities X and Y to attain a certain level of satisfaction, called utility (U), which may be represented algebraically as follows.

$$\boldsymbol{U} = \boldsymbol{U}(\boldsymbol{X}, \boldsymbol{Y}) \tag{5.1}$$

As with the isoquants on the production side, consumption of different bundles of goods provides the same utility which is represented by an indifference curve (refer to Fig. 5.4). As the name implies, along an indifference curve, the utility is constant or the consumer is indifferent to the differing combinations of goods. Figure 5.4 shows indifference curves for two goods, X and Y. Higher indifference curves represent higher levels of utility.

The choice of a specific consumption bundle depends on consumer income and commodity prices. Utility is maximised when the indifference curve is tangent to the price line. In GE, consumers in the whole economy are taken into consideration. Let's look at an economy with two consumers (O_1 and O_2) and two fixed levels of

Fig. 5.4 Indifference curve map for goods X and Y



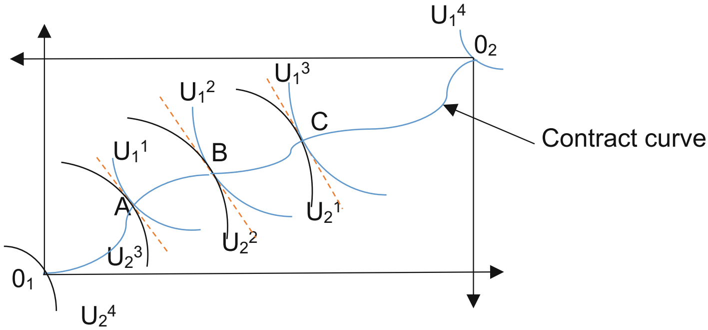


Fig. 5.5 Consumer equilibrium

commodity endowments X and Y. The consumption relationship can be described via an Edgeworth box (see Fig. 5.5).

The horizontal axis shows the quantity of good X, and the vertical axis shows the quantity of good Y which are fixed for the economy. The maximum amount of either good X or good Y that can be produced from all the resources available (all the K and L) is taken as the upper bounds for X and Y. O_1 and O_2 are the two consumers and their indifference curves begin from respective origins. Tangent points of the indifference curves show where both consumers maximise their utility and the locus of those points form the contract curve. Those points are called Pareto efficient. The price ratio decides the consumption point. Unlike production of goods, utilities cannot be quantified and are therefore represented by comparative levels. There is a community indifference curve (CIC) for an economy that takes into account the aggregate income of the country and assumes preferences to be equal. Consumer

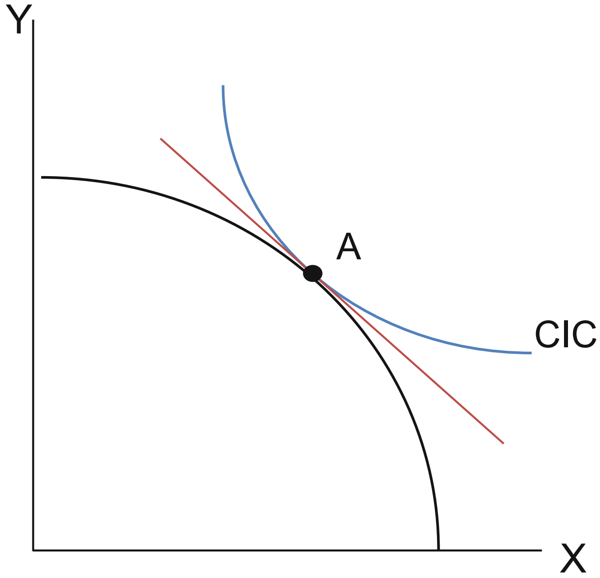


Fig. 5.6 Autarky equilibrium

preferences for the goods X and Y are shown by the CIC. General equilibrium of a non-trading economy is graphically shown in Fig. 5.6.

At the equilibrium point, A, the following conditions are met:

1. $p_a = \frac{p_X}{p_Y} = MRT$ producer optimisation
2. $p_a = \frac{p_X}{p_Y} = MRS$ consumer optimisation
3. $X_c = X_p \ Y_c = Y_p$ market-clearing condition

The first two conditions specify that, at equilibrium, producers and consumers face the same price in a competitive market, while the third condition identifies that demand is equal to supply.

From the above, two theorems of welfare economics can be identified.

The first theorem of welfare economics, or the first important relationship between competitive equilibrium and Pareto optimality, is that *when a competitive equilibrium exists, it attains Pareto optimality* (Just et al. 2005, p. 24).

The second theorem, or the second optimality theorem, states that *any particular Pareto optimum can be achieved through competitive markets by simply prescribing an appropriate initial distribution of factor ownership and a price vector* (Just et al. 2005, p. 28).

5.1.4 General Equilibrium in a Trading Economy

In a trading economy, producers do not depend solely on domestic consumers, nor do consumers depend entirely on domestic producers. Their production and

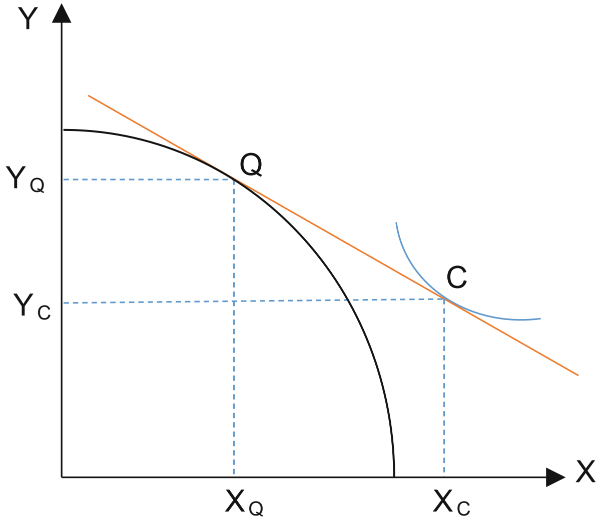


Fig. 5.7 Equilibrium in a trading economy

consumption decisions are influenced by world market prices. National income, the aggregate income of all the consumers, is considered the budget line of all consumers. They spend their income to purchase goods X and Y. The value of production (for X and Y) at world market prices is considered as the income as well. The value of consumption is equal to the value of production at the trading equilibrium. Figure 5.7 shows the equilibrium with trade at point C. At autarky, the equilibrium was at Q but has shifted towards C which is outside the PPF. The excess production of Y, ($Y_q - Y_c$), is exported while the excess demand for X, ($X_c - X_q$), is imported.

The following conditions are met in the equilibrium.

1. $p_a^* = \frac{p_X^*}{p_Y^*} = MRT$ producer optimisation
2. $p_a^* = \frac{p_X^*}{p_Y^*} = MRS$ consumer optimisation
3. $p_X^*\left(X_c - X_p\right) + p_y^*\left(Y_c - Y_p\right) = 0$ trade balance

The first two conditions differ from the autarky condition due to world prices. The third condition says that the summation of the value of imports and exports needs to be zero. For trade to occur, the opportunity cost of two commodities in trading countries has to be different. In other words, the tangent price ratio at the autarky is different for countries (see Fig. 5.8). The difference in autarky prices determines the direction of trade.

Country A has the lower opportunity cost (i.e. amount of X it has to give up to produce one additional unit of Y) and thus comparative advantage for producing good Y. Country B has comparative advantage for X. As a result, country A will produce more of Y and export to country B. Whereas country B would produce more of X and export the excess to country A. Consequently, both countries have the

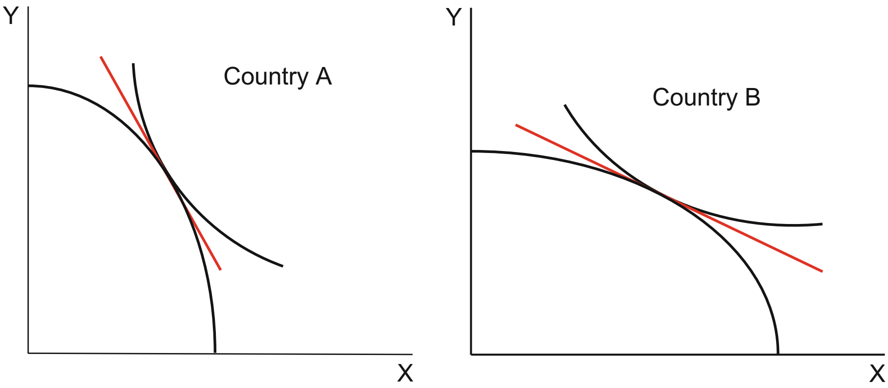


Fig. 5.8 Autarky equilibrium in two countries

opportunity to go for a higher level of utility compared to the non-trading scenario (see Fig. 5.7). For example, at point C in Fig. 5.7, consumers can consume more of X with trade, which is a consumption bundle outside the PPF and is expected to be preferred to Q. This is referred to as gains from trade. Generally, a mutual gain for the trading countries is expected. However, there are counterarguments about distribution effects and unequal gains from trade. The distribution effect within a country shows that the production of one product is favoured while the other product is hindered. If the hindered product is labour-intensive, wages or employment opportunities would be negatively affected, even though total income and consumption of the country increases. This would then require a strategy to use the excess labour. Also, people's preferences for goods X and Y will differ.

The above section graphically shows the economy-wide impact of a change in a commodity market. In reality, the context is more complex since there are more markets and more trading partners.[1] GE models are used when the concerned sector is a significant part of the economy and heavily interlinked with other markets. For more comprehensive and specific commodity market analyses, partial equilibrium (PE) models must be used.

5.1.5 Partial Equilibrium Analysis of Economic Policy

Partial equilibrium (PE) analysis uses the familiar supply-and-demand graphs to determine the impact of a specific action or policy in a market environment. In two-dimensional PE analysis, the market consists of a single commodity or commodity group. The influence of other commodities is assumed to be unimportant in terms of impact on the analysis.

[1]These models with applications will be discussed in part iii of this chapter and in the last two chapters of this book.

There are several advantages to using the PE model. It is a simple model that is applied to one market at a time, making data collection and analysis manageable. The PE model focuses on the impact of policy change on both the consumer and the producer. It addresses both losses and gains and measures both magnitude and direction of impact due to policy intervention and highlights important differences among policy measures.

On the other hand, PE models do not measure economy-wide consideration of policy effects because of the focus on only one commodity and overlook other important variables, including the impact on the budget/income constraints. The PE model “suppresses interactions between commodities that are linked together by substitution and competition” (Houck 1992).

The PE demand-and-supply functions used in the models evaluate the change in market conditions – the impact on the price, quantity supplied, and quantity demanded of the commodity, and the impact on the welfare of buyers, sellers, and institutions that comprise the market. Price and quantity information is generated by the interaction of supply-and-demand forces in the model. Subsequently, the changes in welfare of the various economic agents also can be measured.

5.1.6 Measuring Changes in Market Conditions

Price and quantity information are easily obtained from PE models. As an example, Fig. 5.9, is used to evaluate the market for chicken. The vertical axis of the diagram measures the price of chicken, while the horizontal axis measures the quantity supplied and the quantity demanded. At a price of P_0, a quantity of Qs_0 is supplied and a quantity of Qd_0 is demanded. At a price of P_1, a quantity of Qs_1 is supplied and a quantity of Qd_1 is demanded.

The PE model can be used to measure the impact of a policy that changes price or quantity. Suppose that a policy causes a price change from P_0 to P_1. Then the effect of this price change would be a change in the quantity supplied from Qs_0 to Qs_1. The quantity demanded would change from Qd_0 to Qd_1.

5.1.7 Measuring Welfare Changes

Welfare change is measured by the social surplus-value, or the net economic benefit to society from any policy-induced market change. In a general equilibrium setting, this change can be depicted as a change in utility associated with a movement to a higher indifference curve. Social surplus measures the change in average economic benefits to the producers, consumers, and society in monetary terms. Measurement in monetary terms is quite useful in understanding the magnitude of the impact. To measure the net benefit to society, four welfare concepts are essential: consumer surplus; the change in consumer surplus; producer surplus; and the change in producer surplus.

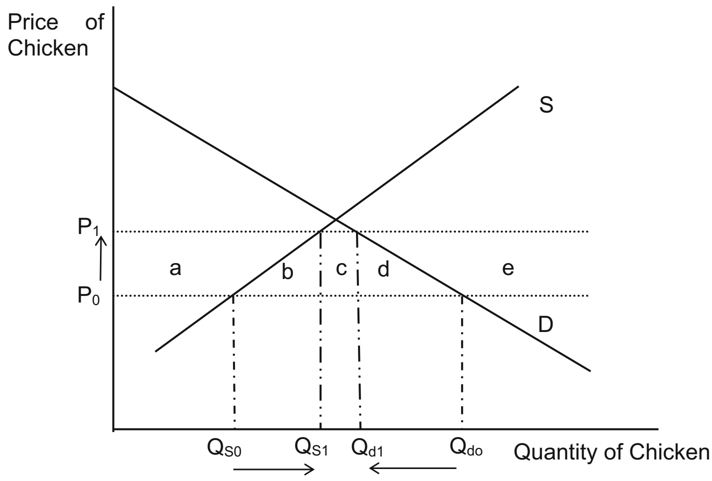


Fig. 5.9 Changes in market conditions

5.1.7.1 Consumers' Surplus

Consumer surplus can be defined as the value of the benefit that consumers receive by being able to purchase an item at a price that is lower than what they were willing to pay. Refer to Fig. 5.10. As mentioned before, the demand curve indicates willingness to pay. Therefore, at a price of P_1, zero units of the commodity are purchased, since there is no consumer willing to pay that price. At price P_2, Q_2 units are consumed. But, given the negative slope of the demand curve, some consumers were willing to pay a price higher than P_2 but not as high as P_1.

Assume that all consumers pay the same price for the item purchased, whether it was the first or last unit purchased. Given this assumption, some consumers benefit because they were willing to pay a price just lower than P_1 for their units but now can purchase at the lower P_2 price. They receive a consumer's surplus by having the market price at P_2. The benefit or consumers' surplus that accrues to those consumers, or more broadly to society, is the triangular area delineated by P_1 P_2 a.

On the other hand, if the market price was at P_3, a quantity Q_3 would be consumed. Consequently, persons who were willing to pay prices above P_3 for the commodity have obtained a surplus value. In this instance, the value of the consumers' surplus that accrues to society is the triangular area delineated by P_1 P_3 b.

Furthermore, the consumers' surplus which accrues to society when the market price is P_5 is delineated by the area P_1 P_5 d. At a market price of P_6, the consumers' surplus is delineated by the triangular area P_1 P_6 e.

This enables a working definition of consumers' surplus that can be applied to the graphical analysis of markets: consumers' surplus is the area that lies under the demand curve (D) but above the price line (P). Is this graphically oriented working

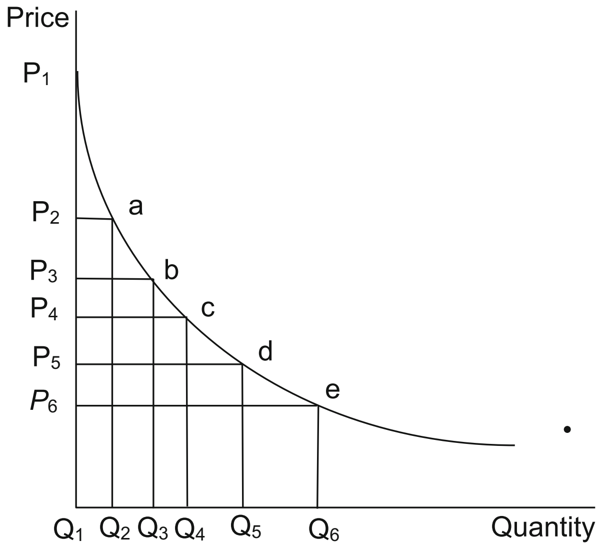


Fig. 5.10 Measuring the total value of consumers' surplus

definition of consumers' surplus consistent with the conceptual definition given at the beginning of this section?

5.1.7.2 Change in Consumers' Surplus

Although it may be worthwhile to calculate the total value of the consumers' surplus, it is much more meaningful in policy work to calculate the net impact on consumers' surplus as a result of a change in market prices or market conditions. Conceptually, the change in consumers' surplus may be defined as the net change in the value of the benefit that consumers receive as a result of a change in the market price of the commodity (refer to Fig. 5.11).

The change in consumers' surplus can be measured as the difference in the total value of consumers' surplus at two different market prices. In Fig. 5.11, at the price P_0, the total value of the consumers' surplus is measured by the area $e + f + g$. If the price were changed to P_1, then the total value of consumers' surplus would be measured by the area g. The change in consumers' surplus is the net value representing the difference in the areas that measure the total value of consumers' surplus at each price. Thus, a change in price from P_0 to P_1 results in a change (in this case a loss) of consumers' surplus equivalent to the area $(e + f + g - g) = e + f$.

On a graph, the change in consumers' surplus is defined as the area that is between the price lines and under the demand curve. Is this graphically oriented working definition of the change in consumers' surplus consistent with the conceptual definition (give at the start of this section) and the results of the measurement given above?

Applying the graphical definition to a price change from P_0 to P_1 in Fig. 5.11 allows us to immediately discern that the change in consumers' surplus is the area $e + f$, or the area bounded by the points P_1baP_0.

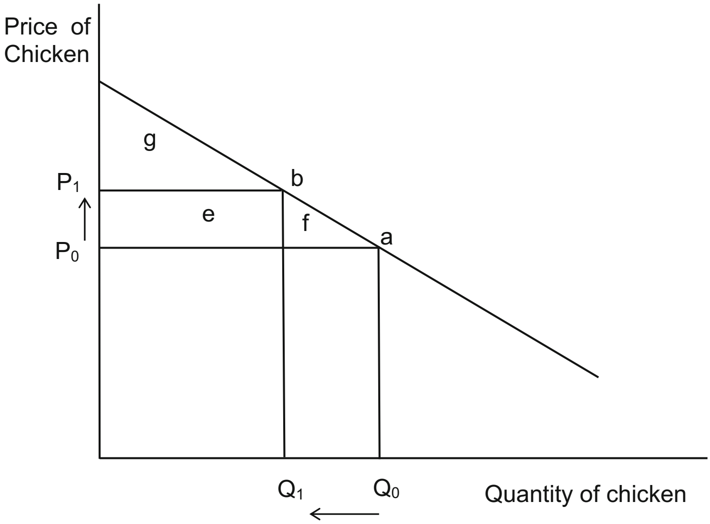


Fig. 5.11 Measuring the changes in consumers' surplus

How do we interpret the areas *e* and *f* for a price increase from P_0 to P_1? The rectangular area *e* represents the additional amount the consumer must pay for the units of goods that s/he continues to buy. The second area *f* represents the surplus that the consumer gives up by reducing consumption from Q_0 *to* Q_1. On the other hand, if there were a price reduction from P_1 to P_0, then the area *e* would represent the value of the benefit consumers receive by being able to buy items at a market price lower than the price they were willing to pay. For a price decrease, the area *f* would represent the surplus value that the consumer would gain by increasing consumption given the lower price.

There are several reasons why the change in consumers' surplus (as opposed to the total value of the consumers' surplus) is more used in policy work. One reason is that less data is required to calculate the change in consumers' surplus. The location and slope of the entire length of the demand curve are required to calculate the total value of consumers' surplus. Only the slope of the demand curve in the region of the existing price is required to calculate the change in consumers' surplus. Moreover, the change in consumers' surplus is more directly applicable to the impact of a policy change that changes the price of a commodity.

5.1.7.3 Producer Surplus

Producer surplus can be defined as the summation of the values of benefits or surplus that individual producers receive by selling at a market price that is higher than their variable cost of production (refer to Fig. 5.12).

The vertical axis in Fig. 5.12 measures the price of the commodity. The horizontal axis measures the quantity of the commodity that producers are willing to supply at different market prices over a given time period. Curve S is the supply curve for the

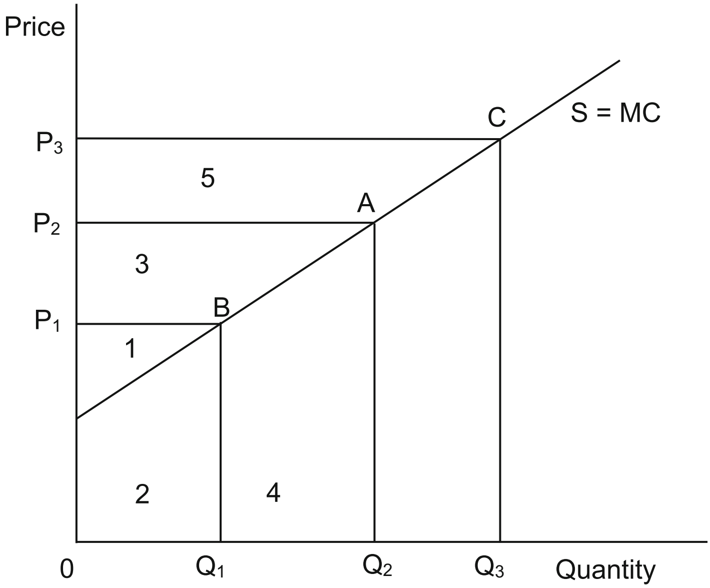


Fig. 5.12 Producer surplus and change in producer surplus

commodity, specifying the total quantities that will be supplied by producers at different market prices. The upward sloping supply curve signals that producers are willing to supply more of the commodity at higher prices.

The market supply curve S is the marginal variable cost (MC) curve for the entire farm sector that produces the commodity. Any point on the supply curve indicates the variable cost (i.e. total cost exclusive of fixed costs) to produce that unit of the commodity. For example, in Fig. 5.12, the Q_1^{th} unit of output costs P_1 in variable costs to produce; the Q_2^{th} unit of output costs P_2 in variable costs to produce. Thus, the diagram suggests that as output increases, the variable cost to produce each successive unit of production also increases.

The total variable cost of production for a quantity of output Q_1 can be calculated by the summation of each marginal cost value beginning with zero and ending with Q_1. In Fig. 5.12, the total variable cost of producing a quantity Q_1 is represented by the area beneath the supply curve over the quantity interval zero to Q_1. On a graph, the total variable cost to produce the quantity sold is identified as the area beneath the supply curve over the relevant quantity interval.

The total revenue collected can be calculated as market price multiplied by the quantity sold ($P \times Q$). The total revenue received by producers for producing the quantity Q_1 is represented by the area contained by P_1 B Q_1 0. The total revenue received by producers for producing quantity Q_2 is represented by the area contained by P_2 A Q_2 0. Thus, the total revenue received by producers can be separated into two components: total variable cost to produce the quantity sold, and a surplus which accrues to producers.

Graphically, producers' surplus can be defined as the area above the supply curve and below the price line. For example, in Fig. 5.12, at price P_1 the producers' surplus is defined as the area bounded by P_1 B S_0, where S_0 is the point at which the supply curve intersects the y-axis. A price of P_2 has a producers' surplus defined by the area bounded by P_2 A S_0. These areas are identical to the result from a calculation of total revenue less total variable cost.

Note that producers' surplus and profit are not identical concepts. Producers' Surplus (PS) is Total Revenue (TR) less Total Variable Cost (TVC), i.e. PS = TR − TVC. However, profit has an additional cost item deducted from total revenue, the Fixed Costs (FC). So, Profit = TR − TVC − FC.

5.1.7.4 Change in Producer Surplus

Conceptually, the change in producers' surplus is the change in surplus or net benefits that accrue to producers as a result of a change in the market price of the commodity (refer to Fig. 5.12). The change in producers' surplus can be measured as the difference in the value of producers' surplus at two different market prices. At the price of P_1, the value of the producers' surplus is measured by area 1, which is bounded by the points P_1 B S_0. At a price of P_2, the value of producers' surplus is measured by the areas 1 + 3, bounded by the points P_2 A S_0. For a price change from P_1 to P_2, the change in producers' surplus would be the difference in the areas that measure the value of producers' surplus at each price. In Fig. 5.12, a change in price from P_1 to P_2 results in a change in producers' surplus equivalent to the area (3 + 1 − 1) = 3. Area 3 is bounded by the points P_2 A B P_1.

On a graph, the change in producers' surplus is defined as the area that is between the price lines and above the supply curve. Is this graphically oriented working definition of the change in producers' surplus entirely consistent with the more conceptual definition given earlier?

Applying the graphical definition to a price change from P_1 to P_2 in Fig. 5.12 shows that the change in producers' surplus is area 3, which is defined by points P_2 A B P_1.

An increase in producer surplus can be viewed as a direct *welfare benefit* to the producer of the commodity. Conversely, a price fall would result in a producer surplus loss and be counted as a *welfare loss* of the price decline. It is important to recognise that the producers' surplus may not be equally shared among the producers. Producers with lower per-unit production costs will enjoy a greater share of the surplus compared to producers with higher per-unit production costs. Bear in mind that in a competitive market we assume that all producers are forced to sell at the same price.

5.1.7.5 Analysis of Welfare Impact on Society

In the previous section, we introduced four measures that can be used to assess the impact of price changes on the welfare of economic agents in the society. Also, we separately determined the impact to producers and to consumers. Now we integrate the analysis and determine the net impact to the society.

Figure 5.9 has both the supply curve and the demand curve for a commodity. If the price of the commodity was increased from P_0 to P_1, what would be the impact to consumers, producers, and society as a whole?

The net impact to consumers of a price change from P_0 to P_1 can be measured by the change in consumers' surplus. In Fig. 5.9, the *change in consumers' surplus* for a price change from P_0 to P_1 is measured by the areas $a + b + c + d$. However, the consumers' surplus has decreased because of the price increase. Thus, the area of the consumers' surplus is a negative value: $-(a + b + c + d)$. As a rule, an increase in the market price of a commodity causes a loss of welfare for consumers because now they either have to pay more for the same quantity or purchase a smaller quantity with the same sum of money. So, consumers' surplus has a negative value as a result of an increase in the market price. As a rule, also, a decrease in the market price of a commodity causes an increase in consumers' surplus.

The *change in producers' surplus* for the price change from P_0 to P_1 is measured by the area a in Fig. 5.9. The producers' surplus has increased in this price change, rendering a positive value for a, $(+a)$. As a rule, an increase in the market price of a commodity increases producers' surplus because the differential between per-unit production cost and per-unit revenue is increased by an increase in market price. Similarly, as a rule, a decrease in the market price of a commodity results in a decrease in producers' surplus.

The net welfare effect to society of the price change from P_0 to P_1 in Fig. 5.9 can be obtained by the summation of the welfare changes enjoyed by producers and by consumers. The net welfare effect of the price change is: $a - (a + b + c + d) = -(b + c + d)$. Thus, in this instance the net welfare effect, or change in social surplus value, is negative.

5.1.8 The Theory of Second-Best and Policy Analysis

A competitive market economy consists of many competitive markets for the supply of inputs and the distribution of outputs of production. The price relationships (price ratios) between the various commodities produced in the economy are a major determinant of the quantities of the various commodities produced. As mentioned earlier, the assumption of competitive markets is often used in agricultural policy analysis. However, in real-world situations this assumption often does not hold.

5.1.9 First-Best and Second-Best Scenarios

The idealised competitive market economy assumes an absence of government interventions and other conditions that would distort price relationships. Here, the price of commodities, the price of factors, and the price relationships between commodities are completely determined within the functioning of competitive markets. Neo-classical economic theory holds that, with a few exceptions, economic welfare and economic growth are maximised in an idealised competitive market economy.

The idealised competitive market economy is viewed as a first-best situation, because economic growth and welfare are maximised and, consequently, the distribution of outputs is such that it is impossible to reallocate to make one person better off without making at least one person worse off. That is, the competitive economy is Pareto efficient or Pareto optimal.

Pareto efficiency suggests an absence of policies or other conditions that distort prices in factor markets and the production, consumption, and international trade of commodities. Thus, producers and consumers face the same prices. Further, producers and consumers in the domestic and foreign markets also face the same prices (assuming the absence of competitive international marketing costs). Deviations from the Pareto-efficient situation are regarded as distortions (second-best conditions). Second-best market situations are the norm rather than the exception in the real world.

In the real world, government intervention or other conditions influence prices, and therefore, the production, consumption, and trade, of commodities in all markets. These distorted markets are examples of second-best situations. Government interventions, such as tariffs, taxes, and subsidies, which distort prices are referred to as policy-induced distortions.

Second-best market situations cannot be regarded as optimal because economic theory holds that the first-best situations allow economic growth and welfare to be maximised and Pareto optimality to be achieved. Maximising economic growth and welfare are two of the fundamental objectives of economic policy. This suggests that the policy analyst should aim to:

1. Propose changes that reduce distortions, thus allowing markets to move towards first-best status
2. Ensure that policies proposed are associated with either zero or a minimal level of distortion

The theory of second-best, also called the theory of generalised distortions, provides approaches for selecting the best policy alternative when in a second-best world (i.e. an environment of market distortions). The goal is to reduce these distortions and move towards the ideal of Pareto optimality.

5.1.10 Types of Distortions

Distortions can be policy-induced or endogenous. Policy-induced distortions are created by government policy. Endogenous distortions are market imperfections that exist even in the absence of government intervention in the market and economic system (a laissez-faire economic system). For convenience, policy-induced distortions may be classified into four major types which can occur either singly or in combination in any given market:

1. Trade distortion, represented as FRT = \ = MRPT = DRS
2. Production distortion, represented as MRPT = \ = DRS = FRT
3. Consumer distortion, represented as DRS = \ = MRPT = FRT
4. Factor-market distortion or non-operation on the efficient production possibility curve

where FRT is foreign marginal rate of transformation and DRS is domestic marginal rate of substitution.

Trade distortions affect international trade of a commodity. Policy-induced trade distortions include tariffs, export taxes, and export subsidies. This type of distortion causes the price of the commodity in the international market to differ from the price of the commodity in the domestic market, i.e. FRT = \ = MRPT = DRS.

Production distortion affects the production of a commodity. Policy-induced production distortions can occur when a government imposes a production tax or a production subsidy. This distortion causes the price received by producers to be different to the price paid by consumers and the international price of the commodity, i.e. MRPT = \ = DRS = FRT.

Consumer distortion affects the consumption of a commodity. Policy-induced consumption distortions can occur if a government imposes a consumption tax or consumption subsidy on a commodity. This distortion causes the price paid by consumers to differ from the price received by producers and the international price of the commodity, i.e. DRS = \ = MRPT = FRT.

Factor-market distortion (such as factor taxes or subsidies) affect the quantity of a factor used in the production process. Factor-market distortion results in non-operation on the PPF because any such distortion would cause a decline in the efficiency of the production process.

5.1.11 Policy Recommendations for Addressing Second-Best Situations

Bhagwati and Srinivasan (1981) offer seven propositions as guidelines for policy work in an environment of market distortions. These propositions provide guidance towards eliminating or reducing market distortions thereby allowing movement towards a first-best situation. Four of the more critical guidelines are given below.

5.1.11.1 Attack the Source of the Distortion Directly

When confronting a distortion/constraint, utilise a policy that is directed at the source of the distortion/constraint. Resolve a trade distortion with trade policies, *not* production, consumption, or factor-market policies. Resolve a production problem with a production policy, a consumption problem with a consumption policy, and a factor-market distortion with factor-market policies.

Using a policy that directly attacks the source of the distortion will eliminate or minimise the distortion. To do otherwise would introduce additional distortions into the economy, leading to further reductions in efficiency. For instance, using a trade policy to deal with a production distortion will increase the amount of distortion in the economy.

5.1.11.2 Rank and Select from Alternate Policies

Given the above, it is possible to rank policies in terms of their relevance for resolving a particular distortion. For instance, a trade policy is the first-best policy for dealing with a trade distortion. So, too, a production policy is the first-best policy for dealing with a production problem.

5.1.11.3 Reduce the Degree of a Single Distortion

If there is (only) a single distortion, then successive reduction in the degree of this distortion reduces the market distortion and invariably increases welfare.

5.1.11.4 Reducing the Degree of a Distortion Will Not Necessarily Be Welfare-Increasing if There Is Another Distortion in the System

The challenge in situations when several distortions are present is to identify the most critical distortion/problem(s). To do so requires use of constraint analysis, economic theory, and other means and techniques to identify the most critical distortion/constraint.

5.2 Assumptions of the Partial Equilibrium Models

The rest of this chapter will focus on using partial equilibrium models to analyse domestic and trade policies. It is important to recognise certain assumptions and working definitions associated with the PE models that will be used in these analyses. Important assumptions are:

1. A single commodity market is being analysed.
2. The commodity being analysed is homogeneous (i.e. no variation in quality, grade, etc. within and among countries).
3. There are no changes in the following variables (i.e. they are held at a constant during the analysis): prices of other commodities; income of households; population; consumer preferences; and technology.
4. The following costs are not included in the analysis: transport charges; handling costs; and exchange rates.

   Important working definitions:

1. Change in producer surplus – the area between the price lines and above the supply curve.
2. Change in consumer surplus – the area between the price lines and below the demand curve.

5.3 Effects of Domestic Policies in a Partial Equilibrium Setting

Domestic agricultural policies are the deliberate actions of governments (i.e. policies) targeted at specific agricultural commodities or the agricultural sector. They influence domestic consumption, marketing, or production of particular agricultural commodities. Domestic agricultural policies include input subsidies, output subsidies, commodity-specific taxes, guaranteed prices, price stabilisation programmes, consumer subsidies, production control programmes, forced marketing arrangements, and direct payments.

These domestic policies may have the effect of encouraging agricultural production, such as through output subsidies or effective guaranteed prices. Others, such as forced marketing arrangements in which producers are forced to sell at low prices to a parastatal marketing organisation, may have the effect of discouraging agricultural production.

Note that these beneficial or harmful effects to agricultural production may be unintended consequences of implementing the policy; i.e., they may not have been the reason(s) for government instituting the policy. The policy may have been put in place, for instance, to stabilise the incomes of farmers.

This section assesses the economic impact of one domestic policy measure that is used to increase the output of agricultural commodities and the incomes of farmers: a guaranteed price on output.

5.3.1 The Impact of a Minimum Guaranteed Price

A minimum guaranteed price for a commodity is the domestic price set by a government to support domestic production and/or incomes of farmers. To be effective in an open economy, this domestic price must be higher than the world market price. A stand-alone minimum guaranteed price will not be effective in an environment of free trade as imports would enter the country and the world price would prevail. Thus, a minimum guaranteed price may be accompanied by a protective trade policy (e.g. a variable levy).

A variable import levy is a price tax on imports of the commodity that is equal to or greater than the difference between the world market price and the domestic guaranteed price of the commodity. Variable import levies are also referred to as minimum import price schemes and are used to protect minimum guaranteed prices from the effects of changing world market prices. In other words, variable import levies change in value as the world market price increases or decreases, so that the minimum guaranteed price can remain at one value. Government revenue is generated in situations where the world market price is lower than the fixed minimum guaranteed price.

Box 5.1 The Need for Variable Import Levies

"Tariffs and quotas have operational drawbacks when introduced as measures to protect internal price guarantees. Fixed or ad valorem tariffs allow fluctuations in world prices to be transmitted fully or partly into the domestic market. Import quotas, if binding, insulate the domestic market from world price changes, but they may amplify domestic price swings caused by internal demand and supply fluctuations. Downward domestic price fluctuations from whatever source usually undermine protective policies. A number of policy schemes have been devised over the years by nations to overcome these shortcomings of traditional tariffs and quotas. Two prominent examples for import products are variable import levies and deficiency payments. Their primary function is to protect a domestic producer price guarantee from being undermined or overwhelmed by the behaviour of international markets" (Houck 1987, 61–62).

The following is an analysis of the impacts of a guaranteed price complemented with a variable import levy.

5.3.1.1 Initial Equilibrium Before Implementing the Guaranteed Price and the Variable Levy

In Fig. 5.13, two possible initial equilibria exist depending on the world price. If the world price is at P_{w1}, the following equilibrium exists:

- P_{w1} is the world market price.
- Os_1 is the quantity that would be produced at the world price, P_{w1}.
- Od_1 is the quantity that would be consumed at the world price P_{w1}.
- Imp_1 is the quantity that would be imported at the world price P_{w1}.

If the world price is at P_{w2}, the following equilibrium exists:

- P_2 is the world market price.
- Os_2 is the quantity that would be produced at the world price P_{w2}.
- Od_2 is the quantity that would be consumed at the world price P_{w2}.
- Imp_2 is the quantity that would be imported at the world price P_{w2}.

5.3.1.2 The Policy

A minimum guaranteed price complemented by a variable levy.

5.3.1.3 Analysis and End Equilibrium

The economic impact of a policy of a guaranteed price complemented by a variable levy is very similar to the impact of a tariff policy, because both policies raise the domestic price above the world price. The domestic price, with the price guarantee, is P_g, which is higher than P_{w1} or P_{w2}.

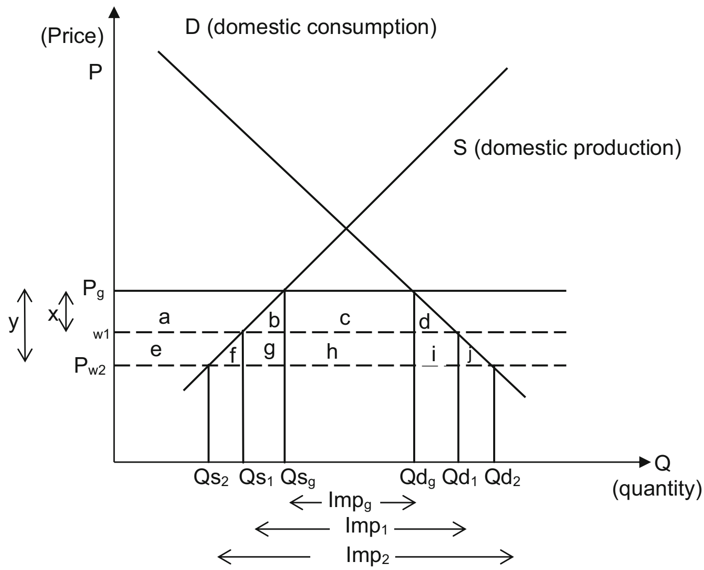


Fig. 5.13 Policy effects of a price guarantee and variable import levy scheme

The following market equilibrium changes occur when the domestic price is P_g and the world price is P_{w1}:

Domestic price of the commodity increases from P_{w1} to P_g, ($P_g > P_{w1}$).

Domestic production increases from Qs_1 to Qs_g ($Qs_g > Qs_1$).

Domestic consumption decreases from Qd_1 to Qd_g ($Qd_1 > Qd_g$).

Quantity imported decreases from Imp_1 to Imp_g ($\text{Imp}_1 > \text{Imp}_g$).

x is the value of the (variable) import levy when the world price is P_{w1}.

The following welfare changes occur when the world price is P_{w1} and the domestic price is P_g:

Change in consumer surplus $= -(a + b + c + d)$

Change in producer surplus $= +a$

Levy revenues collected $= +c$

Change in net welfare of society $= -(b + d)$

When the world market price falls to P_{w2}, the government adjusts the tariff to y ($P_g - P_{w2}$) in order to protect the domestic price of P_g. The welfare effects at price P_{w2} are alike to that for P_{w1}, except that the areas (and values) are larger because of the larger differential between the world price and the guaranteed price.

Market equilibrium changes when the domestic price is P_g and the world price is P_{w2}:

Domestic price of the commodity increases from P_{w2} to P_g, ($P_g > P_{w2}$).

Domestic production increases from QS_2 to QS_g ($QS_g > QS_2$).

Domestic consumption decreases from QD_2 to QD_g ($QD_2 > QD_g$).

Quantity imported decreases from Imp_2 to Imp_g; ($\text{Imp}_2 > \text{Imp}_g$).

y is the value of the (variable) import levy when the world price is P_{w2}.

Welfare changes when the domestic price is P_g and the world price is P_{w2}:
Change in consumer surplus = $-(a + b + c + d + e + f + g + h + i + j)$.
Change in producer surplus = $+(a + e)$.
Levy revenues collected = $+(c + h)$.
Change in net welfare of society = $-(b + d + f + g + i + j)$.

A policy of a guaranteed minimum price complemented by a variable import levy operates by maintaining the fixed domestic price even as world prices fluctuate. The variable levy protects the domestic guaranteed price and disconnects world prices from the domestic market, so that the domestic guaranteed price is stable even when domestic supplies and demands vary or international prices fluctuate. In Fig. 5.13, the guaranteed price is fixed at P_g, while the world price fluctuates between P_{w1} and P_{w2}. The impact of this policy is similar to that of a tariff policy because both raise the domestic price above the world price.

This policy generates revenues for the government in the importing country and provides producers with higher prices that are guaranteed. The policy, however, is unpopular with importers; the quantity they bring into the country decreases. Further, importers are never certain of how much levy must be paid until the goods have arrived in the port.

5.4 Effects of Trade Policies in a Partial Equilibrium Setting

Agricultural trade policies are the deliberate actions of governments enforced at the country's border and that target specific agricultural commodities. They change the pattern and volume of international trade in agricultural commodities between countries. Examples of international trade policies applied by governments include tariffs, export taxes, export subsidies, variable levies, quota restrictions, domestic content regulations, and, at times, sanitary restrictions.

Some agricultural trade policies, such as quota restrictions, when applied to a specific agricultural commodity may have the effect of encouraging domestic production of that commodity. Other trade policies, for example, an export tax, when applied to a specific agricultural commodity may have the effect of discouraging domestic production of that commodity.

Some trade policies, such as a tariff or export tax, may be implemented primarily for revenue collection by the government but have unintended consequences to the farm community. In the case of a tariff, farmers benefit from higher prices. In the case of an export tax, farmers suffer a decline in prices. The unintended consequences of policy can be minimised if the appropriate analytical methods are used before the introduction of the policy. This analysis should draw on the experiences of other countries and/or commodities.

One important distinction in the analysis is that of small country and large country in the context of international trade. The terms "small" and "large" refer to the influence that a country has in the international commodity markets. A large country can influence price in international commodity markets as a result of changes in its demand or supply of that commodity. A small country has no such impact. The designation of large or small country is done on a commodity-by-commodity basis. For example, Sri Lanka is a large country in the market for cinnamon because it has a relatively large share of the supply to the international markets. Thus, changes in Sri Lanka's export supply of cinnamon can cause changes in the world price for cinnamon. On the other hand, Sri Lanka is a small country in the international wheat market; changes in wheat consumption in Sri Lanka will not affect the international price of wheat. In the following sections the analysis will first focus on small countries with the final section presenting analysis for a large country.

5.4.1 Impact of a Tariff

There are various types of tariffs. An *ad valorem tariff* is a percentage tax on the value of the imported item. A *fixed-rate tariff* is a flat rate money tax per physical unit imported (e.g. USD 10 per kg of coffee). A *variable levy* is the difference between an agreed minimum import price and the fluctuating world price.

The impact of a tariff policy in the domestic market of a specific commodity, for example, coffee, is represented graphically in Fig. 5.14. Note that the three types of import tax listed above will cause market and welfare changes that all move in the same direction. However, the magnitude of the impact may differ.

5.4.1.1 Initial Equilibrium

Assume that in the initial equilibrium, there exist:

- A price P_w, which is the price of the commodity on the international market.
- The same value for the world price and the domestic price (i.e. $P_w = P_d$).
- A quantity QS_0 being supplied by local producers.
- A quantity QD_0 being consumed by local consumers.
- A quantity Imp_0 being imported into the country.
- Zero tariff revenue is being collected on imports of this commodity.

The price P_w is the world price of the commodity. This is an efficiency price because it is the opportunity cost of the commodities the country chooses to consume or produce. National welfare is maximised if both consumers and producers within the country are allowed to trade at the world price. In the initial equilibrium, the domestic price is equal to the world price.

Also, note that the quantity imported into the country is the difference (or shortfall) between the quantity consumed by domestic consumers and the quantity produced by domestic producers.

5.4.1.2 The Policy

The government imposes a tariff on the commodity imported into the country.

5.4.1.3 Analysis and End Equilibrium

Several changes in market equilibrium are caused by the imposition of a tariff. First, the tariff increases the domestic market price of the commodity above that of the world market price (P_w). In a small country, the difference between the world price and the domestic price is equal to the value of the tariff. Producers respond to the increased price in the domestic market by increasing domestic production of the commodity from QS_0 to QS_1. On the other hand, consumers respond by reducing the quantity demanded from QD_0 to QD_1. The quantity of the commodity imported into the country decreases from Imp_0 to Imp_1. The quantity of imports declines because domestic production has increased and consumption decreased.

The welfare effects of the policy can be assessed using changes in consumer surplus and producer surplus. In Fig. 5.14, the change in consumer surplus is $-(a + b + c + d)$. Since the price of the commodity has increased, the change in consumer surplus is negative, i.e. consumers have suffered a loss in welfare by the imposition of the policy. The change in producers' surplus is measured as +a. The change in producers' surplus is positive – producers benefit with the increased commodity price.

Government tariff revenues have increased and are measured by the area labelled c in Fig. 5.14. With the imposition of the tariff, government collects a tariff of $P_{d1} - P_w$ on each unit quantity (or value) of the commodity imported into the country. The quantity imported (at the price P_{d1}) is Imp_1. Thus, the value of the tariff revenue collected is $(P_{d1} - P_w) \times \mathrm{Imp}_1$, i.e. the area c.

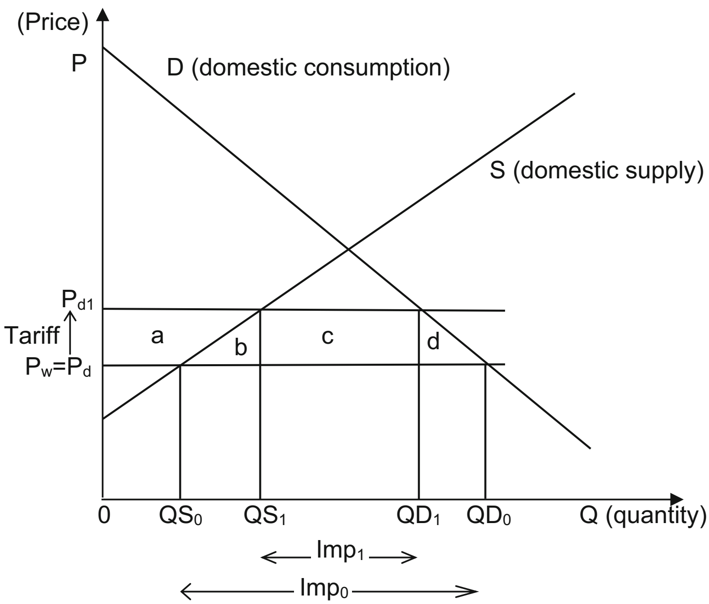


Fig. 5.14 Policy effects of a tariff

These welfare changes and the net welfare impact to the country are presented below:

Changes in consumer surplus = $-(a + b + c + d)$

Changes in producer surplus = $+a$

Change in tax revenue = $+c$

Change in net welfare of society = $-(b + d)$

The net welfare impact of the policy on society is a loss of the areas *b* and *d*. The net welfare impact is calculated by adding the areas gained and lost. In this addition, the gains of producers ($+a$) and government taxes ($+c$) offset the equivalent areas ($-a$ and $-c$) lost by consumers. In effect, therefore, the area *a* was a transfer from consumers to producers as a result of the price increase. The area *c* was lost by consumers but captured by the government. Thus, the areas *a* and *c* are not a net loss to the society; they have been redistributed within society.

Areas *b* and *d* are referred to as Deadweight Loss (DWL), because they represent a loss in welfare to the society due to the imposition of the policy. Both DWL areas are triangular.

Area *b* is associated with the supply curve and is therefore a production efficiency loss to society. This DWL is caused by the removal of resources from the production of some other commodity in order to increase production of this commodity. Note that we assume that the competitive equilibrium (before the imposition of any policy) allows an optimal allocation of resources to the production of all the commodities produced in the country. Thus, the policy change implies that some of the resources that were efficiently being used to produce another commodity are now taken away to produce more of this commodity.

Area *d* is associated with the demand curve and is therefore a consumption efficiency loss to society. This DWL is caused by consumers having to change their optimal consumption bundle; consumers must either consume less of this commodity or consume less of some other commodity to remain within their budget constraint. Note that we assume that before the policy was imposed, the competitive equilibrium was such that consumers had the optimal quantities of commodities in their consumption bundle.

The imposition of the tariff has distorted the competitive equilibrium of the domestic economy. The tariff increases the domestic price of the commodity by the full extent of the tariff because the country is small in international trade. The results of the analysis show that imposition of a tariff causes:

Changes in market equilibrium – The domestic price increases ($P_{d1} > P_w$), the quantity produced increases ($QS_1 > QS_0$), the quantity consumed declines ($QD_1 < QD_0$), and the quantity imported declines ($\mathrm{Imp}_1 < \mathrm{Imp}_0$).

Changes in the distribution of welfare benefits – Consumers lose welfare. Some of this loss (area *a* in Fig. 5.14) is captured by producers; some of the consumer loss (area *c* in Fig. 5.14) is captured by the government in the form of tariff revenues. Producers benefit to the extent of area *a*. Government benefits by higher tariff revenues (area *c*).

Changes in net welfare of society – The policy causes welfare loss that is not captured by any economic agent in the society. This loss, represented by the small triangles (b and d) in Fig. 5.14, is deadweight loss, resulting from a reduction in the efficiency of resource use in the economy (production efficiency loss) and a reduction in quantities consumed (consumption efficiency loss).

5.4.2 Impact of an Import Quota

An import quota is a quantitative restriction on the units of the commodity allowed to be imported into the country. Tariffs are often administered by issuing licenses to individuals, groups, or firms. Governments often impose quotas to protect domestic producers from "cheap" imports. Quotas like tariffs have the impact of increasing the domestic price of the commodity.

The quota licenses, the right to import the commodity into the country, can be administered in a wide variety of ways. The quota licenses can be given freely to selected individuals, firms, or groups, or the government can charge a fee for the license that captures all or part of the difference.

The impact of a quota is represented in Fig. 5.15. In the analysis, note the similarities between the impact of the quota and the impact of a tariff. The discussion will be limited to highlighting areas of differences.

5.4.2.1 Initial Equilibrium

Assume that in the initial equilibrium (as shown in Fig. 5.15), there exist:

- A price P_w, which is the price of the commodity on the international market.
- The same value for the world price and the domestic price ($P_w = P_d$).
- A quantity QS_0 being supplied by local producers.
- A quantity QD_0 being consumed by local consumers.
- A quantity Imp_0 being imported into the country.
- Zero quota revenue being collected on imports of this commodity, because there are no trade barriers in this initial equilibrium.

Note that the quantity imported into the country is the difference (or shortfall) between the quantity consumed by domestic consumers and the quantity produced by domestic producers.

5.4.2.2 Policy

Assume that the government wished to impose a quota that would reduce the quantity of the commodity imported into the country from Imp_0 to the smaller quantity Imp_1. The effects of this policy are detailed in Fig. 5.15.

5.4.2.3 Analysis and End Equilibrium

The government has reduced, by decree, the quantity imported from Imp_0 to Imp_1. Thus, the analysis of quota policies begins with the reduction of the quantity. Figure 5.15 shows that the quota causes an increase in the domestic market price of the commodity from (P_w) to (P_{d1}). The domestic price is now greater than the world market price. In a small country, the difference between the world price and the domestic price is referred to as the *tariff-equivalent effect* of the quota, because the quota has a measurable impact on price that can allow us to compare its effect to that of a tariff.

Market equilibrium changes:

Quantity imported decreases from Imp_0 to Imp_1 ($\mathrm{Imp}_1 > \mathrm{Imp}_0$).

Domestic price increases and is greater than the world price ($P_{d1} > P_w$).

Domestic production increases from QS_0 to QS_1 ($QS_1 > QS_0$).

Domestic consumption decreases from QD_0 to QD_1 ($QD_0 > QD_1$).

Welfare changes:

Change in consumer surplus $= -(a + b + c + d)$

Change in producer surplus $= +a$

Change in quota rent revenue $= +c$

Change in net welfare of society $= -(b + d)$

Where,

area b is a production efficiency loss

area d *is* a consumption efficiency loss

Area c is referred to as a *quota rent*. Rent is an economic term that implies that it is a surplus, over and above the normal returns to the activity. In this case, rent may be conceived of as excess profit, earned by whoever has the quota licence.

Significantly, a quota has identical impacts on market equilibrium as that of a tariff of equivalent value.

The welfare impact of a quota depends on who obtains the value of area c, the quota rent. Area c is identical with the tariff revenue collected from a tariff of equivalent value. Thus, the institutional story of how the quota licences are allocated is very important when assessing the welfare implications of a quota. If the government collects the entire quota rent, *then and only then* will the quota have identical impacts on welfare as that of a tariff of equivalent value. Government can collect all the quota rent if it charges a licence fee that captures the entire tariff equivalent value of the quota.

Citizens of the country capture the quota rent if government gives away (for free) the quota licence to citizen importers. In such a case, there is a transfer of area c from consumers to these individual citizens. Then the net welfare change of the policy is ($-b$ and $-d$), as stated in Fig. 5.15.

If the government gives the quota licence to foreigners, then the quota rents are captured by foreigners. Here, the value of the quota rent is an additional welfare loss to the society. The net welfare loss of the policy would be ($-b$ $-c$ $-d$). Giving away the quota rent to foreigners has the worst possible impact on national welfare. Of course, the government may charge a licence fee that captures part of the quota rent, in which case the distribution of area c is again affected: part of area c goes to government and the rest to another domestic or foreign economic agent.

The imposition of a quota distorts the competitive equilibrium. A quota increases the domestic price of the commodity; the magnitude of the price change can be used to assess the tariff equivalence of the quota. A quota has similar effects on market equilibrium as its tariff equivalent. The welfare impact of a quota depends on how

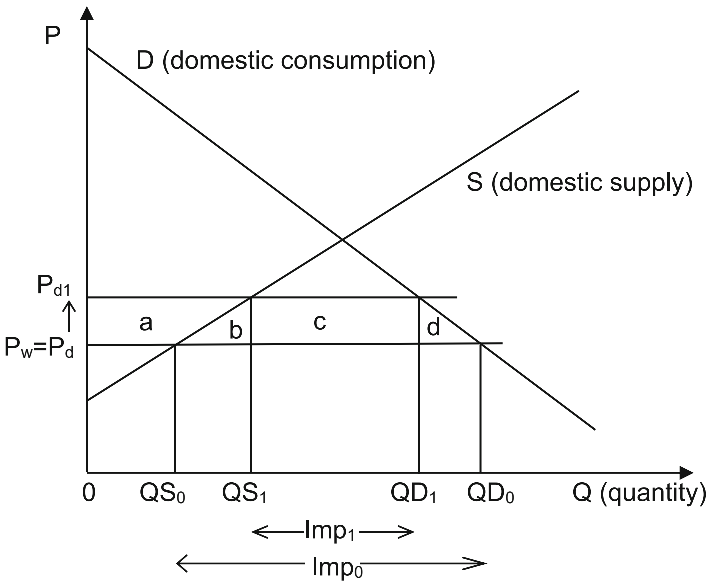


Fig. 5.15 Policy effects of an import quota

and to whom the quota licences were allocated. However, a quota will have an identical impact on welfare as a tariff of equivalent value *if and only if* the government captures the entire quota rent.

5.4.3 Export Tax

An export tax is a tax levied at the border of a country on items exported out of the country. Governments use export taxes to collect revenue. This practice is more likely to occur in countries with poorly developed capabilities for collecting income or corporation tax. Export taxes, like tariffs, cause world price and the domestic price of the commodity to differ. Specifically, export taxes lower the domestic price of a commodity below that of the world market price. Figure 5.16 presents the impact of an export tax with the subsequent paragraphs providing explanations of the changes.

5.4.3.1 Initial Market Equilibrium

Assume that in the initial equilibrium (before imposition of the export tax) there exists:

- A price P_w, the price of the commodity on the international market.
- The same value for the world price and the domestic price (i.e. $P_w = P_d$).
- A quantity QS_0 being supplied by local producers.
- A quantity QD_0 being consumed by local consumers.

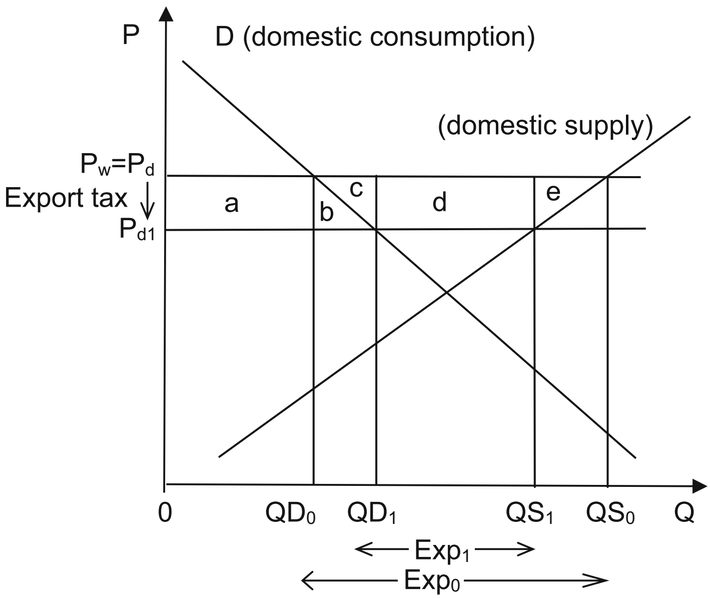


Fig. 5.16 Policy effects of an export tax

- A quantity Exp_0 being exported from the country. The quantity exported is the difference (or surplus) between the quantity consumed (QD_0) and the quantity supplied (QS_0).
- No export tax revenues are collected in this initial equilibrium because there are no barriers to free trade.

5.4.3.2 The Policy

The government introduces an export tax on the quantity or value of the commodity exported from the country.

5.4.3.3 Analysis and End Equilibrium

The imposition of an export tax causes several changes in market equilibrium. First, the export tax reduces the domestic market price of the commodity below that of the world market price (P_w). This occurs because the tax is, in effect, a cost to export. Thus it becomes profitable to sell at a lower price on the domestic market where the tax is avoided. In a country with too little exports to affect global prices, the difference between the world price and the domestic price is equal to the value of the export tax. Producers respond to the decreased price on the domestic market by decreasing domestic production of the commodity from QS_0 to QS_1. On the other hand, consumers respond by increasing the quantity demanded from QD_0 to QD_1. The quantity of the commodity exported from the country decreases from Exp_0 to Exp_1. The quantity of exports declines because domestic production has decreased and consumption increased.

The welfare effects of the policy can be assessed using changes in consumer surplus and producer surplus. The change in consumer surplus is equivalent to the area $a + b$ in Fig. 5.16. This is a positive change since consumers benefit from the price decrease. The change in producers' surplus is measured by the area $a + b + c + d + e$ in Fig. 5.16. The change in producers' surplus is negative, as producers lose because of the price change.

Government tariff revenues are measured by the area labelled d in Fig. 5.16. With the imposition of the export tax, government collects a tariff of $P_w - P_{d1}$ on each unit quantity exported. The quantity exported (at the price P_{d1}) is Exp_1. So the value of the tax revenue collected is $(P_w - P_{d1}) \times \text{Exp}_1$, i.e. the area d.

These welfare changes and the assessment of the net welfare impact on the country are presented below:

Changes in consumer surplus = $(a + b)$

Changes in producer surplus = $-(a + b + c + d + e)$

Change in tax revenue = $+d$

Change in net welfare of society = $-(c + e)$

The net welfare impact of the policy on the national society is a loss of the areas c and e. The net welfare impact is calculated by adding the areas gained and lost. In this addition, the gains of consumers $(+a + b)$ and government taxes $(+d)$ offset the equivalent areas $(-a, -b,$ and $-d)$ lost by producers. In effect, therefore, areas a and b were transferred from producers to consumers as a result of the price decrease. Area d was lost by producers but captured by the government. Thus, areas a, b, and d are redistributed among the economic agents within society.

Areas c and e are deadweight losses because they represent a net loss in welfare to society due to the imposition of the policy. Area c is associated with the demand curve and, therefore, a consumption efficiency loss to society. Area e is associated with the supply curve and, therefore, a production efficiency loss to society.

The imposition of the export tax has distorted the competitive equilibrium of the domestic economy. The export tax reduces the domestic price of the commodity by the full extent of the tax because the country is "small" in international trade. The results of the analysis show that imposition of an export tax causes:

Changes in market equilibrium – The domestic price decreases ($P_w > P_{d1}$), the quantity produced decreases ($QS_1 < QS_0$), the quantity consumed increases ($QD_1 > QD_0$), and the quantity exported declines ($\text{Exp}_1 < \text{Exp}_0$).

Changes in the distribution of welfare benefits – Producers lose welfare. Some of this loss (areas a and b) is captured by producers; some of the producer loss (area d) is captured by the government in the form of tax revenues. Consumers benefit to the extent of areas $a + b$. Government benefits by higher tariff revenues (area d).

Changes in net welfare of society – The policy causes welfare loss that is not captured by any economic agent in the society. This DWL, represented by the triangles (c and e), results from a reduction in the efficiency of resource use in the economy (i.e. production efficiency loss), and a reduction in quantities consumed (i.e. consumption efficiency loss).

5.4.4 Graphical Analysis of Policies in Large Countries

Policies instituted in a large country (i.e. a country with a significant share of world imports or exports of a commodity) may influence world prices and market equilibrium and welfare in other countries. The domestic and international impacts of policies instituted in a large country can be captured graphically using three-panel diagrams, which is a single partial equilibrium diagram that shows both export and import markets for a commodity.

5.4.4.1 Developing a Three-Panel Diagram

Figure 5.17 displays a partial equilibrium model of a commodity market in a country. At the price P*, a quantity Q* is produced and consumed, and the country is self-sufficient (domestic supply is equal to domestic demand). At any price higher than P*, the country is an exporter of the commodity because, at those prices, the quantity produced by domestic producers exceeds the quantity demanded by consumers. Such is the case at price P_1 in Fig. 5.17. At P_1, the quantity produced, QS_1, exceeds the quantity demanded, QD_1. As a result, the difference, or excess supply, is exported. At any price lower than P*, the country is a net importer of the commodity because the quantity demanded exceeds domestic production. Thus, at prices higher than P* the country is a net exporter and at prices below P* the country is a net importer.

The three-panel diagram allows for the international impacts of trade and domestic policy changes to be graphically modelled and assessed. It is assumed that the world consists of two countries with one exporting and the other importing the commodity. A world market allows for trade of the commodity between the importing and exporting country. Excess demand and excess supply curves in the world market for the commodity link the exporting country and the importing country into a market system. Excess supply is the excess quantity produced by domestic producers over what domestic consumers want at a certain price. This will occur whenever the market price is above P*, the price at which domestic demand is equal to domestic supply. The excess supply produced at varying prices in the exporting country is available for trade in the world market. Conversely, there is excess demand in a country when quantity demanded is greater than domestic supply. This occurs at prices below P.* Excess demand is met with imports.

A world excess supply curve can be derived using the data on excess quantity available at varying prices in the exporting country. The excess supply curve is derived from the underlying domestic demand and supply curves in the exporting country. In Fig. 5.17 (Panel A), domestic demand is equal to domestic supply when the price is P^*. At this price, there is no excess quantity available for supply to the world market. Thus, at the price P^*, the excess supply curve records zero quantity and intercepts the y axis in Panel B, the world market. When the price increases to P_1, domestic supply exceeds domestic demand ($S_1 > D_1$) in the exporting country. Thus, the quantity ($S_1 - D_1$), or "b", is available for export at the price P_1. This defines another point on the excess supply curve. A further increase of the price to P_2 results in an excess supply of ($S_2 - D_2$), or "a". Again, this defines another point on

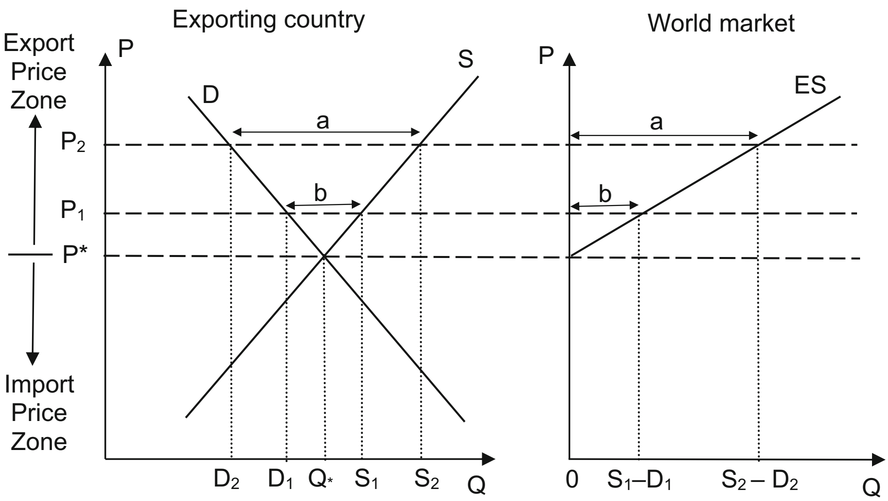


Fig. 5.17 Deriving the excess supply curve

the excess supply curve. The graphical excess supply curve is obtained by joining the points of excess supply at various prices. In similar fashion, an excess demand curve can be derived from the data in the importing country.

5.4.4.2 Determining the World Price and the Quantity Traded

The world price and the quantity traded are determined at the point where excess demand is equal to excess supply in the world market. The middle panel of Fig. 5.18 depicts the world market for the commodity. Consequently, the world price, P_w, is determined at the intersection of the excess demand and excess supply curves. The end panels (left and right panels) describe the domestic market conditions in the exporting and the importing countries, respectively.

5.4.5 The Economic Impact of a Tariff in a Large Country

Figure 5.19 analyses the impact of a tariff imposed in a large country.

It is important to note that the assumptions for partial equilibrium analysis with the single-panel diagrams remain relevant here too. In addition, it is assumed that the world consists of two countries (or groups of countries), an exporting country and an importing country.

5.4.5.1 Initial Equilibrium

Assume in the initial equilibrium, there exist:

- A price P_w, which is the price on the world market and in the exporting and importing countries

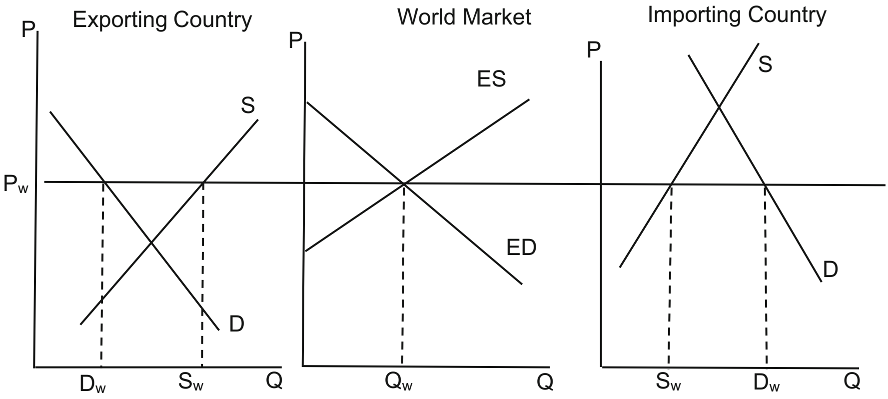


Fig. 5.18 World market equilibrium

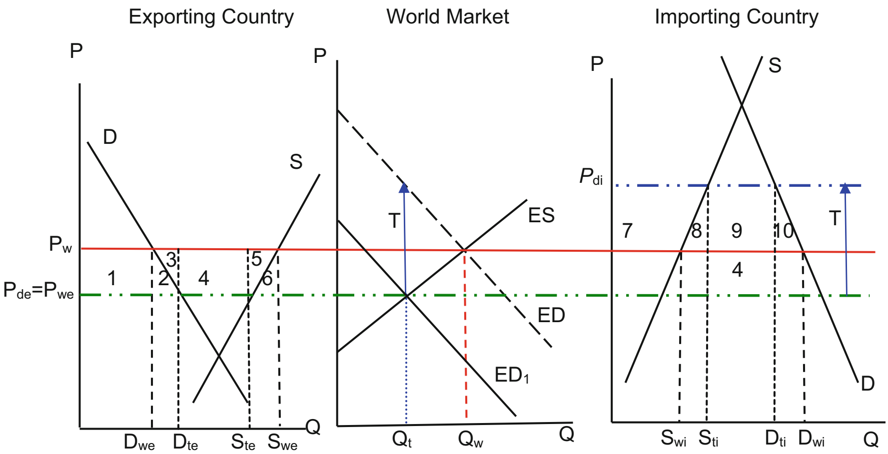


Fig. 5.19 Analysis of the economic impact of a tariff

- A quantity S_{we} being produced in the exporting country
- A quantity D_{we} being demanded in the exporting country
- A quantity S_{wi} being produced in the importing country
- A quantity D_{wi} being demanded in the importing country
- A quantity Q_{w} being traded on the world market
- A quantity $(S_{\mathrm{we}} - D_{\mathrm{we}})$ being exported
- A quantity $(D_{\mathrm{wi}} - S_{\mathrm{wi}})$ being imported
- Quantity exported $(S_{\mathrm{we}} - D_{\mathrm{we}})$ is equal to quantity imported $(D_{\mathrm{wi}} - S_{\mathrm{wi}})$

The above describes a competitive equilibrium before the imposition of the policy. Our analysis will assess the impact of policy intervention (a tariff on imports) that distorts this competitive equilibrium.

5.4.5.2 Policy

The government of the importing country introduces a tariff, T, on the commodity.

5.4.5.3 Analysis and End Equilibrium

The tariff (T) will cause the price in the importing country to increase and so reduce quantities demanded from the world market at any given price. Therefore, the excess demand curve in the world market shifts to the left. This new policy-induced excess demand curve is labelled ED_1 in Fig. 5.19. The vertical difference between ED and ED_1 measures the tariff rate.

The world price and quantity traded in the presence of the tariff is determined in the world market by the intersection of the policy-induced excess demand curve (ED_1) and the excess supply curve (ES). This new world price and quantity are labelled P_{we} and Q_{t}, respectively. Thus, with the imposition of a tariff in a large country importer, the world price and the quantity traded on the world market have both decreased. P_{we} is the new world price; both the importer and exporter see this price on the international market.

In the importing country, the tariff has introduced a wedge between the domestic price and the world price. The price in the importing country is higher than the world price by the tariff rate. The domestic price in the importing country, P_{di}, is found by adding the tariff to the new world price. At this higher price, more is produced and less demanded so that a smaller quantity is imported. The quantity imported ($\mathrm{D}ti - Sti$) is equal to the internationally traded amount (Qt).

In the exporting country, the tariff causes the domestic price to decrease. The domestic price in the exporting country (P_{de}) is equal to the world price (P_{we}), because there are no trade measures instituted at the border of the exporting country. Figure 5.19 shows that the lower domestic price in the exporting country causes an increase in the quantity demanded and a decrease in the quantity produced. The quantity exported ($\mathrm{S}te - Dte$) is equal to the internationally traded amount (Qt).

Figure 5.19 demonstrates that a tariff, when applied by a large country, increases the price in the importing country, decreases the price in the exporting country, and reduces the quantity of the commodity exported, imported, and traded internationally.

D – Demand curve

S – Supply curve

ED – Excess demand curve

ES – Excess supply curve

P_{w} – World market price in the initial equilibrium

P_{we} – World price with the tariff in effect

P_{di} – Domestic price in the importing country after the tariff is applied

P_{de} – Domestic price in the exporting country after the tariff is applied

D_{wi} – Quantity demanded at the initial world price in the importing country

D_{we} – Quantity demanded at the initial world price in the exporting country
D_{ti} – Quantity demanded at the new world price in the importing country
D_{te} – Quantity demanded at the new world price in the exporting country
s_{wi} – Quantity produced at the initial world price in the importing country
s_{we} – Quantity produced at the initial world price in the exporting country
s_{ti} – Quantity produced at the new world price in the importing country
s_{te} – Quantity produced at the new world price in the exporting country
Q_w – Quantity traded in the world market at the initial world price
Q_t – Quantity traded in the world market at the new world price
T – Tariff imposed in the importing country

The following are the market equilibrium changes in the world market*:*

The world price has declined from P_w to P_{we}.
The quantity traded has decreased from Q_w to Q_t.

The following are the market equilibrium changes in the importing country:

Domestic price has increased and is now greater than the world price ($P_{di} > P_w$).
Domestic production has increased from S_{wi} to S_{ti}.
Domestic consumption has decreased from D_{wi} to D_{ti}.
Quantity imported has decreased from ($D_{wi} – S_{wi}$) to ($D_{ti} – S_{ti}$).

The following are the market equilibrium changes in the exporting country:

Domestic price has decreased and is now less than the world price ($P_w > P_{de}$).
Domestic production has decreased from S_{we} to S_{te}.
Domestic consumption has increased from D_{we} to D_{te}.
Quantity exported has decreased from ($S_{we} - D_{we}$) to ($S_{te} - D_{te}$).

The following are the Welfare changes in the importing country:

Change in consumer surplus = −(7 + 8 + 9 + 10)
Change in producer surplus = +7
Change in government tariff revenue = +(9 + 4)
Change in net welfare of society = + 4 − (8 + 10)
Where,
Area *8* is a production efficiency loss.
Area *10* is a consumption efficiency loss.
Area *4* is an international transfer of rent from the exporter.

The following are the welfare changes in the exporting country:

Change in consumer surplus = +(1 + 2)
Change in producer surplus = −(1 + 2 + 3 + 4 + 5)
Change in net welfare of society = −(3 + 4 + 5)
Where,
Area *3* is a consumption efficiency loss.
Area *5* is a production efficiency loss.
Area *4* is an international rent transfer to the importer.

There has been a reduction in the economic welfare of the world by the imposition of the tariff because the two countries have suffered net losses in welfare. The importing country has lost (areas 8 + 10) and the exporting country has lost (areas 3 + 5). These are efficiency losses in consumption and production.

The production efficiency losses are measured in the context of the optimal allocation of resources that existed in the competitive equilibrium. Production efficiency losses occur because increasing or decreasing production in response to policy-induced price changes means that resources have to be moved out of production of at least one commodity. The resources pulled from a commodity would have been making a greater contribution to economic output in production of *that* commodity, as against the policy-favoured commodity. Consumption efficiency losses occur because consumers are forced to consume too much or too little of a commodity, compared to the situation in the competitive equilibrium.

Area *4* is an international transfer of rent. The exporting country loses area *4* because the policy has caused it to sell all the units now exported at a lower price. The importing country gains area *4*, since it now purchases on the international market at a lower price. Thus, area *4* measures this international transfer of rent from the exporter to the importer.

The large importing country may be able to enjoy a net welfare benefit from imposing a tariff if the value of its efficiency losses in production and consumption is smaller than the value of the international transfer of rent from the exporting country. Specifically, if $4 > 8 + 10$, then the exporting country has increased its welfare position. However, if $4 < 8 + 10$, then the policy has caused a welfare loss in the importing country. The possibility that an importing country can impose a tariff and enjoy a net welfare benefit has led to the concept of the optimal tariff. The theory of the optimal tariff aims to determine a tariff rate that would allow $4 \geq 8 + 10$.

Therefore, a large importing country, by imposing a tariff, depresses the price of the commodity in the exporting country and the world market. This effect is different from the case of the small importing country. The small importing country is a price taker and therefore cannot affect price in the international market.

A large importing country may be able to enjoy a net welfare benefit from imposing a tariff if its efficiency losses in production and consumption are smaller than the value of the international transfer of rent from the exporting country. The international transfer of rent occurs because the importing country, by its policy, has depressed the world price and is therefore now able to import at the cheaper price. Small importing countries cannot benefit from international transfers of rent because they cannot influence price on the international market. Thus, importing small countries suffer a net welfare loss by imposing a tariff.

5.5 Recommended Readings

Krugman P and Obstfeld M (1988) International economics: theory and policy. Scott, Foresman and Co., Illinois.

5.6 Assignments

1. Refer to Fig. 5.9 again. Suppose that the price of the commodity changes from P_1 to P_0. What would be the impact to the quantity sold; quantity demanded; the change in consumers' surplus; the change in producers' surplus; and the net benefit to society?
2. Identify commodities in relation to which your country could be classified as a small country. Are there any commodities that would allow your country to be classified as a large country?
3. What are the welfare implications if the government gives away (for free) the quota licences to producers of the commodity?

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Measuring Competitiveness of Agricultural Markets

6

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Abstract

Measuring competitiveness, including identifying the source of a lack of competitiveness, is essential to formulate appropriate policy responses on assistance or support schemes, if any, that can be provided to an industry, such as provision of export assistance, technological assistance, input subsidies, and import regulations. This chapter explores the concept of competitiveness of agricultural products both in the domestic and the export markets and provides guidelines for measuring and interpreting competitiveness indicators at global, national, industry, and farm levels.

Keywords

Export competitiveness · Policy analysis matrix · S-C-P paradigm · Agricultural productivity

6.1 Characteristics of Agricultural Value Chains

A good understanding of the structure of agricultural value chains is preconditional to conduct an assessment of competitiveness. This chapter hence first provides a general description on agricultural value chains. A number of sequential value-

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Fig. 6.1 A simple value chain. Source: Coconut Research Institute of Sri Lanka (2010)

addition activities (i.e. farming, transportation, processing, packaging, retailing, and so on) are involved in transforming a product for consumer use. Kaplinsky and Morris (2002) describe value chains as "the full range of activities required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers and final disposal after use" (p. 4). Figure 6.1 shows a simple value chain where goods and services flow towards consumers and feedback is communicated from consumers to the producers.

Value chains that produce closely similar products compete to satisfy consumer wants and needs. Success in this competition may be reflected in an increasing upward trend in sales, profits, and standing with consumers. This sustained upward trend may indicate an advantage over other competitors, in effect competitive advantage. Competitiveness may be due to several factors including better technology, more efficient logistic systems, superior customer service, better location or climate, or more aggressive and customer-oriented strategic decision-making, or it may be due to characteristics inherent in the product, such as quality and taste.

It would be rewarding to measure or quantify competitiveness including identifying the sources of competitiveness or uncompetitiveness. This would be helpful to entrepreneurs and policymakers. Entrepreneurs would have information to assist in strategic decisions covering areas such as research, production, transportation, and marketing. Policymakers can explore possibilities for policy responses in areas such as export assistance, technological assistance, input subsidies, and import regulations.

The agricultural value chains can generally be classified into three major groups, self-sufficient units, short chains, and long complex chains, with the latter further categorised into importable, exportable, and non-tradable products value chains.

Self-sufficient units refer to the production of agricultural goods solely for home consumption. Examples of self-sufficient units include backyard cultivation of green leaves, green chillies, some vegetables, coconut palm, paddy land, or rearing a cow for household milk consumption and rearing poultry, without involvement in a barter (exchange) system. This involves production, some processing, and household consumption.

Short chains involve selling harvested perishable goods at the farm gate or at the village market. For instance, fish harvested from the village tank or fruits and vegetables sold at the village level go through short chains with minimum value addition.

Long chains are of varying lengths and complexity. For example, in Sri Lanka paddy rice reaches a miller straight from the producer or through a dealer after some grading. The miller does the processing, grading, packing, labelling, certification (if required), and distribution to wholesale and retail markets. Similar long chains exist for some legumes, fruit processing, coconut oil, vegetables, etc.

Imported goods, like potato, onions, and chillies, are transported and distributed to wholesale and retail markets to reach consumers. Some imported goods are used as raw material for producing another good: for instance, wheat grains are imported by authorised millers and processed, packaged as flour, and transported to wholesalers and retailers for use in bakery products and household consumption. Edible oils imported in bulk are refined, packed, and labelled before distribution to island-wide wholesale and retail markets. Several imported goods fall into the essential consumer goods category with government involvement for purchasing via the Cooperative Wholesale Establishment (CWE).

Exported goods follow a different path since these products cross the border to reach different consumer groups. Based on the requirements of foreign buyers, processors acquire inputs for the production process, following which raw materials are processed under certain standards and quality certifications obtained; the processors need to satisfy both local and foreign certification requirements. Local authorities will check for compliance with local quality standards to protect the country of origin's reputation, with overlaps sometimes causing unnecessary burdens for the processors. After packing and labelling, the product is transported to the harbour if directly exported through joint ventures or sold through a broker who auctions the product to an exporter. Generally, processing is done for future orders for which there is a forward contract. Tea, coconut and rubber products fall under this category.

As agricultural products go through several points from input acquisition and production to the ultimate consumer in a consumer-oriented process, each point is connected through a buyer-seller interaction where supply and demand interact to form a price. A production process will require input markets for fertiliser, labour, land, planting material, agrochemicals, animal feed, machinery and so on. At the farm gate, the farmer sells his produce to a collector for a price determined at this point. A wholesaler purchases from a collector and sells to a retailer, placing the product in reach of the consumer. Sometimes the wholesaler may sell to a processor or exporter. Consequently, there are input markets, farm-gate markets, wholesale markets, retail markets, and export markets.

Agricultural markets are characterised by high volatility in supply and prices (relative to, for instance, manufactured products). Unlike other products, agricultural goods are an outcome of plants and animals, which are very sensitive to environmental factors, such as climatic conditions, pests and diseases, soil conditions, and management practices. A fundamental driver of volatility is that supply quantities in markets inherently fail to respond in the short term due to perishability, high cost of storage, and long-term processes involved in producing agricultural products (Norwood and Lusk 2008).

While the above characteristics are common to agricultural markets globally, the manner in which each country adjusts to minimise the negative impacts will be different. There is a clear difference evident between developed and developing economies that is directly related to resource capacity, inclusive of the capacity to deploy technology. Technology plays a vital role in adjusting to seasonal impact through, for example, storage facilities, and cultivation in regulated environments. Wealthy economies do not hesitate to invest in these technologies with commercial large-scale farms facilitating mechanisation and cost minimised due to returns to scale. Many developed countries produce a large quantity of output and hold considerable market share in world markets making them capable of influencing the world price through supply and price controls.

On the other hand, developing countries invest insufficiently in agriculture sector technologies due to competing priorities and budget deficits. Comparatively high energy and fuel costs are constraints on providing storage facilities and transportation. Poor handling techniques for agricultural products lead to high wastage as a result of mechanical damages. Simply put, post-harvest losses are quite high in developing countries. Moreover, with scattered, small-scale farming units eliminating the scale effect and constraining mechanisation, these markets are affected by labour shortages, declining labour productivity, lack of cost-efficient irrigation technologies, and high input costs. Many developing countries face difficulties in reaching global value chains due to lack of information, heterogeneity of farm products, lack of entrepreneurial skills, and difficulties in meeting quality standards and maintaining a continuous supply of products.

In Sri Lanka, agricultural markets are mostly characterised by a large number of producers at the farm level and a large number of consumers at the retail level. Such market structures are “perfectly competitive” since supply and demand relationships decide the price. However, markets deviate from this principle for many reasons and imperfections exist. A case in point is the paddy rice market which is characterised by many producers but a few large-scale processors and buyers comprising the middle level of the value chain. These large buyers can dominate negotiations for prices with farmers. Government may intervene in these imperfect markets to ensure a reasonable price for both producers and consumers. In Sri Lanka, the State sets a floor price (minimum price) for paddy and purchases directly from farmers through the Paddy Marketing Board. The State also intervenes at several other points in the paddy rice value chain in Sri Lanka. Where the input market is concerned, fertiliser is subsidised, pesticides controlled for standards and intended health hazards, and the land market controlled under fragmentation and ownership laws. The middle levels of the value chain are controlled through price floors and price ceilings. Exports and

Table 6.1 Mentions of competitiveness in agriculture sector policy and related documents

Agency	Policy document	How competitiveness is cited
Ministry of Agriculture	Mission statement	To achieve globally *competitive* production
	Overarching Agricultural Policy (OAP)—vision & objectives	Globally *competitive* agriculture sector for national prosperity To enhance *competitiveness* of agriculture and agri-businesses (Ministry of Agriculture 2019)
Export Development Board (EDB)	Mission statement	Enable export *competitiveness* through Innovation, Entrepreneurship & Global Integration (Export Development Board 2018)
Tea Research Institute (TRI)	Vision statement	"In order to make Sri Lankan tea the most preferred tea in the world, at a *competitive* price" (Tea Research Institute 2010)
Sugarcane Research Institute (SRI)	Mission statement	Develop and transfer appropriate sugarcane technologies to enhance *competitiveness* of, and to contribute to expand and develop, the local sugarcane industry, in a sustainable manner (Sugarcane Research Institute 2019)

Sources: Ministry of Agriculture (2018, 2019), Export Development Board (2019), Sugarcane Research Institute (2019), Tea Research Institute (2010)

imports are controlled through taxes, labelling, certification, as well as sanitary and phytosanitary conditions.[1]

As shown in Table 6.1, the concept of competitiveness figures frequently in agriculture sector policy documents in Sri Lanka.

6.2 The Concept and Measurement of Competitiveness

Competitiveness in markets is defined using different terms (Latruffe 2010) and evolves over time (Aiginger et al. 2013). Competitiveness, a comparative concept, is generally defined as trying to do as good as or better than others. Policymakers may view competitiveness in social or equity terms. While policymakers may prefer to see perfect competition, firms may build up a certain level of market power through innovations and technology, and this may be acceptable to policymakers to encourage innovations in an industry funded by private profits. Market power acquired through innovations is sometimes considered a competitive advantage in the context of an oligopoly (Aiginger 2006); nevertheless, a low cost of production is considered misleading in measuring competitiveness when it takes wages as the main input, omitting the importance of other inputs such as capital, energy, and taxes (Aiginger and Firago 2015; Krugman 1994). Therefore, in some literature, productivity is considered as the meaningful measure of competitiveness (Aiginger and Firago

[1]Different interventions are discussed in detail through Chaps. 6 and 12.

Table 6.2 Definitions for competitiveness

Source	Definition
Global Competitiveness Report, 2019	"By competitiveness, we mean the attributes and qualities of an economy that allow for a more efficient use of factors of production. The concept is anchored in growth accounting theory, which measures growth as the sum of growth in the factors of production—that is, labour and capital—and of total factor productivity (TFP), which measures factors that cannot be explained by labour, capital or other inputs. The Global Competitiveness Index (GCI) measures what drives TFP." (World Economic Forum 2019)
The Organisation for Economic Co-operation and Development (OECD)	[the] "ability of companies, industries, regions, nations, and supranational regions to generate, while being and remaining exposed to international competition, relatively high factor income and factor employment levels on a sustainable basis." (1996)
The European Commission—European Research Area	"Ability of a country (region, location) to deliver the beyond-GDP goals for its citizens today and tomorrow." (Aiginger et al. 2013)
The European Commission	"The ability of an economy to provide its population with high and rising standards of living and high rates of employment on a sustainable basis." (2011)
Porter (1990)	"The only meaningful concept of competitiveness at the national level is national productivity."

Sources: World Economic Forum (2019), The Organisation for Economic Co-operation and Development (1996), European Commission (2011), Aiginger et al. (2013), Porter (1990), Latruffe (2010)

2015; Aiginger et al. 2013; Kohler 2006; Porter 1990). Total Factor Productivity (TFP)[2] is the main measure in global competitiveness analysis where Sri Lanka is placed 84th among 144 countries (World Economic Forum 2019). Table 6.2 shows some definitions for competitiveness which has macroeconomic implications.

While neo-classical economics measures competition as the success of a country or a product in international trade, it can also be seen in terms of the strategies and structures utilised by firms in gaining more profits, including efficiency and productivity concepts. Since there is no exact definition and measure for competitiveness, generally, a combination of those measures is used to analyse competitiveness (Latruffe 2010).

The competitiveness of the agriculture sector can be evaluated at three levels. At the global level, this relates to whether a country's product can compete or perform better than the other exporters in catering to consumer preferences. How competitive is Sri Lankan tea compared to other tea producers? At the border level, competitiveness may be about how much protection is given to local market participants—

[2]TFP has many dimensions, with 12 aspects used to form a composite index.

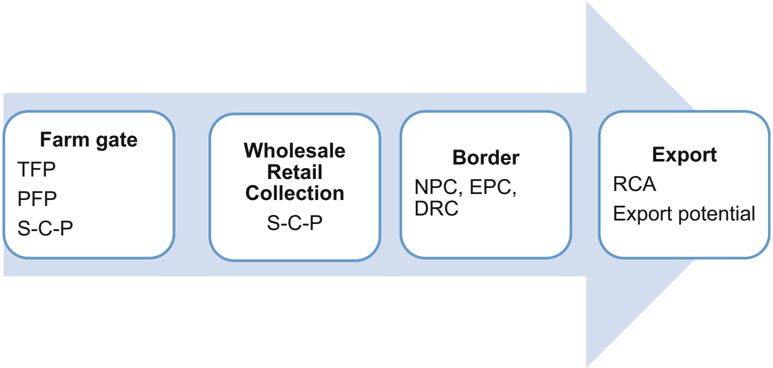

Fig. 6.2 Measuring competitiveness along the value chain

producers and consumers. At the market level, it may be about the competitiveness of different value chain actors at retail, wholesale, collector, farm gate, and input market levels.

Different indices have been developed to measure the competitiveness at each of the above levels (see Fig. 6.2). Global competitiveness or export competitiveness is widely assessed with measures such as the Relative Comparative Advantage (RCA), Relative Import Advantage (RMA), Relative Trade Advantage (RTA), Revealed Competitiveness (RC), Extensive and Intensive margins (EM, IM), export shares, growth rates, and export potential. These measure success in international trade. At the border level, where government policy can have direct impacts, competitiveness may be analysed using a model such as the Policy Analysis Matrix (PAM) which estimates indicators such as private profitability, Nominal Protection Coefficient (NPC), Effective Protection Coefficient (EPC), and Domestic Resource Cost (DRC). At the industry level, competitiveness can be gauged by Structure-Conduct-Performance (S-C-P) models. In this framework, retail, wholesale, and collector concentration ratios and market power indices are used to analyse the structure of the market. Further, some theory and concepts of industrial and new industrial organisation are used to understand the strategic behaviour of markets. Farm-level efficiencies are measured using total factor productivity and Partial Factor Productivities (PFP) of inputs such as land, labour, water, fertiliser, and capital.

6.3 Global-Export Competitiveness Indicators: Export Potential, Diversification

Competitiveness can be measured at global, regional, country, and sectoral levels, as well as value chain or product levels. A product-level analysis shows more specific information compared to aggregate measurements for sectoral policy decisions. This section discusses indicators that assess the success of international trade.

6.3.1 Concepts

Competitiveness in the export market is basically illustrated by the comparative advantage theory. Countries are successful in international trade for goods in which they have comparative advantage. If a country is capable of producing a commodity at a lower cost than another country, the former has an *absolute advantage* over the other. Consider two countries: they will choose to produce goods for which they have the highest return, export the excess, and import goods for which they are comparatively inefficient. Sometimes, part of the requirement is produced and the rest is imported. This is referred to as interdependence. Product diversification, market diversification, market penetration, and strategic behaviours are also important in gaining competitiveness in trade.

6.3.2 Measures

There are a number of indicators to measure the export competitiveness of commodities. Revealed Comparative Advantage (RCA) is the most widely used index. Others include growth rate, export shares, export diversification index, export concentration or the Hirschman-Herfindahl Index (HHI), trade intensity index, export specialisation index, trade complementarity index, export potential, and export dynamics. It should be noted that a single index does not provide all of the information required to measure competitiveness: each indicator measures a component of competitiveness. Therefore, a combination of indicators is used to construct a more complete picture (see Table 6.3 for a breakdown of the advantages and disadvantages of indices).

6.3.3 Numerical Examples

Table 6.4 provides the raw data collected (approximated and hypothetical values for 2017) to analyse the competitiveness of Sri Lankan tea in the export market.

First, we begin with the simplest indicators.

Table 6.3 Advantages and disadvantages of indices measuring export competitiveness

Index	Advantages	Disadvantages
Export shares	• Easy to measure • Measures the relative importance of a sector	• Does not give specific information on industry structure, comparative advantage, and diversification • Comparisons can be misleading
Growth rate	• Easy to measure • Shows the trend of market growth over the time • Helps to identify dynamic sectors • Comparisons across countries are useful for trade decisions	• Does not measure the significance, diversification, and comparative advantage of an industry • Sources of growth are not explained • Long-term evaluations are complex with the changes in measurement and methods • Need to be careful in using nominal figures since exchange rate moves
Revealed Comparative Advantage (RCA)	• Easy to measure • Avoids double counting in export shares • Comparative advantage is measured	• Does not provide specific information on industry size of a product and limits comparisons • Product diversification is not measured This is sometimes considered as a specialisation index rather than a competitiveness measure (Fischer and Schornberg 2007). Used together with RMA, RTA, and RC
Hirschman-Herfindahl Index (HHI)	• Easy to measure • Product diversification is measured	• Comparative advantage of the industry and economic significance in trade are not measured
Trade Intensity Index	• Easy to measure • Important in analysing bilateral trade agreements	• Does not measure the comparative advantage or significance of a specific product in the world market
Trade Complementarity Index	• Easy to measure • Significance of a potential destination can be identified	• Specific information on comparative advantage, trends, and diversification are not measured
Index of Export Market Penetration	• Easy to measure • Market diversification is measured	• Does not provide information on market shares of each country, comparative advantage, and product diversification
Hummels-Klenow (products) intensive margin	• Easy to measure when data is available • Significance of a country in world trade is measured	• Specific information on comparative advantage and diversification are not provided

(continued)

Table 6.3 (continued)

Index	Advantages	Disadvantages
Hummels-Klenow (products) extensive margin	• Easy to measure when data is available • Significance of a country's export products range in the world export market is measured	• Specific product information is not provided
Export Specialisation Index	• Easy to measure • Measures the competitiveness of a product relative to another market	• Product diversification, trends, and industry structure are not measured
Relative industry size	• Easy to measure • Significance of a specific product in the world market for that product is measured	• Economic significance, trends, and diversification are not covered

Sources: Del Rosal (2019), Fetscherin et al. (2010), Latruffe (2010), World Bank (2010), Mikic & Gilbert (2007)

6.3.3.1 Export Shares

Several export shares are used to show the economic significance of a certain product or industry in its domestic and world economy.

- *Country's share of world exports*: This is a measure of a country's significance in the world export market. The export value of a country with respect to the export value of the world is measured.
- *Share of product in total exports*: This is the total export sales value of each product with respect to the total export sales value of the country. It indicates the significance of a particular product in the country's export economy.
- *Share of market in total exports*: This is the value of the quantity of exports sold in each foreign country with respect to the total export value of the exporting country.

Values range from 0 to 100. The higher the value, the higher the importance of the product in the export market.

Calculations

- Country's share of world exports for tea

$$S_i = \frac{1500}{6000} = 0.25 \tag{6.1}$$

Table 6.4 Trade data of Sri Lankan tea industry in a given year

	Export value of tea from SL (USD mln)	Export value of all goods (USD mln)	Export value of tea in the world market (USD mln)
World	1500	15,000,000	6000
Sri Lanka		12,000	
Turkey	200		
Russia	150		
Iran	100		
Green tea small packs	45		
Green tea large packs	5		
Black tea small packs	650		
Black tea large packs	800		
2013 total tea exports	1500		
2014 total tea exports	1,600		
2015 total tea exports	1300		
2016 total tea exports	1250		
2017 total tea exports	1500		
Total import value of country	**Import value of tea (US$ mln)**	**Import value of all goods (US$ mln)**	**Import value of tea in the world market (US$ mln)**
World		15,500,000	5500
Sri Lanka	20	20,000	
Iran	300	50,000	

Source: UN Comtrade Database (2019)

- Share of product in total exports

$$S_{\text{tea}} = \frac{1500}{12,000} = 0.125 \tag{6.2}$$

- Share of market in total exports

$$S_{\text{Turkey}} = \frac{200}{1500} = 0.13 \tag{6.3}$$

Export value of tea—Sri Lanka	Value in Turkey	Value in Russia	Value in Iran
1500	200	150	100
Export share	0.13	0.10	0.06

Interpretation

Sri Lanka holds 25 per cent of the world tea market. Tea contributes to nearly 12.5 per cent of Sri Lanka's export income. Nearly 13 per cent, 10 per cent, and 6 per cent, respectively, of Sri Lankan tea is exported to Turkey, Russia, and Iran.

6.3.3.2 Growth Rate

The growth rate of a product's exports indicates how competitive the product is in the export market. The values that result from this computation range from -100 to $+\infty$. Values greater than zero indicate that, for the period under consideration, competitiveness is increasing over time: the said product is becoming more competitive. Values of zero indicate that the growth of exports is stagnating: the product is maintaining its competitiveness. Values less than zero indicate that it is decreasing: the product is becoming less competitive. The Compound Annual Growth Rate (CAGR) is used to calculate the growth rate of an industry or a product.

$$G_i = \left[\left[\frac{\sum_{sw} X'_{sw}}{\sum_{sw} X^0_{sw}}\right]^{\frac{1}{n}} - 1\right] \times 100 \tag{6.4}$$

where G_i is the compound growth rate, s is the set of countries in the source, w is the set of countries in the world, X^0 is the bilateral total export flow in the start period, X^1 is the bilateral total export flow in the end period, n is the number of periods (not including the start).

Calculation

Assume that the export value of tea for a period of time is given. Then the average growth rate during the last 5 years can be calculated as shown below.

Year	2013	2014	2015	2016	2017
Export value (US$ million)	1500	1600	1300	1250	1600

$$G_i = \left[\left[\frac{1600}{1500}\right]^{\frac{1}{4}} - 1\right] \times 100 \qquad = (1.02 - 1) * 100 = 2$$

6.3.3.3 Revealed Comparative Advantage (RCA)

RCA is a widely used index for measuring the competitiveness of internationally tradable goods. This method was initially developed by Balassa (1965a) and is known as the Balassa Index. The export value of a particular good of a country, relative to the country's total export value, is the numerator. The denominator is the export value of the particular product in the world market, divided by the value of all the export products in the world export market.

$$\mathrm{RCA}_{ij} = \frac{\left(X_{ij}/X_{ik}\right)}{\left(X_{nj}/X_{nk}\right)} \tag{6.5}$$

where X is the value of exports, "i" is a country, "j" is a product, k is all the products other than product "j", and "n" is all the countries other than country "i"; where X_{ij} is the export value of product j from country i, X_{ik} is the export value of other products by country i, X_{nj} is the export value of product j by all the other countries, X_{nk} is the export value of other products by all the other countries.

The above index was further improved by Vollrath (1991) to avoid double counting (Latruffe 2010). Therefore, the total export value of country "i" (X_{ik}) excludes product "j"; the world export value of product "j" (X_{nj}) excludes country "i"; and the total value of world exports (X_{nk}) excludes product "j". Considering that the above values are export figures, Vollrath's (1991) improved index is called the Relative Export Advantage (RXA).

$$\mathrm{RCA}_{ij} = \mathrm{RXA}_{ij} \tag{6.6}$$

If the RCA is greater than 1, that product is said to be competitive or has a revealed comparative advantage. If it is less than 1, the product is said to be non-competitive. Value 1 is considered as the breakeven and may take any value up to infinity.

Calculation

Below, the RCA is used to find out whether Sri Lankan tea has a comparative advantage in the export market. Given below are the values for 2017.

Values	Sri Lanka	World
Export value of tea US$ million	1500	6000
Total exports—all products US $ million	12,000	15,000,000
X_{ij}	1500	
X_{ik}	(12,000 − 1500)	
X_{nj}		(6000 − 1500)
X_{nk}		(15,000,000 − 6000 −(12,000 − 1500))

$$\mathrm{RCA}_{ij} = \frac{\left(X_{ij}/X_{ik}\right)}{\left(X_{nj}/X_{nk}\right)} = \mathrm{RXA}_{ij}$$

$$\mathrm{RCA}_{ij} = \frac{(0.14)}{(0.0003)} = 475.66$$

Interpretation

The RCA is greater than unity for tea in 2017. Therefore, the composite category "tea" shows a comparative advantage.

6.3.3.4 Relative Import Advantage (RMA)

Similarly, the Relative Import Advantage (RMA) is measured using import values. If the value of the index is less than one, the comparative advantage is revealed or the competitiveness is high.

$$\mathrm{RMA}_{ij} = \frac{\left(M_{ij}|M_{ik}\right)}{\left(M_{ni}|M_{nk}\right)} \tag{6.7}$$

where M_{ij} is import value of product j from country i, M_{ik} is import value of other products by country i, M_{nj} is import value of product j by all the other countries, M_{nk} is import value of other products by all the other countries.

Calculation

Values	Sri Lanka	World
Import value of tea	20	5,500
Total imports—all products	20,000	15,500,000
M_{ij}	20	
M_{ik}	(20,000 − 20)	
M_{nj}		(5,500 −20)
M_{nk}		(15,500,000 − 20,000 − (5500 − 20))

$$\mathrm{RMA}_{ij} = \frac{\left(M_{ij}/M_{ik}\right)}{\left(M_{nj}/M_{nk}\right)} = \frac{(0.0010)}{(0.0004)} = 2.83$$

Interpretation

This value is greater than 1, indicating a comparative disadvantage in imports.

6.3.3.5 Revealed Trade Advantage (RTA)

The difference between RCA and RMA is called the Revealed Trade Advantage (RTA). A value greater than 1 indicates a revealed comparative advantage.

$$\mathrm{RTA}_{ij} = \mathrm{RXA}_{ij} - \mathrm{RMA}_{ij} \tag{6.8}$$

Calculation

$$\mathrm{RTA}_{ij} = 475.67 - 2.83 = 472.84$$

Interpretation

This value is greater than 1, indicating revealed comparative advantage.

6.3.3.6 Revealed Competitiveness (RC)

The difference between the logarithmic forms of RXA_{ij} and RMA_{ij} gives RC_{ij} which is called revealed competitiveness.

$$\mathrm{RC}_{ij} = \log \mathrm{RXA}_{ij} - \log \mathrm{RMA}_{ij} \tag{6.9}$$

Calculation

$$\mathrm{RC}_{ij} = \log 475.67 - \log 2.83$$

$$\mathrm{RC}_{ij} = (2.67 - 0.45) = 2.23$$

Interpretation

A value above 1 indicates a competitive advantage.

6.3.3.7 Hirschman-Herfindahl Index (HHI)

This index shows the degree of export diversification. It is the sum of the squared value of each product's export share. The export share of each product is the value of export of each product, divided by the total export value of a country during the given period (Del Rosal 2019).

$$H_i = \sum_{j=1}^{N} \left(\frac{X_{ij}}{X_i} \right)^2 \tag{6.10}$$

where X_{ij} is export value of jth product of country, i, X_i is total export value of country, i, j is export products, N is number of export products.

The value can range from 0 to 1. A value of zero means perfect diversification, and one means no diversification. This index can be used to determine the export diversification of each product sector instead of by country.

Calculation

Type of product	Trade value (X_{ij})	$\frac{X_{ij}}{X_i}$	$\left(\frac{X_{ij}}{X_i}\right)^2$
Green tea small packs	45	0.0038	0.000014
Green tea large packs	5	0.0004	0.00000016
Black tea small packs	650	0.0541	0.003

(continued)

Black tea large packs	800	0.0666	0.004
Total export value of country(X_i)	12,000		

$$H_i = 0.007$$

Interpretation

The value of zero is considered to be perfect diversification. The estimated value is 0.007 which is nearly perfect diversification.

6.3.3.8 Index of Export Market Penetration

This index is a measure of a country's export relationships. The number of countries to which the product is exported is divided by the number of countries in the world importing that product. The value ranges from 0 to 1. If the markets are fully penetrated, the value is one. If it is less than one, there are more potential markets in the world. This calculation is useful in identifying the existence of potential markets.

$$\mathrm{MP} = \frac{n_{ij}}{m_{wj}} \tag{6.11}$$

where n_{ij} is number of countries to which product j is exported by country i, m_{wj} is number of countries in the world who import product j.

Calculation

Suppose Sri Lanka has exported tea for 92 countries in 2017. The number of countries in the world that imported tea is 98 in 2017.

$$\mathrm{MP} = \frac{92}{98} = 0.938$$

Interpretation

A value closer to 1 indicates near-perfect market penetration.

6.3.3.9 Relative Industry Size

In graphical analyses, the total market value is shown by the area of a circle, and shares are drawn as sub-circles considering their relative size or weight (Fetscherin et al. 2010). The following calculation is for the tea industry.

$$w = \frac{X_{ij}}{X_{wj}} \tag{6.12}$$

where X_{ij} is the export value of tea from Sri Lanka, X_{wj} is the export value of tea in the world market.

Calculation

$$w = \frac{1500}{6000} = 0.25$$

Interpretation

The value shows that Sri Lanka possesses a 25 per cent share of the world tea market.

6.3.3.10 Export Specialisation Index

This modification to the RCA is measured as the ratio of a product's export share in a country to the product's import share in the import market.

$$\mathrm{ES} = \frac{(X_{ij}/X_{it})}{(m_{kj}/m_{kt})} \tag{6.13}$$

where X_{ij} is export value of product j in country i, X_{it} is total export value of country i, m_{kj} is import values of product j in market k, m_{kt}
is total import value of market k.

Similar to RCA, a value greater than one shows export specialisation, while less than one shows a comparative disadvantage.

Calculation

$$\mathrm{ES} = \frac{(X_{ij}/X_{it})}{(m_{kj}/m_{kt})} = \frac{(1500/12,000)}{(5500/15,500,000)} = \frac{0.125}{0.00035} = 352.27$$

Interpretation

The ES value is greater than one, indicating a comparative advantage for tea in the world market in 2017.

6.3.3.11 Trade Complementarity Index

Trade complementarity index is useful in intraregional trade arrangements. It shows the possibility of occurring trade between two countries. The difference between the export significance of the product in the exporting country and the import significance of the concerned product in the possible importing country is measured. It can be shown as below.

$$\mathrm{TC}_{ij} = 100\left(1 - \mathrm{sum}\left(\left|m_{ik} - X_{ij}\right|/2\right)\right) \tag{6.14}$$

where X_{ij} is share of good i in country j's world exports, m_{ik} is share of good i in country k's all imports.

A zero value for the index means no trade between the countries, and 100 means exports and imports are equal.

Calculation

TC for Iran is calculated below.

$$\mathrm{TC}_{ij} = 100\left(1 - \mathrm{sum}\left(\left|m_{ik} - X_{ij}\right|/2\right)\right) = 100(1 - |0.006 - 0.125|/2) = 102$$

Iran total imports all goods	50,000
Tea imports from world by Iran	300

Interpretation

A value equal to 100 shows imports and exports are equal between the countries. A value of 102 shows a favourable condition for Sri Lanka in bilateral trade.

6.3.3.12 Trade Intensity Index

This index is used to determine the direction of expected trade between two countries based on their importance in world trade. It is the ratio of the export share of a particular product in a country to a partner country, to the export share of the concerned product in the world.

$$\mathrm{T}_{ij} = \frac{\left(\mathrm{X}_{ij}/\mathrm{X}_{it}\right)}{\left(\mathrm{X}_{wj}/\mathrm{X}_{wt}\right)} \tag{6.15}$$

where X_{ij} is country *i*'s exports to country *j*, X_{it} is country *i*'s total export value, X_{wj} is world export to country *j*, X_{wt} is world total export value.

If T is greater than one, the bilateral flow would be larger than the expected value. If it is less than one, the trade flow would be smaller to the country *j*.

For example, assume that country *i* is Sri Lanka and country *j* is Iran. Sri Lanka exports goods worth of 1000 USD million to Iran while world (all the countries) exports 15,000 USD million worth of goods and services.

Calculation

$$\mathrm{T}_{ij} = \frac{(1000/12,000)}{(15,000/15,000,000)} = \frac{0.083}{0.001} = 83$$

Interpretation

The value is greater than one, indicating a positive trade flow for country *i* through bilateral trade.

6.3.3.13 Hummels-Klenow (Products) Intensive Margin

This is a measure of export share in the world market which considers products exported by the country concerned. The value of exports by the exporting country is divided by the total value of those products in the world export market.

$$\mathrm{IM}_i = \frac{\sum_j X^i{}_{j \in k^i}}{\sum_j X^w{}_{j \in k^i}} \tag{6.16}$$

where X_{ij} is the sum of value of products exported by country i, X_{wj} is world value of products exported by country i.

Calculation

$$\mathrm{IM}_i = \frac{12,000}{5,000,000} = 0.0024$$

Interpretation
The value is closer to zero, indicating Sri Lanka's insignificance in world trade.

6.3.3.14 Hummels-Klenow (Products) Extensive Margin

This index is different from the intensive margin since it considers the total value of all goods in the export market as the denominator; the numerator is the total value of products exported by country i in the world market. It measures the significance of country i's product range k^i in world exports.

$$\mathrm{EM}_i = \frac{\sum_j X^w{}_{j \in k^i}}{\sum_j X^w_j} \tag{6.17}$$

where $X^w{}_{j \in k^i}$ is world value of products exported by country i, X^w_j is the value of all the products in the world market.

Calculation

$$\mathrm{EM}_i = \frac{5,000,000}{15,000,000} = 0.33$$

Interpretation
The value indicates that nearly 33 per cent of world trade is in categories of goods Sri Lanka exports. Sri Lanka is not involved in trade of the remaining 67 per cent of goods.

6.3.3.15 Other User-Friendly Applications and Tools

These indices can be computed using https://wits.worldbank.org. Further, export potential can be examined and analyses obtained using www.intracen.org.

Suppose that one needs to analyse the export competitiveness of the desiccated coconut industry in Sri Lanka. The following account draws upon www.intracen.org to analyse the industry's export potential, export diversification, and market penetration.

Export Potential and Market Diversification

Figure 6.3 shows the potential export markets for Sri Lankan desiccated coconut (HS Code 08011100). The major potential destinations are the USA, the UK, and the Netherlands, respectively. The closest export destination India has comparatively a very small export potential.

Figure 6.4 shows the actual potential existing in each country for Sri Lankan desiccated coconut. The highest potential gap is for the UK at USD 8.5 mln.

Competing producers, their potential for further expansion, and Sri Lanka's position are depicted in Fig. 6.5. Sri Lanka is the third-largest producer, using only 48.7 per cent of its potential markets.

The market access map in Fig. 6.6 shows the potential for market diversification.

This section demonstrated the user-friendly sources available for quick analyses in export competitiveness. Using these tools, it is possible to visualise a country's place in world markets, its competitors, potential export destinations, etc. Consequently, such analyses may provide guidance for policy decisions. For example, the above analyses for desiccated coconut show that export promotion authorities should look at tapping into unexplored growing markets, like the USA, address barriers, and provide the required technical and other trade facilitation requirements to capture those markets.

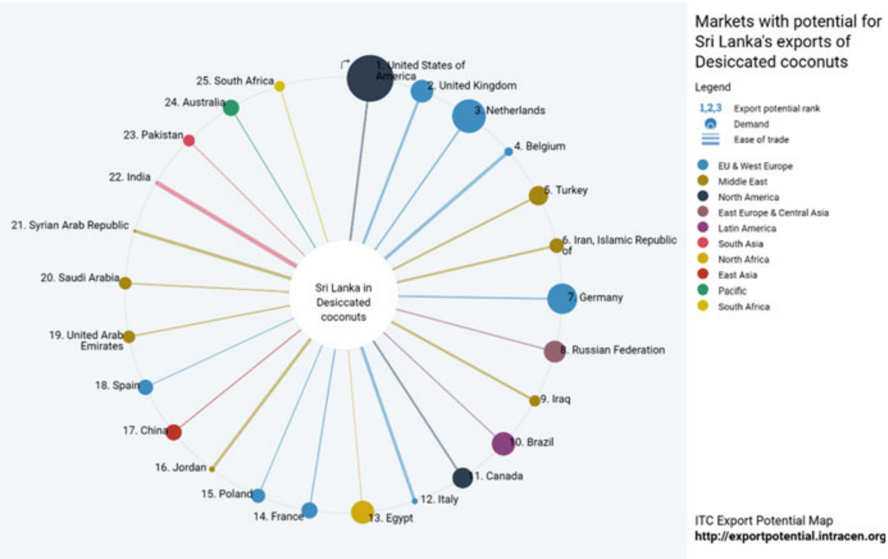

Fig. 6.3 Potential export markets for Sri Lankan Desiccated coconut. Source: International Trade Centre (2019)

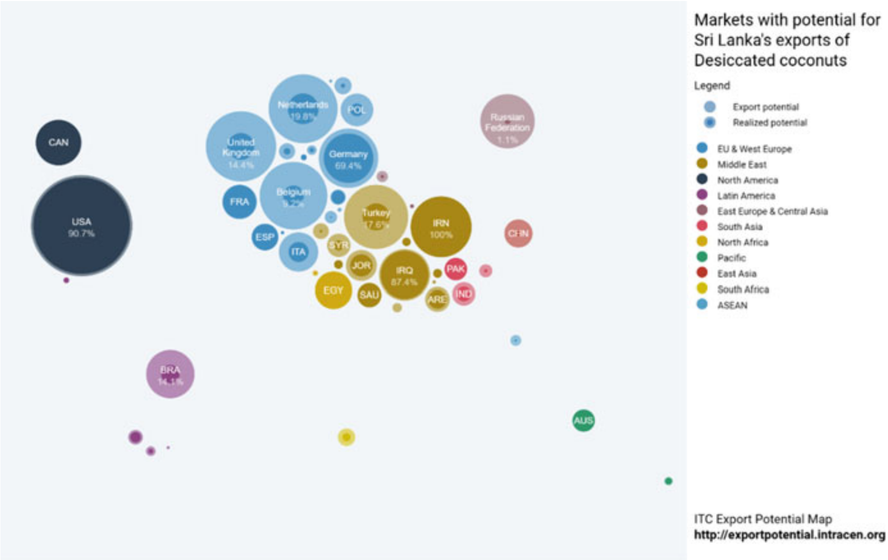

Fig. 6.4 Markets showing potential gap to penetrate. Source: International Trade Centre (2019)

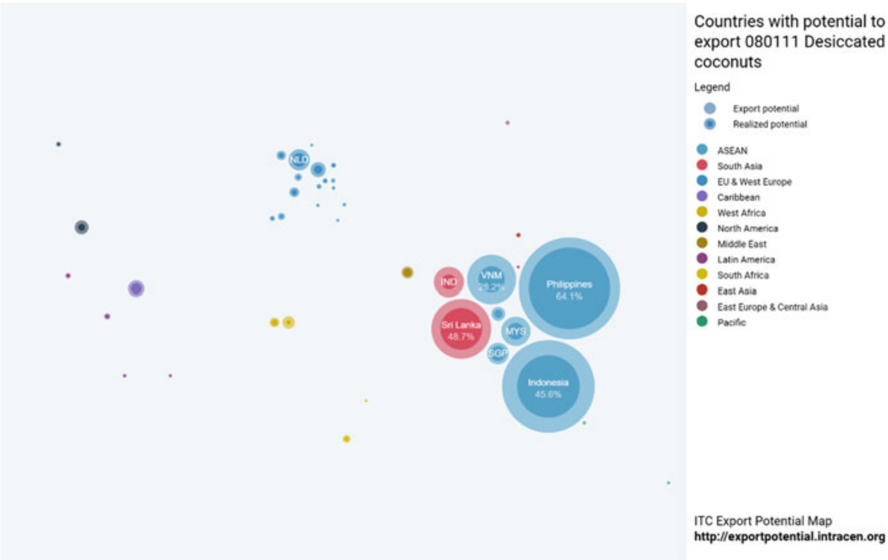

Fig. 6.5 Major players and their potential for expansion. Source: International Trade Centre (2019)

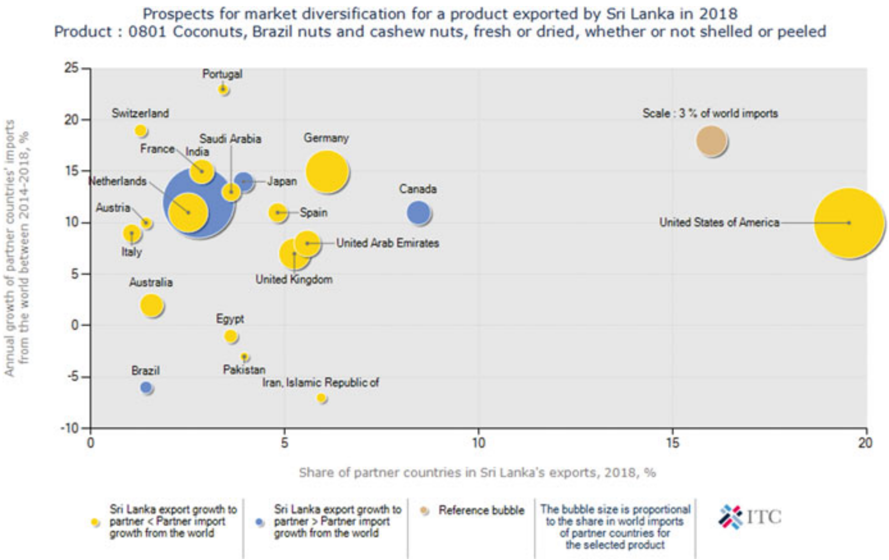

Fig. 6.6 Potential for market diversification

6.4 Measuring Competitiveness at the Border: The Policy Analysis Matrix

Measuring competitiveness at the border level helps to identify different kinds of price distortions in domestic agricultural markets. These distortions are government interventions including incentives (such as export and cultivation subsidies) and trade protection measures (such as import tariffs and bans). Similarly, there are disincentives (such as export taxes and income taxes). To discover the actual competitiveness of domestic products with respect to the other countries, estimates of production costs after making corrections for the distortions are important. At the initial stage, distortions can be measured through indicators. However, distortions in foreign markets cannot be taken into account when comparing efficiencies using cost of production. Therefore, the validity of cost of production as a measure of comparing efficiency has been called into question.

6.4.1 Concepts

Similar to any other policy instrument, agricultural pricing policies are used to address efficiency or equity issues in agricultural markets. In relation to equity objectives, there is a trade-off with efficiency. As mentioned above, any such policy which encourages or discourages agricultural activities is a price distortion. Sometimes measuring distortions is followed by further impact analysis studies using partial equilibrium and general equilibrium techniques. This section demonstrates how to quantify price distortions of agricultural markets using indicators.

6.4.2 Measures

The most commonly used indicators in measuring the impact of pricing policies are Effective Protection Coefficient (EPC) and Domestic Resource Cost (DRC), each possessing advantages and disadvantages based on the analytical requirement. The difficulties encountered in measuring these individual indicators were addressed by an alternative approach called the Policy Analysis Matrix (PAM), initially developed by Pearson et al. (1981). Thereafter the method was further developed, incorporating the DRC approach (Monke and Pearson 1989). The basis of the PAM is cost and revenue data and a set of profit and loss identities that are found in any business activity. The PAM is used to calculate NPC, EPC, and DRC.

Policy Analysis Matrix (PAM)
The PAM represents a convenient method to calculate policy impacts, competitiveness, and comparative advantage as measures of economic efficiency. This framework is particularly useful to identify the appropriate direction of change in policy (Gonzales et al. 1993).

The advantages of the PAM are that it allows varying levels of disaggregation; makes the analysis of policy-induced transfers straightforward; and makes it possible to identify the net effect of a set of complex and contradictory policies and sort out the individual effects of those policies. The uses of PAM are to suffer from several weaknesses, primarily the assumption of fixed input-output coefficients, though the possibility of introducing supply response parameters is also discussed under this approach (Monke and Pearson 1989; Nelson and Panggabean 1991). Production data used in the PAM is characterised by a series of techniques, each of which has fixed input-output coefficients and represents some share of the total production.

The PAM approach can be used to:

- Investigate the impact of policy on competitiveness and profitability
- Identify current policies affecting crop and input prices and how profits change as policies are altered
- Examine the influence of an investment policy on economic efficiency and comparative advantage
- Understand comparative advantage in the commodity or country and the extent to which new investment might change the current pattern of efficiency
- Study the effects of agricultural research policy on changing technologies

PAM results are useful in identifying proper use of economic analyses to determine research needs effectively to improve social profits (Monke and Pearson 1989; Nelson and Panggabean 1991).

Table 6.5 Framework of a policy analysis matrix

Description	Revenues	Costs		Profit
		tradable inputs	Domestic factors	
Private prices	A	B	C	D
Social prices	E	F	G	H
Divergences/policy transfers	I	J	K	L

Source: Monke and Pearson (1989)

The PAM uses a double-accounting technique that begins with a summary of budgetary information of all the activities of a farm (Kanaka and Chinnadurai 2015). It allows examination of the impact of a policy by constructing two enterprise budgets, one valued in market (or private) prices and the other valued in social prices. The effects of policies and market failures (distortions) are captured in the budget valued in market prices. Social prices are devoid of distortions: thus, that the budget valued in social prices do not have distortions. The impact of policy is then captured as the difference between the budget in private and the budget in social prices.

The first step in the process is to build the enterprise budget in private prices. This enterprise budget is built from the actual cost and revenue data for the commodity, taking account of the level (farm, wholesale market, processing plant, etc.) of the analysis. The second step is to recalculate the enterprise budget that is in private prices into one valued in social prices. This is intended to eliminate distortions, such as taxes and other transfer payments. Once these two enterprise budgets (one in private prices and one in social prices) are constructed, the data is summarised and transferred to the PAM.

The PAM itself is a matrix consisting of columns and rows—four columns and three rows, in its simplest structure (refer to Table 6.5). This structure allows two accounting identities to be easily laid out and therefore the profits and divergences to be easily calculated.

As shown in Table 6.5, the first column of the PAM records data on revenue. The value of revenue is the quantity of the output times the price. The next two columns separate the cost items into tradeable and non-tradeable (domestic cost) components. Thus, in constructing the enterprise budgets for the PAM, intermediate inputs such as seeds, fertilizers, pesticides, and transportation should be separated into tradeable and non-tradeable components and valued. The final column is calculated as a result of the identity: Profit = Total Revenue − Total Cost. Thus, the first row, which is valued in private prices, shows that revenue (A) less costs of tradable inputs (B) less costs of domestic factors (C) is equal to profit (D). The second row shows similar information but valued in social prices, i.e. E-F-G = H.

The two accounting identities in the PAM are found in the final column and final row of the matrix. The final column of the PAM measures profitability as the difference between revenues and costs, i.e. Profit = revenues − costs. The final row measures distortion (or divergence) in revenues, costs, and profits as the difference between these values at market prices and at social prices. Thus, in each column in the matrix any divergence between the observed private (actual market) price and the estimated social (efficiency) price must be explained by the effects of policy or by the existence of market failures. This critical relationship follows directly from the definition of social prices (Monke and Pearson 1989).

We can see from Table 6.5, that the PAM provides a visually appealing way of capturing and presenting the data on divergences and the profits. These profits and divergences can be labelled as follows:

Private profit (D)	=A-B-C	Social Profit (H)	=E-F-G
Output Transfers (I)	=A-E	Input Transfers (J)	=B-F
Factor Transfers (K)	=C-G	Net Transfers (L)	=D-H, this also equals I-J-K

How to Use PAM to Estimate NPC, EPC, and DRC

Price distortions due to interventions on prices, market structure, trade, fiscal, and monetary policy and exchange rates give inappropriate price signals to producers and consumers. Therefore, one of the important objectives of economic adjustment is the elimination of economic inefficiencies resulting from price distortion. Also, policy-induced distortions can provide protection or support to a commodity in international trade. Policy work therefore can benefit from an assessment of the extent of distortions in commodity systems. One benefit of the PAM is that it makes calculation of measures of distortion or protection relatively easy. For example:

- Nominal protection coefficient (NPC) for tradable outputs (NPCO) = A/E
- Nominal protection coefficient (NPC) for tradable inputs (NPCI) = B/F
- Effective protection coefficient (EPC) = (A − B)/(E − F)
- Domestic resource cost ratio (DRC) = G/(E − F)

6.4.2.1 Nominal Protection Coefficient (NPC)

Protection can easily be measured using the price gaps. The nominal protection coefficient is defined as the percentage ratio between the domestic distorted price and the counterfactual (undistorted) price or the ratio between the local prices to the price of the border. The undistorted price in a small country is calculated by adjusting the border price for undistorted transport and marketing costs to the point (e.g. wholesale market or farmgate) at which the comparison will be made. A common currency is used to measure the prices with a suitable exchange rate. Instead of NPC, economists often use the equivalent definition of Nominal Protection Rates (NPR) defined as NPC – 1 (Sadoulet and Janvry 1995; Scandizzo 1989). The NPC concept dates back at least to Book IV of Wealth of Nations in which Adam Smith assessed the effects of England's Corn Laws by comparing the domestic price of wheat with import costs.

Nominal Protection Coefficient has interpreted the following Mahjob (2000, p. 56):

(a) NPC > 1: The producer prices are greater than border prices in the sense that local producers receive higher prices. This type of protection is called positive protection. In this case, consumers have to pay a higher price.
(b) NPC $= 1$: The protection is neutral. This means that producers and consumers face domestic prices equal to the prices that they face from the border without government intervention.
(c) NPC < 1: The support prices are less than border prices. The protection of the product is negative; there is inhibition against the producer and a preference for the consumer.

6.4.2.2 Effective Protection Coefficient (EPC)

The oldest measure to aggregate the effects of both product and input market policies is the EPC, which was introduced by Barber (1955) and has been widely used since the mid-1960s. The concept of Effective Rate of Protection has been defined by Balassa (1965b) as "under the usual assumptions of international immobility of labour and capital, the effective rate of duty will indicate the degree of protection of the value added in the manufacturing process" (p. 576). In other words, the effective rate of tariff establishes a relationship between the tariff and the domestic value added. Such a tariff rate can be a true measure of the actual rate of protection that the nominal tariff affords to the domestic import-competing industries. As per Corden (1966), "The effective protective rate is the percentage increase in value added per unit in an economic activity which is made possible by the tariff structure relative to the situation in the absence of tariff but with the same exchange rate" (p. 222).

An EPC greater than one would indicate positive incentive effects of a commodity policy (an export subsidy to producers), but an EPC less than one shows negative incentive effects (a tax on producers). Both the EPC and the NPC ignore the effects of transfers in the factor market and, therefore, do not reflect the full extent of incentives to farmers.

6.4.2.3 Domestic Resource Cost (DRC)

DRC is widely used in policy analysis and advice. It identifies efficient and inefficient production and suggests where policies should be targeted and in which areas productivity should be improved. The DRC approach was developed by Michael Bruno in the 1960s. It compares the domestic social costs of export production to foreign exchange earned; DRC analysis measures the economic resource costs of production based on social prices, that is, the prices of goods that reflect the true economic value devoid of price distortions from taxes, subsidies, price controls, import tariffs, or other government policies. Gorton and Davidova (2001) stated that the DRC compares the opportunity costs of domestic production to the value-added it generates. DRC is the most useful indicator in comparison with NPC and EPC. It is used to compare the relative efficiency or comparative advantage between agricultural commodities. The DRC indicates whether the use of domestic factors is socially profitable (DRC < 1) or not (DRC > 1).

Domestic production is considered to be efficient and competitive when compared with other countries when DRC is less than unity. In other words, the opportunity cost of using domestic resources is less than the loss incurred through importing the commodity. Therefore, import substitution is a foreign exchange saving for the country for these commodities and gains are high from exports. This indicates that the product has a comparative advantage. Values less than one would mean that the denominator (value-added measured at world prices) exceeded the numerator (the cost of the domestic resources measured at their shadow prices). The opposite is true when the DRC is larger than 1. The balanced case is when DRC equals 1.

6.4.3 Numerical Examples

Suppose you have to analyse the impact of pricing policies or government intervention on rice production in Sri Lanka. Table 6.6 shows the raw data received for the analysis.

First, we need to derive the PAM.

6.4.3.1 Policy Analysis Matrix (PAM)

Calculation

We need to calculate the social prices/shadow prices (Table 6.7) from the raw data.

$$\text{Shadow price} = \text{Market price} \times \text{Conversion factor}$$

Table 6.6 Data on Sri Lankan paddy production

	Quantity	Market price	Import tax	Import subsidy	Conversion factor
Labour	12.30	50			1.00
Water	2.20	100			1.66
Land	31.84	80			0.84
Fertilisers	14.80	30		20.71	
Output	18.21	150	35.94		

Table 6.7 Calculation of shadow prices

Inputs	Quantity	Market price	Import tax	Import subsidy	Conversion factor	Shadow price
Labour	12.30	50			1.00	50.00
Water	2.20	100			1.66	166.00
Land	31.84	80			0.84	67.20
Fertilisers	14.80	30		20.71		37.84
Output	18.21	150	35.94			110.34

Table 6.8 Calculation of private and social prices

	Inputs	Value in private prices	Value in social prices
Domestic factors	Labour	615	615
	Water	220	365.2
	Land	2547	2139.64
Tradable input cost—Fertiliser		444	560
Revenue		2731	2009

$$\text{Shadow price for labour} = 50 \times 1.00 = 50$$

$$\text{Shadow price for water} = 100 \times 1.66 = 166$$

$$\text{Shadow price for land} = 80 \times 0.84 = 67.2$$

For the tradable inputs,

$$\text{Shadow price for fertiliser} = \frac{\text{Market price}}{(1 - 20.71\%)} = 37.84$$

$$\text{Shadow price for output} = \frac{\text{Market price}}{(1 + 35.94\%)} = 110.34$$

Now we have data on private and social prices (Table 6.8).
Now these values can be used to populate the PAM, as in Table 6.9.

Interpretation

The results of the arbitrary values indicate that rice cultivation in Sri Lanka are privately and socially unprofitable. The principal cause of that result is the opportunity cost of land. Private profitability is less negative than social profitability as a result of transfers to producers.

We can use PAM to estimate NPC, EPC, and DRC.

6.4.3.2 Nominal Protection Coefficient

The NPC is the ratio between the domestic price and border price of a commodity measured by direct price comparison between the border and the farmgate price. It is estimated as follows:

$$\text{NPC} = \text{Pd}/\text{Pb} \tag{6.18}$$

where Pd = the domestic producer price, Pb = the border equivalent producer price.

Calculation

NPC on tradable inputs (NPCI): B/F

Table 6.9 PAM for the Sri Lankan paddy rice production

Description	Revenues	Costs		Profit
		Tradable inputs	Domestic factors	
Value in private prices	2731	444	(615 + 220 + 2547) = 3,382	[2,731 − (444 + 3,382)] = −1,095
Value in social prices	2009	560	(615 + 365.2 + 2139.6) = 3,119.8	[2,009 − (560 + 3,119.8)] = −1,670.8
Divergences/policy transfers	(2731 − 2009) = 722	−116	262.2	573

$$\mathrm{NPC} = \frac{B}{F} = \frac{444}{560} = 0.79$$

NPC on tradable outputs (NPCO): A/E

$$\mathrm{NPC} = \frac{P_d}{P_b} = \frac{150}{110.34} = 1.36$$

Interpretation

The input market is not protected and a value less than 1 indicates tax on inputs. The output market is protected with tariffs.

6.4.3.3 Effective Protection Coefficient

The EPC is estimated as the ratio of value added in private prices to value added in social prices. It shows the overall effect of policies in tradable input markets.

$$\mathrm{EPC} = \mathrm{V_{Pd}}/\mathrm{V_{Pb}} \tag{6.19}$$

where $\mathrm{V_{Pd}}$ is the value added in domestic price (private price), $\mathrm{V_{Pb}}$ is the value added in border price (social price).

Calculation

EPC: (A − B)/(E − F)

$$\mathrm{EPC} = \frac{(\mathrm{A}-\mathrm{B})}{(\mathrm{E}-\mathrm{F})}$$

$$\mathrm{EPC} = \frac{(\mathrm{A}-\mathrm{B})}{(\mathrm{E}-\mathrm{F})} = \frac{(2731-444)}{(2009-560)} = \frac{2287}{1449} = 1.57$$

Interpretation

EPC is greater than 1, indicating that the domestic production is protected.

6.4.3.4 Domestic Resource Cost

The DRC coefficient was estimated as given below.

$$\mathrm{DRC} = \frac{\sum_{j=k+1}^{n} a_{ij} V_j}{P^r_j - \sum_{j=1}^{k} a_{ij} P^r_j} \tag{6.20}$$

where a_{ij}, $j = k + 1$ to n is the technical coefficient for domestic resources and non-tradable inputs, V_j is the shadow price of domestic resources and non-tradable inputs necessary to estimate the opportunity costs of domestic production, P^r_j is the border/reference price of traded output, a_{ij}, $j = 1$ to k is the technical coefficient for traded inputs, P^r_j are the border/reference prices of traded inputs (Gorton and Davidova 2001).

The numerator shows the cost of non-tradable inputs (e.g. land and labour) which were used in production and marketing of the commodity. The denominator shows the cost of tradable or imported inputs. All the costs are based on shadow prices.

Tradable inputs can be adjusted to the border price mostly using the CIF (Cost, Insurance, and Freight) value. It is adjusted to the farmgate level in many studies. Only in the case of a net exporter is the FOB (Free on Board) price used (Gorton and Davidova 2001).

The social cost of labour and land are measured using opportunity cost. The cost of labour in sectors other than agriculture (manufacturing or construction labour) is used as the shadow price of agriculture labour. The land rental value of the next best alternative crop is used as the shadow price of agriculture (Gorton and Davidova 2001).

Calculation

Domestic resource cost ratio (DRC): G/(E − F)

$$\mathrm{DRC} = \frac{3119.8}{(2009 - 560)} = 2.15$$

Interpretation

DRC is greater than 1, indicating that the cost of domestic production of rice is greater than that of other countries. There is a tendency for rice imports to be profitable. The NPC and EPC also indicate that the industry is protected due to its inefficiency. However, deciding on total imports depends on the risk attached with import dependence for a staple food.

6.5 Measuring Competitiveness of Industries: Structure-Conduct- Performance Paradigm

This section shows how to understand a market using the structure-conduct-performance (S-C-P) paradigm. Theories of industrial organisation began to develop in the 1930s to understand real-world markets which lay between perfect competition and monopoly. In 1959, the S-C-P paradigm was introduced by Joe S. Bain Jr. in his book *Industrial Organisation*. Thereafter, the concept was further developed by incorporating concepts of behavioural economics and referred to as new industrial organisation, a combination of consumer theory, producer theory, and game theory (Tremblay and Tremblay 2012).

6.5.1 Concepts

Structure, conduct, and performance are interrelated concepts. Each market has a *structure* formed of its participants, buyers and sellers. The way they are organised to form a market is explained by the structure: perfectly competitive, monopoly, monopsony, and oligopoly. Each type of structure is associated with specific characteristics and behaviours. *Conduct* refers to this structure-led behaviour of a market. In other words, it is how firms with a certain structure behave in the market. Ultimately, the performance of a firm or an industry is the outcome of a social experience. The society expects markets to perform in a responsible way ensuring efficiency, equity, and macroeconomic stability (Tremblay and Tremblay 2012). Earning exorbitant economic profits and use of unfair and dishonest practices are not expected by society.

The objective of policy should be to maximise the welfare of a society. Therefore, perfectly competitive markets interest policymakers because these markets allocate resources efficiently and ensure equity. In a real-world situation, a firm's efficiency assists in increasing market share and competitiveness among others to earn more profits. A firm is interested in becoming towards a monopoly or an oligopoly. Policies can influence market structure and, hence, the conduct of firms. For example, a government may impose anti-trust policies to control collusion among firms to balance market power. But antitrust policies can be a disincentive for inventions (Tremblay and Tremblay 2012). Moreover, technology plays an important role in efficiency gains by firms. Occasionally, high-performing firms with an advantage in terms of cost-reducing technology may acquire a greater market share.

Figure 6.7 illustrates the S-C-P paradigm. The dynamic nature of markets leads a top-down to bottom-up governing nature.

Analysing the structure of a market helps with understanding the key characteristics of markets in order to classify and compare them. Knowledge of

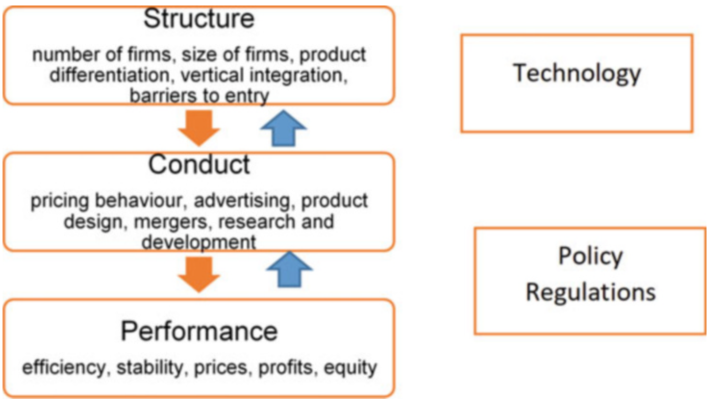

Fig. 6.7 S-C-P paradigm. Source: Tremblay and Tremblay (2012)

market structure is used to evaluate the conduct and performance of firms in those markets.

6.5.2 Measures

Structure

Structure is explained by a number of variables: the number and size of firms; product differentiation; vertical integration; barriers to entry and exit; and similarities for mergers (Tremblay and Tremblay 2012). A policymaker's objective (of efficiency and equity) is achieved in a perfectly competitive market.

Empirically, market structures are imperfect (as described in Fig. 6.8), and measuring the degree of deviation of a concerned market from perfect competition is important for policy decisions. A firm's objective is to maximise profits. In order to earn economic profits, it attempts to deviate from perfect competition to imperfect competition. If price is not exogenously determined by the interaction of buyers and sellers, it is decided internally by firms. In such situations, one party exerts market power over the others. Market concentration is measured by buyer concentration and seller concentration ratios. However, there are other variables that determine the structure.

Product differentiation and barriers to entry and exit encourage imperfect market structures. Product differentiation occurs in monopolistic competition where a large number of producers differentiate their products through branding, quality, or some other attributes, catering to a variety of consumer preferences. A perfectly competitive market is free of barriers to entry and exit. The entry and exit costs are zero. An oligopoly or a monopoly is characterised by barriers: natural, legal, or strategic.

We use concentration curves, concentration ratio, and the Herfindahl-Hirschman Index (HHI) to analyse market structure.

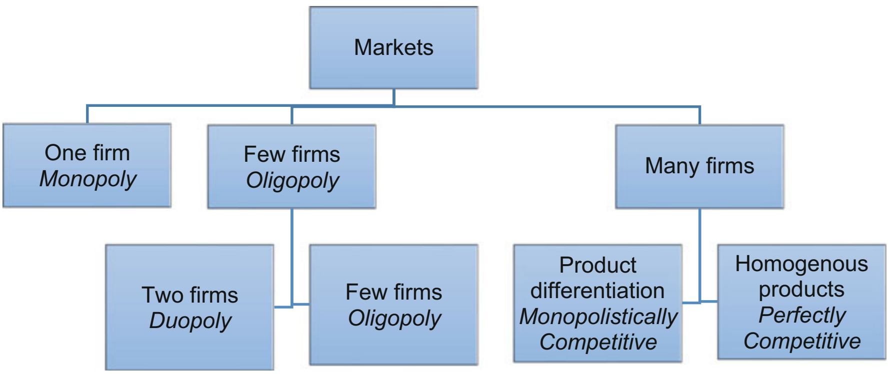

Fig. 6.8 Different market structures in an economy. Source: Mankiw (2018)

Conduct
Conduct refers to the behaviour of buyers and sellers in the market: pricing behaviour, advertising, product design, possible mergers, research and development cost, and so on. These are decisions or choices made by firms. All these strategies are used to exert market power. Market power is explained as the ability of a firm to charge a price above the price that would prevail under perfect competition (i.e. marginal cost). In a static situation, we expect marginal cost pricing is allocative-efficient. However, in dynamic settings, price is higher than the marginal cost as firms invest in technology and research and development, expecting long-run low costs with scale economies. Strategic pricing, such as price discrimination, mergers to increase size, and oligopolies such as cartels, earn firms more profits.

It is difficult to estimate market power due to limitations in data availability. We consider the indicators that measure market power in static markets. We will elaborate on price-cost margin, Lerner index (L), and Tobin's q with numerical examples. New approaches use cost and price elasticities of demand as measures to discover market power. In perfectly competitive industries, change in cost is totally transmitted to consumers, referred to as the pass-through rate of cost. In perfectly competitive markets, this rate is equal to one. When market power exists, this is not equal to one.

Performance
From the policymaker's viewpoint, performance improves society's welfare, which is considered as efficiency, stability, prices, profits, and equity. Deadweight loss shows the value of inefficiency. Equity is important in welfare distribution to prevent only a few actors getting all the benefits. Firms are interested in profits, prices, market share, and efficiency of their production. Efficiency and equity always involve a trade-off. However, the distribution of welfare at the expense of efficiency is considered to be in society's interest. In instances where technological innovations matter for efficiency, the government can allow firms to earn profits as an incentive. Profit rate (r), profit to sales ratio, and Relative Profit Differences (RPD) will be used in assessing the performance of a firm.

6.5.3 Numerical Examples

Suppose we are given a certain industry and need to make appropriate policy decisions to improve its competitiveness. Assume that we rely on indicators used for static markets. The industry consists of 11 firms. Their production capacities are given in Table 6.10.

Indicators Measuring Structure
First, we have to calculate the market share of each firm (Table 6.11), rank the firms, and graphically show the cumulative market shares (Fig. 6.9).

Table 6.10 Production capacities of firms

Firm	Production
A	1,137,100
B	150,000
C	80,000
D	200,000
E	3,142,925
F	700,000
G	900,000
H	1,513,000
I	300,000
J	100,000
K	60,000

Table 6.11 Cumulative market share

Firm	Production	Market share (%)	Cumulative market share
E	3,142,925	37.94	37.94
H	1,513,000	18.27	56.21
A	1,137,100	13.73	69.94
G	900,000	10.87	80.80
F	700,000	8.45	89.26
I	300,000	3.62	92.88
D	200,000	2.41	95.29
B	150,000	1.81	97.10
J	100,000	1.21	98.31
C	80,000	0.97	99.28
K	60,000	0.72	100.00

6.5.3.1 Concentration Curve

Concentration curve is the graphical representation of the cumulative market share of firms which is a plot from the largest to the smallest firm. It is a single straight line which goes through a 45°angle when the firms are of equal size. It shifts and moves up when market share of the individual firms is different. It helps us to visualise the distribution of market share and the possibility of cartels or oligopolies. There are indices to identify the concentration. The number of firms is not an adequate measure of concentration, as it does not provide a satisfactory picture unless the firms are of equal size and do not help in understanding the dominant firms in the market.

Interpretation

A concentration curve is not a straight line. Firms have different market shares. Firm E holds nearly 40 per cent of the market share. It can be the leading firm in the industry. This can be considered as a market structure with oligopoly power.

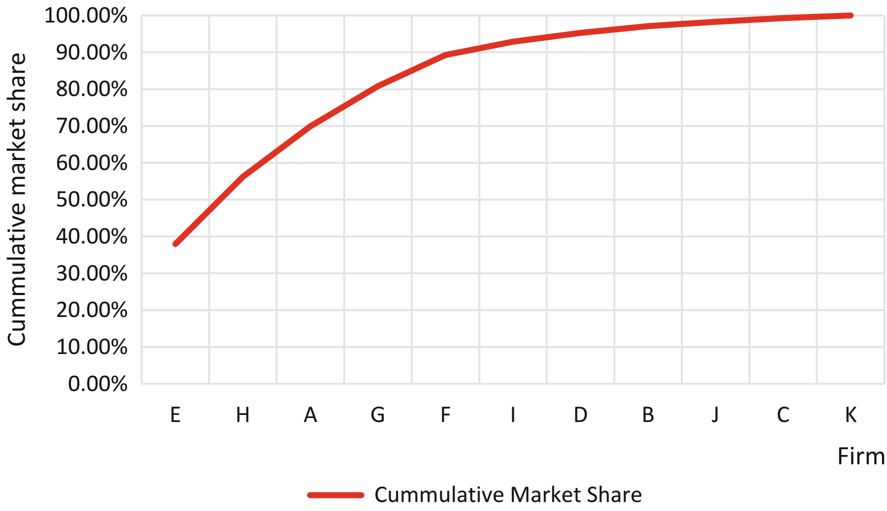

Fig. 6.9 Concentration curve

6.5.3.2 Concentration Ratio

A concentration ratio is the most common way of measuring concentration. It is the sum of the market shares of the largest "m" number of firms. More often "m" is 4; it may be a smaller or larger number. If the C_4 value is closer to zero, the industry is considered as extremely competitive. When the value is closer to 90, the market is a monopoly. Generally, a value greater than 50 is considered as allowing firms to exert market power. However, when it reaches 40 per cent, it is considered a possible oligopoly; when it exceeds 60 per cent, it can be a tight oligopoly.

$$C_m = \sum_{i=1}^{m} S_i \tag{6.21}$$

where C_m Concentration ratio, S_i Market share of ith firm.

There are limitations to selecting four firms. There is no consideration of the distribution of market share among the firms. For example, adding the fourth firm may increase the cumulative share by a smaller amount. On the other hand, adding the fifth firm may give out a higher concentration ratio. Further, it is difficult to compare the concentration of industries. Therefore, concentration ratios do not provide a clear picture on the distribution of concentration among industries and possible relationships among those. A concentration curve shows the distribution of concentration from largest to smallest firm.

Calculation

We can calculate the concentration ratio. Let's calculate the C4 concentration ratio.

$$C_m = \sum_{i=1}^{m} S_i$$

$$C_4 = (37.94 + 18.27 + 13.73 + 10.87)$$

$$C_4 = 80.80$$

Interpretation

The market has a possibility of being an oligopoly.

6.5.3.3 Herfindahl-Hirschman Index (HHI)

This is an alternative measure of market concentration which provides more insight into market structure. It is the sum of each firm's market share squared. Market share is taken in percentage terms.

$$\mathrm{HHI} = \sum_{i=1}^{n} S_i^2 \tag{6.22}$$

When we calculate the market shares in percentage terms, for a monopoly, the index is 10,000, and for a perfectly competitive industry it is zero. A market is considered to be un-concentrated when HHI is less than 1000. The values between 1000 and 1800 show moderately concentrated and above 1800 show highly concentrated. This is a better measure of market concentration and in taking into account all the firms in the industry. The value of the index is more sensitive to larger firms since the square of the market share is taken. If there is a shift in market share among larger firms, the HHI will change. When the decimal form of market share is used, it shows the following relationship.

$$\mathrm{HHI} = n\sigma^2 + 1/n \tag{6.23}$$

An increase in the variance of the firms increases the HHI. For a market with firms of equal size, the variance becomes zero and HHI $= 1/n$. This gives an idea of the number of firms there ought to be when the firms are of equal size. If the number of firms is less, it is an indication of large firms.

There are other variables that contribute to the structure of the market. Identification of close substitutes is crucial when defining a market. Cross price elasticity values provide information on close substitutes. Sometimes geographical disaggregation (regional, national, and international) also matters in defining a market. If we wrongly define a market, the measures will not give us a correct picture.

Calculation

$\mathrm{HHI} = \sum_{i=1}^{n} S_i^2$

$\mathrm{HHI} = (37.94^2 + 18.27^2 + 13.73^2 + 10.78^2 + \ldots + 0.72^2)$.

$\mathrm{HHI} = 2176.50$ or 21.76.

Interpretation

Value is greater than 1800 showing that the market is highly concentrated.

Indicators Measuring Conduct

Assume that the above firms face marginal costs and prices as shown in Table 6.12. We can find the market power using Lerner's index for each firm and the industry as a whole. Table 6.13 shoould come here which explains calculating Learner's Index (it is misplaced under section 6.6

Price-Cost Margin

Price-cost margin is used as an indicator of market power in the presence of symmetric firms. Since marginal cost is different for firms, it does not hold in the real world.

Lerner Index (L)

This is an index of market power which is defined as the difference between output price (P) and the marginal cost (MC) divided by the output price. (Table 6.13)

Table 6.12 Price and marginal cost of firms

Firm	MC	P
E	75	100
H	90	100
A	93	100
G	93	100
F	93	100
I	92	100
D	92	100
B	92	100
J	92	100
C	92	100
K	92	100

Table 6.13 Price, marginal cost, and Lerner's index of firms

Firm	MC	P	$P - MC$	L-index	msi*(($P - MC$)/P)
E	75	100	25	0.25	0.094860
H	90	100	10	0.1	0.018266
A	93	100	7	0.07	0.009610
G	93	100	7	0.07	0.007606
F	93	100	7	0.07	0.005916
I	92	100	8	0.08	0.002897
D	92	100	8	0.08	0.001932
B	92	100	8	0.08	0.001449
J	92	100	8	0.08	0.000966
C	92	100	8	0.08	0.000773
K	92	100	8	0.08	0.000579
Industry					0.144854

$$L = \frac{P - MC}{P} \tag{6.24}$$

For a perfectly competitive market, P = MC; thus L = 0. If MC = 0, L = 1, indicating a monopoly. The index can vary from 0 to 1. In practice, computing this index has data limitations on marginal cost. The Lerner index can be computed for an industry using market shares (ms_i) as weights.

$$L = \sum_{i=1}^{n} ms_i \frac{p_i - MC_i}{p_i} \tag{6.25}$$

Market power is determined by the technology and price elasticity of demand. Lerner index measures the market power.

Calculation

For a single firm:

For firm E,

$$L = \frac{100 - 75}{100} = 0.25$$

For an industry:

$$L = \sum_{i=1}^{n} ms_i \frac{p_i - MC_i}{p_i} = 0.14$$

Interpretation

The value is above zero, showing that there is a certain level of market power; but it does not go closer to one, signalling the absence of monopoly power.

Tobin's *q*

Tobin's q ratio is an alternate measure given the limitations (data collection of marginal cost) of the Lerner Index. It is the ratio of the market value of the firm to the replacement value of the firm's assets. In a perfectly competitive market, this ratio equals 1. If the firm is imperfectly competitive, then it earns economic profits, and the replacement value is high making the ratio greater than 1.

$$q = \frac{\text{market value of installed capital}}{\text{replacement cost of capital}} \tag{6.26}$$

Calculation

Assume that the stock market value of the firm is LKR1500, and the price of capital at the market is LKR 500. With Tobin's q ratio, we can tell whether the firm is earning economic profits.

$$q = \frac{1500}{500} = 3$$

Interpretation

It is greater than one, indicating that the firm is earning economic profits. A firm can sell its shares and keep adding capital. It measures accounting profits.

Indicators Measuring Performance

We need to evaluate the performance of a firm. Suppose firm A's sales are 300,000 kg at LKR 100. Total revenue (TR) is equivalent to quantity multiplied by market price. A tax (T) on income is charged at 1 per cent. Assume the wage rate (p_L) is LKR 1500 and 1000 labour days (L) are used. Similarly, the material unit price (p_M) is LKR 40 and the quantity used is 1000. Capital depreciation rate is 0.15 (15 per cent) and market interest rate is 0.1 (10 per cent). Capital investment is assumed 13,500,000 LKR.

Profit Rate (*r*)

This is the rate of return on each rupee invested during a given period of time. Profit rate is defined as follows.

$$r \equiv \frac{\mathrm{TR} - \mathrm{T} - \mathrm{p_L L} - \mathrm{p_M M} - \delta \mathrm{p_k K}}{\mathrm{p_K K}} \tag{6.27}$$

where TR total revenue, T tax on profit, L
labour, M material, K physical capital, $\mathrm{p_L}$, $\mathrm{p_M}$, $\mathrm{p_K}$ price of labour, price of material, and price of capital (rental rate), δ−
capital depreciation.

If profit rate "*r*" exceeds the nominal interest rate or investing the money in the next best alternative, the firm earns economic profits.

Calculation

$$r \equiv \left(\frac{(300{,}000 * 100) - (300{,}000 * 100 * 0.01) - (1500 * 1000) - (40 * 1000) - (0.15 * 0.1 * 13{,}500{,}000)}{0.1 * 13{,}500{,}000} \right)$$

$$r = \frac{30,000,000 - 300,000 - 1,500,000 - 40,000 - 202,500}{1,350,000}$$

$$r = \frac{27,957,500}{1,350,000} = 20.71$$

Interpretation

The profit rate is greater than the nominal interest rate. Firm A earns economic profits.

Profit to Sales Ratio

Profit (π) is divided by the total revenue (TR). This ratio is easy to estimate. In the long run, it is equivalent to the Lerner index.

$$\frac{\pi}{\mathrm{TR}} = \frac{\mathrm{TR} - \mathrm{TC}}{\mathrm{TR}} \tag{6.28}$$

Calculation

$$\frac{\pi}{\mathrm{TR}} = \frac{30,000,000 - 2,042,500}{30,000,000} = \frac{27957500}{30,000,000} = 0.93$$

Interpretation

A value above zero implies endogenous price determination. Firm A operates with market power.

Relative Profit Differences (RPD)

This is called the index of relative profit differences. It is used to measure the degree of competition among firms. This index can be applied to an industry which has different efficiency levels; it holds the condition that increasing competition harms inefficient industries the most. It is assumed that profit is a function of efficiency (E_i) and behaviour (θ) of the firm. The degree of competition increases when θ reduces. θ varies from 0 to n (cartel).

$$\pi_i^v = \pi_i^v(E_i, \theta)$$

$$\mathrm{RPD} = \frac{\pi_1^v - \pi_3^v}{\pi_2^v - \pi_3^v} \tag{6.29}$$

A fall in RPD over time indicates a reduction in market power over time. This is called Boone's index. The average variable cost of firms is taken to measure efficiency, and firms are ranked from high efficiency to low efficiency.

Calculation

$$\text{RPD} = \frac{\pi_1^v - \pi_3^v}{\pi_2^v - \pi_3^v} = \frac{500_1 - 300_3}{400_2 - 300_3} = \frac{200}{100} = 2.0$$

Interpretation

If we observe 2.0 this year and 3.0 in previous year, they show that the market power of the industry is declining.

6.6 Agriculture Productivity Measurements as Measures of Competitiveness

Efficient use of resources indicates the competitiveness of agricultural products at the farm level. It gives the productivity of a cultivation or crop production activity, highlighting the technology in use. Land, labour, capital, and entrepreneurship are generally considered as the inputs in farm-level production. To identify farm-level competitiveness, the efficiency of these inputs individually and in combination at a given ratio (technology) to achieve the total production must be analysed. In this section, we consider land and labour as inputs.

6.6.1 Concepts

Productivity is a measure of performance, the ratio of outputs to inputs or the relationship between the volume of output and the volume of input used to generate that output. Everything else being equal, higher productivity results in higher production and higher profits or income. Agricultural productivity is a subject of interest for policymakers and analysts. For example, the second Sustainable Development Goal (SDG 2), which targets ending hunger and malnutrition, emphasises the link between farm productivity and incomes. Farms can allocate scarce resources efficiently to other pursuits by increasing productivity. Farm incomes can be assessed more precisely through the measurement of agricultural productivity. A good measure of productivity depends on the relevance and quality of data.

6.6.2 Measures

Agricultural productivity (P) is the ratio of outputs (O) to inputs (I), expressed either in values (values at constant prices) or in physical quantities (kg, tonnes, etc.), depending on the formulation of the indicator. For any period, t:

$$P_t = \frac{O_t}{I_t} \tag{6.30}$$

The growth rate in productivity ($\dot{P}_t$) is approximately equal to the difference between output and input growth, respectively, $\dot{O}_t$ and $\dot{I}_t$.

$$\dot{P}_t = \dot{O}_t - \dot{I}_t \tag{6.31}$$

Productivity growth can be defined as the growth in output not explained by the growth in inputs, or residual growth (Solow 1957). Productivity growth is easier to interpret than productivity (ratio of outputs to inputs) when multiple outputs and inputs are considered. Productivity indicators are generally found in two forms: partial factor productivity and total factor productivity.

6.6.2.1 Partial Factor Productivity (Single-Factor Productivity)

Partial factor productivity measures the volume of output generated by a single input (e.g. labour productivity, land productivity, capital productivity). Partial factor productivity indicators can be easily interpreted, understood, and calculated.

Land Productivity

Land productivity measures the amount of output generated by a given amount of land. The broad measure of land productivity is the ratio between the value of all agricultural products (crops and livestock) and total land used in agriculture. This type of land productivity is referred to as returns to land. Other land productivity measures can be calculated by dividing single crop production by the amount of planted land (in hectares or acres). This type of land productivity is referred as crop yield. Given that land may be used to grow many different crops, monetary values on respective outputs are needed to aggregate the output of different crops.

$$\text{Land productivity} = \frac{\text{volume of output}}{\text{planted area}}$$

Using harvested area instead of planted area tends to give overestimations of yields and returns to land because this area includes the most productive segments of the parcel.

Labour Productivity

Labour productivity in agriculture measures the number of units of output (s) produced per unit of labour used. It is a partial productivity indicator that is calculated by dividing the quantity of output by the total units of labour used.

$$\text{Labour productivity} = \frac{\text{volume of output}}{\text{units of labour used}}$$

There are two ways to assess the quantity of labour input: the number of workers active on the farm and the number of hours worked. The Organisation of Economic Cooperation and Development (2001) recommends that labour input should be measured using the number of hours effectively worked. Distinctions must be made between different age groups, educational levels, family/hired labour, part-time/full-time workers, and workers' gender.

Capital Productivity

Capital productivity measures the contribution of capital employed in the production process to the output. Machinery, equipment, and buildings are traditionally considered capital. Capital productivity is computed using the following formula.

$$\text{Capital Productivity} = \frac{\text{Volume of output}}{\text{volume of capital input}}$$

In order to determine capital input, we must consider the services we derive from capital inputs. To estimate capital service, it is necessary to first estimate the stock of productive capital used for each asset type, then determine rental prices and, finally, estimate capital service flows. The capital service flows are calculated as the rental rate multiplied by the capital stock.

$$\text{Capital Service} = \text{Rental price} \times \text{Capital stock}$$

In general, partial productivity measures may misrepresent the performance of the farm or the farming sector. It is more difficult to make evidence-based analysis or policy decisions using partial factor productivity. Changes in single-factor productivity reflect the combined effect of efficiency, technical change, and change in the use of other inputs.

6.6.2.2 Total Factor Productivity (Multifactor Productivity)

Total factor productivity (TFP) accounts for the contribution of all the major inputs into production and provides a measure of how efficiently they are combined in the production process. TFP is often measured as a growth rate. The difference in terminology between TFP and multi-factor productivity (MFP) is that the term MFP more explicitly acknowledges the fact that it is impossible to capture all inputs while TFP measures always capture only the main inputs. For this reason, the term MFP is often preferred to TFP in the technical literature.

In the case of a single output and multiple inputs, MFP measures the productivity of a commodity with respect to the bundle of inputs used in its production. When a crop is cultivated in intensive monoculture systems, a commodity-specific measure of productivity is also relevant. The numerator of this ratio can be either the gross output or the value added. When gross output is used, the denominator comprises both intermediate inputs and factors of production. When the value added is used, the denominator only comprises factors of production. The different inputs are aggregated by converting the quantities used into their monetary equivalents. As the output is a single commodity, the numerator can be expressed in either physical or monetary units.

In the case of multiple output and multiple inputs, TFP (or MFP) is calculated as the ratio of total output to total inputs. The numerator and denominator of the ratio are expressed in terms of monetary value. This indicator measures the overall efficiency or performance of production. When the value-added approach is used, TFP measures the returns to factors of production. TFP or MFP indicators are typically expressed in growth rates, particularly when they are compiled at industry level. TFP growth is defined by as the change in agricultural output that is not accounted for by the change in all or several agricultural inputs (land, capital, labour, and intermediate inputs). TFP growth can be measured using different methods. The most common methods use the growth accounting approach, stochastic frontier approach, and Data Envelopment Analysis.

6.6.2.3 The Growth Accounting Approach

This approach is the most widely used to measure aggregate productivity growth. The growth accounting approach is consistent with the national accounting framework. It is also easier to understand and more easily replicable by statistical organisations than alternatives based on econometric models or linear programming. However, the growth accounting approach requires data on quantities and prices for all of the outputs and the major inputs.

TFP growth is the difference between total output and input growth. Fuglie (2015) derives an operational formula where TFP growth is calculated as the difference between the revenue-weighted outputs and cost-weighted inputs:

$$\dot{\text{TFP}}_t = \sum_{i=1}^{n} R_i \dot{O}_{i,t} - \sum_{j=1}^{k} S_j \dot{I}_{j,t} \tag{6.32}$$

where $R_i = {}^{P_i O_i}\!/\!\sum_i P_i O_i$ is the share of commodity i in total production value, $S_j = {}^{P_j I_j}\!/\!\sum_j P_j I_j$ is the share of input or factors of production j in total costs of production.

The decomposition is valid under the following assumptions: the production technology is represented by a Cobb-Douglas function with constant returns to scale; farmers adopt a profit-maximising strategy so that the cost shares equal the elasticity of output to each input; and, markets are in long-run competitive equilibrium so that aggregate revenue $\sum_i P_i O_i$ is equal to aggregate cost $\sum_j P_j I_j$.

Other growth accounting approaches, with different assumptions on the production technology and weights (Tornqvist indexes, Laspeyres or Paasche index) can also be used. The decomposition proposed by Fuglie (2015) provides an operational and flexible calculation framework. Little statistical or modelling work is required to determine weights and growth rate.

6.6.2.4 Data Envelopment Analysis (DEA)

This method attempts to construct a production frontier to measure changes in technical efficiency and technology. DEA constructs the best-practice frontier through a linear optimisation model. The frontier "envelops" the observed input-output combinations at the farm level. The main advantages of using DEA to measure productivity growth are the absence of assumptions on the production technology of the farm or sector; the fact that it can be used at any level of aggregation; easy accommodation of multiple outputs and inputs; and the fact that only the quantities produced and the inputs used are necessary. This method is relatively complex to implement and explain to users. Given that it is based on an optimisation procedure, the results may also be unstable.

The Malmquist productivity index using Data Envelopment Analysis is conventionally defined as the geometric mean of two indices. In this approach, x is the set of inputs that can be used by a farm to produce a set of outputs y. The technology T is defined as the set of all possible input-output combinations. The output set $P(x)$ is the set of all technologically possible outputs. The output distance function $D(x,y)$, with respect to T, is the maximum possible expansion of output allowed by the technology. The first Malmquist index (M) compares the distance of the output-input combinations of periods t and $t + 1$, relative to the technology of period t:

$$M_t = {}^{D_t(\boldsymbol{x},\boldsymbol{y})_{t+1}}\!/_{D_t(\boldsymbol{x},\boldsymbol{y})_t}$$

The second compares the same observations by using period $t + 1$ technology as a reference:

$$M_t = {}^{D_{t+1}(\boldsymbol{x},\boldsymbol{y})_{t+1}}\!/_{D_{t+1}(\boldsymbol{x},\boldsymbol{y})_t}$$

The final Malmquist productivity index is the geometric mean of these two indices.

$$M_{t,t+1} = \sqrt{M_t, M_{t+1}},$$

One possible decomposition is:

$$M_{t,t+1} = \frac{D_{t+1}(\boldsymbol{x},\boldsymbol{y})_{t+1}}{D_t(\boldsymbol{x},\boldsymbol{y})_t} * \left[\frac{D_t(\boldsymbol{x},\boldsymbol{y})_t}{D_{t+1}(\boldsymbol{x},\boldsymbol{y})_t} * \frac{D_t(\boldsymbol{x},\boldsymbol{y})_{t+1}}{D_{t+1}(\boldsymbol{x},\boldsymbol{y})_{t+1}}\right]^{1/2}$$

The first term measures the contribution of technical efficiency to productivity changes. The term in brackets captures the contribution of technological change to productivity changes.

Numerical Examples

Suppose we are given the following raw data (Table 6.14) for a red onion farm "A".

First, we need to calculate the partial factor productivity for each input. It is obtained by dividing the total production of each year by the input quantity of the corresponding year. Table 6.15 shows the PFP values for farm "A" for the years 2018 and 2019.

Table 6.14 Red onion production and input data for farm "A" in 2018 and 2019

Year	Total production (kg)	Land (Ac)	Total labour (days of labour)	Material (Seeds and fertiliser) (kg)
2018	4560	8	120	3684
2019	4788	7	110	3773

Calculation

Table 6.15 PFP of farm "A" in 2018 and 2019

Year	PFP land	PFP labour	PFP material (seeds and fertiliser)
2018	570.00	38.00	1.24
2019	684.00	43.53	1.27

Interpretation

PFP has increased for each input from 2018 to 2019. Next, we need to calculate the rate of growth for output and inputs. Table 6.16 shows the growth rates from 2018 to 2019.

Table 6.16 Rate of growth of output and inputs by 2019

Year	Rate of growth of output	Rate of growth of land	Rate of growth of labour	Rate of growth of material
2018				
2019	5.00	−12.50	−8.33	2.42

Calculation

Interpretation

Output has a positive growth rate from 2018 to 2019. Input growth for land and labour is negative but positive for materials. This means that the output has increased with a lesser amount of land and labour and more materials. In other words, the efficiency of land and labour has increased, while the use of materials has been increased with the expansion of production activity (Table 6.16).

Then, we need to estimate the TFP. Suppose we are given the factor shares or the input elasticities as below (Table 6.17).

Table 6.17 Factor shares or the input elasticities

	Land	Labour	Material
Input elasticities (factor shares)	0.5	0.3	0.2

Calculation

$$\text{TFP} = (5) - (-12.5 * 0.5) - (-8.33 * 0.3) - (2.42 * 0.2)) = 13.27$$

Interpretation

TFP is 13.27 which is greater than the output growth rate of 5. TFP gives us a clear picture of improvements in overall productivity with technological advancements.

6.7 Assignments

1. Suppose you are asked to analyse the export competitiveness of rubber products. What indicators will be helpful in measuring export competitiveness? Next, obtain relevant data from relevant sources (for instance, the Comtrade website) for 5 years and assess the situation of the rubber industry during this period. Try to support your findings with the analyses that can be derived from a market access map.
2. Calculate the NPC for paddy and sugar markets over the last 5 years. Consider the intra-annual variation.
3. Can you explain the rice market or vegetable market of Sri Lanka using the S-C-P paradigm?
4. Calculate the total factor productivity and partial Factor Productivity for paddy cultivation, taking one season and one irrigation system of cultivation. You may refer to the cost of cultivation data published by the Department of Agriculture.

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Qualitative Methods for Policy Analysis: Case Study Research Strategy

7

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Abstract

Many policy researchers are predisposed to use either quantitative or qualitative research methods regardless of the research questions at hand, leading to varying degrees of gaps in their findings and policy recommendations. Qualitative approaches effectively address *why* and *how* types of research questions to complement the answers for *who*, *what*, *where*, *how many*, and *how much* research questions, obtained using quantitative research methods, enabling researchers to make policy outcomes meaningful and contextually relevant. This chapter introduces the case study as an appropriate research strategy for accommodating qualitative and quantitative methods, followed by a brief account of qualitative research methods.

Keywords

Policy analysis · Qualitative research · Case study approach

7.1 Introduction

The main objective of policy analysis is to assess whether a given policy or set of policies has achieved its intended goals/objectives and, if not, why and how they can be fine-tuned for increased effectiveness. Policy analysis can be carried out using both quantitative and qualitative approaches. Both approaches have respective strengths and weaknesses depending on the research questions to be answered. Quantitative approaches are good at effectively addressing policy research questions

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that ask *who*, *what*, *where*, *how many*, and *how much*, while qualitative approaches are good at addressing *why* and *how* types of research questions. Therefore, a careful selection of proper tools of inquiry is required to match the research questions being answered (Downey and Ireland 1979).

Although a broad range of research questions must be addressed to gain a holistic understanding of policies being analysed, there seems to be a clear demarcation between academics/researchers whose dominant approach is either quantitative or qualitative methods. Therefore, operating within one's comfort zones would give him/her incomplete solutions to the problem being investigated. To further elaborate on this, Arabian folklore regarding Mulla Nasrudin could be cited:

"There Is More Light Here"

Someone saw Nasrudin searching for something on the ground.

'What have you lost, Mulla?' he asked.

'My key,' said the Mulla.

So, they both went down on their knees and looked for it.

After a time, the other man asked: 'Where exactly did you drop it?' 'In my own house.' 'Then why are you looking here?' 'There is more light here than inside my own house." Idries V (2014). The Exploits of the Incomparable Mulla Nasrudin, ISF Publishing. London. pp. 9.

Similarly, many researchers gravitate towards approaches they are familiar with and comfortable using, without regard to the research questions and specific research settings at hand. Therefore, are predisposed to use a particular research strategy regardless of the research questions (Yin 2003). Scepticism towards other approaches makes collaboration extremely difficult, resulting in varying degrees of gaps in research findings and subsequent policy recommendations.

One should keep in mind that the world is not fragmented in the way we perceive it through our own lenses. Gartner and Birley (2002) argue that some research questions simply do not get asked or cannot be asked in quantitative research. Therefore, adopting one approach vis-à-vis the other would only allow us to unravel parts of the jigsaw puzzle, making it impossible to make complete sense of what is happening around us. Failure to gain a complete picture of the situation means that policies formulated/analysed and recommendations made are contextually inappropriate, resulting in varying degrees of inefficient and ineffective policy outcomes.

Therefore, qualitative and quantitative methods play complementary and interdependent roles in gaining a holistic understanding of the phenomenon being researched.

Though the other chapters of this book have been dedicated to exploring various quantitative methods that can be used in policy analysis, the objective of this chapter is to familiarise the reader with qualitative research methods. Consequently, researchers and policy analysts will be in a better position to make their research findings and policy recommendations relevant and contextually more appropriate by incorporating qualitative tools into their repertoire of research toolkits or by collaborating with qualitative researchers.

This chapter will first introduce case study research as an appropriate methodology for conducting policy analysis research, mainly because of its ability to accommodate qualitative and quantitative research methods. Then the chapter will present a brief account of qualitative methodology with justification for its suitability for complementing quantitative research strategies in policy analysis research in the context of case study research.

7.2 Case Study as an Appropriate Research Strategy for Policy Analysis

Researchers unfamiliar with the case study strategy sometimes harbour the misconception that it is a means of producing narratives/stories. This is mainly due to a lack of rigour and systematic procedure in many case studies (Yin 2003). The case study methodology is considered as a broad umbrella research strategy that can accommodate several methods (Hartley 1994, p. 209; Hartley 2004). This is used to understand a complex social phenomenon by focusing on it in-depth while retaining a holistic and real-world perspective, either by carrying out a single case study or using it in combination with other methods such as surveys and quantitative techniques (Yin 2018). This flexible accommodation of multiple methods makes the case study approach an ideal research strategy for policy analysis as it provides much-needed flexibility for doing behavioural research because of its capability to accommodate multiple research tools/methods (Eisenhardt 1989, p. 535; Hammersley 1989, p. 93; Stoecker 1991, p. 99; Hamel et al. 1993, p. 1; Hartley 1994, p. 209–210; Yin 1994; Hartley 2004).

Case study strategies are adopted when the researcher is focusing on a contemporary phenomenon/event in its real-life context without control over the event (Yin 2018); when the phenomenon is not isolated from its context (Yin 2003; Hartley 2004); and, when we need to understand how behaviour and/or processes are influenced by the context (Hartley 2004). The case study strategy has the ability to: (a) explore a given process(es)/event(s) (Hartley 1994, p. 211–213; Stoecker 1991; Gummesson 1991, p. 76; Eisenhardt 1989, p. 535); (b) describe the process (Bonoma 1985 p. 198–203; Hamel et al. 1993, p. 39); (c) differentiate general processes from exceptions (Stoecker 1991, p. 95); (d) see whether a decision or set of decisions complies or deviates from general patterns (Miles and Huberman 1994,

p. 29); and (e) explore why certain decisions were taken, how they were implemented, and with what outcomes (Schram 1971; Yin 1981; Yin 2018). The latter is an essential aspect of policy analysis.

Furthermore, case study strategy (a) can piece together the required contextual factors (Miles and Huberman 1994, p. 27; Geertz 1973; Miles 1979, in Bonoma 1985, p. 201; Hartley 1994, p. 208, 212; Yin 1994, p. 48; Zonabend 1992; Gummesson 1992, p. 17; Gummesson 1991, p. 76); (b) offers the tools to study the research issue in a bounded context (Miles and Huberman 1994, p. 25); (c) provides ways and means to understand the dynamics of a single setting (Eisenhardt 1989, p. 534; Stoecker 1991, p. 97–98), within a particular historical period of a social unit (Stoecker 1991, p. 97–98) longitudinally (Hartley 1994, p. 212); and (d) helps understand those social processes in their organisational/environmental context (Hartley 1994, p. 212), within the meanings of the actors (Hamel et al. 1993 p. 33; Hartley 1994, p. 212).

The case study approach can be broadly used as a frame demarcating the boundaries of data /information-gathering (Stoecker 1991, p. 9; Kodithuwakku 1997; Kodithuwakku and Rosa 2002) rather than treating only the respondents as focal points. These boundaries can be physical/geographical, i.e. based on the level and the extent of the population (Stoecker 1991, p. 109), social, and/or a defined time period (see Yin 1994, p. 24 for a similar argument). For example, suppose we are to analyse the effects of a new fertiliser subsidy policy on farmers. In that case, is essential to cover farming and associated activities by farmers in a given geographical/social unit at least over an entire cropping season to gain a complete picture (see Burgess 1982, p. 76 for a similar argument in different contexts).

In economics, the case study strategy can be used to study a structure of a selected industry, or the economy of a given city or a region, or even the international relations (Yin 2003) that also define the geographical, social, economic, and political boundaries. In policy analysis, the time dimension can be used to define the boundaries of the case study as well (Yin 2003). Furthermore, a holistic view of behaviour can only be gained through a longitudinal analysis of people's activities vis-à-vis cross-sectional studies. A longitudinal analysis would also provide an opportunity to show how cause and effect occur (Stoecker 1991) over a chronological sequence of activities (Brunåker 1993) and help explore the historical contexts of processes, leading to a clear understanding of overall pictures of the behaviours, including critical events and their consequences (Kjellen and Soderman 1980; Gummesson 1991). With respect to policy analysis, the case study can be considered as an ideal strategy for fulfilling this requirement as the researcher may investigate how and why a certain programme has worked or not worked (Yin 2003). As was discussed before, given the case study strategy's ability to combine multiple methods, the researcher's understanding of the phenomenon could further be enhanced through conducting a survey or examining economic data under the umbrella of the case study. This will enhance capabilities of unravelling what the outcomes of a given policy or programme are, how many people have been affected, and with what kind of benefits/costs (Yin 2003). According to the same author, the case study approach relies on multiple sources of evidence, with data collected based on previously developed theoretical propositions converging in a triangulating fashion.

Since researchers have the freedom to define the approriate boundaries of the case study, they can capture a 360-degree view of the phenomenon being researched, which also has important implications for sampling decisions. The coverage can be from a single case study to carefully matched pairs to multiple cases (Hartley 2004). Furthermore, a single case has the ability to accommodate several sub-cases or sub-units of analysis (McClintock 1985; Yin 2018) selected through probability or non-probability sampling techniques (McClintock 1985; Yin 1994, p. 41), leading to a multiple embedded case-study design (Yin 1994).

7.3 Qualitative Methods and Their Appropriateness for Policy Analysis

Understanding behaviours is an essential aspect of policy analysis research, as policies are formulated and implemented to achieve sustainable socioeconomic development by changing/improving socioeconomic behaviours of target populations, so that wealth creation can be enhanced by minimising the misallocation of scarce resources. Therefore, policymakers/analysts must have a sound understanding of human behaviours and their causes. Fletcher (2017) argues that qualitative methods, in particular Critical realism, has helped researchers to search for causation through explaining social events and suggesting practical policy recommendations to address social problems. Fletcher provided a lucid example of Critical realism as an applied qualitative methodological framework to study Canadian farm women's experience with agricultural policy.

Quantitative research usually uses questionnaires for gathering primary data. They are designed with the assumption of individuals as the unit of analysis. However, the decision on the appropriate unit of analysis can only be made when the researcher accurately specifies the research questions (Yin 2003). For example, in rural farming contexts, behaviours can be understood by treating the household/family as the unit of analysis, enabling researchers to capture information on family dynamics (Kodithuwakku 1997; Kodithuwakku and Rosa 2002). Furthermore, treating the household/family as the unit of analysis has helped to gain insights into the production behaviours of farmers (Herrmann and Uttitz 1990, p. 8; Eboli and Turri 1988; Redclift and Whatmore 1990, p. 189; De Vries 1993). It has been widely argued that the behaviour of an individual or a social entity can meaningfully be understood within their environmental contexts (Bonoma 1985; Rosa and Bowes 1990; Miles and Huberman 1994, p. 27; Hartley 1994, p. 209). Therefore, we need to have a holistic perspective of the environmental context within which the behaviour takes place (Hartley 1994, p. 208–209; Hammersley 1989, p. 93; Gummesson 1992, p. 17; Rosa and Bowes 1990). Questionnaire surveys may have a limited capability in aiding researchers to gain an understanding of contextual factors (Miles and Huberman 1994, p. 35; Yin 2018). Furthermore, questionnaires are not capable of going beyond snapshots of events, such as by cutting across temporal and contextual gestalts of situations (Bonoma 1985, p. 204).

The qualitative research method is an umbrella term for a variety of techniques that aim to explain, decode, and translate the meaning-not frequency-of a naturally occurring phenomenon within the social world (Van Maanen 1979, p. 520. These techniques are described as “holistic” (McClintock et al. 1979, p. 612; Jick 1979, p. 609). They assist in unravelling complex patterns and social interconnections (Gummesson 1992, p. 15). Qualitative research accepts that several ways can be adopted to make sense of the world (Jones 1995, p. 2). They allow researchers to capture peoples’ view of the world and also the meanings perceived by them (Jones 1995, p. 2; Pope and Mays 1995, p. 42; Miles and Huberman 1994, p. 10). Qualitative methods allow the research to go beyond “snapshots” of “how many” to just “how” and “why” things happen (Pope and Mays (1995, p. 42), which statistical analyses are unable to fulfil (Miles and Huberman (1994, p.10) and Stoecker (1991, p. 94)).

In qualitative methods, explanation replaces measurement, and understanding replaces generalisability (Jones 1995, p. 2). This allows detailed examination of social processes and identification of factors peculiar to each case and a greater understanding of causality (McClintock et al. 1979, p. 612). Moreover, Hamel et al. (1993) highlighted the value of knowledge about the actor’s perspective of a given situation.

Qualitative data is generally regarded as superior to quantitative data concerning the density of information, vividness, and clarity of meaning – a characteristic very important in holistic work (Weiss 1968, p. 344; Jick 1979, p. 609). Data elicited by qualitative research is contextually embedded (Van Maanen 1979, p. 521; Miles and Huberman 1994, p. 10) in that they help to understand an observed behaviour within its environmental context (Van Maanen 1979, p. 521; Miles and Huberman 1994, p. 10). Therefore, unlike quantitative methods, qualitative methods are sensitive to the sociocultural context of collected data (Cassell and Symon 2004), and therefore, operating in a qualitative mode reduces the distance between context and actions (Van Maanen 1979, p. 520) and help to understand social phenomena in their natural settings (Pope and Mays 1995, p. 42) which is an essential requirement for improving the design and targeting of policies. Thus qualitative research methods may be the major or only valid knowledge accrual devices for studying human behaviours (Bonoma 1985, p. 203) in their real-life settings.

7.4 The Need for a Theoretical Framework

There is a misconception among some researchers that qualitative research adopts only the grounded theory approach. According to Yin (1994), grounded theory tempts the researcher to collect almost every piece of data without a clear direction. Such an approach would yield fascinating details about life in a particular context without wider significance (Hartley 1994). Similarly, research without theory would lead to an accumulation of anecdotes without regard to contextual differences

(Cochrane 1987, in Stoecker 1991). This necessitates the researcher to identify the central research question that governs the policy analysis process beforehand.

Policies are formulated with important socioeconomic theories in mind with the expectation of certain behavioural changes in the target populations once the policies are implemented. Therefore, for analysing a given policy or set of policies, it is important that researchers formulate a theoretical/conceptual framework beforehand by taking into account the behavioural changes that were expected during the policy formulation stages, based on which theoretical propositions can be developed to collect relevant data. Consequently, adopting a deductive approach would enable the researcher (a) to define the appropriate research design and methods of data collection and analysis as well as (b) to generate relevant results (Yin 1994). However, although adopting a positivist approach requires the researcher to formulate a theoretical framework prior to data collection and analysis, operating in a qualitative mode gives the researcher the freedom to modify the initially formulated theoretical/conceptual framework with the progress of data collection and analysis (Hartley 1994).

Adopting a theoretical framework in qualitative research would enable making choices with the progress of data collection to decide on/explore the appropriate line of further inquiries and discard inappropriate lines of inquiry, as well as identify relevant data and eliminate irrelevant variables during data analysis (Smith et al. 1992, p. 74; Bryman and Burgess 1994, p. 5; Jick 1979; Miles and Huberman 1994, p. 16–23; Ritchie and Spencer 1994, p. 176; Yin 1994, p. 104). This also enables the researcher to carry out sampling by looking at only some actors in some contexts dealing with some issues and relationships (Miles and Huberman 1994, p. 22). Thus, a theoretical framework provides clarity and focus, especially for inexperienced qualitative researchers concerned about diffuseness and data overload (Miles and Huberman 1994, p. 17), avoiding the vulnerability of researchers becoming overwhelmed by data and drawn into narratives (Hartley 1994).

Using a topic guide (i.e. loose template to assist in data gathering and analysis) developed based on the theoretical framework as the data collection tool assists researchers to carry out continuous data gathering and data analysis throughout the fieldwork. A topic guide also has the flexibility to accommodate new topics during the research, helping to capture a complete picture of the relevant behaviour.

Developing a theoretical framework prior to the collection of data also fulfils the requirement of adopting a theoretical sampling strategy when operating on a qualitative mode in order to gain a complete understanding of the phenomenon being studied.

7.5 Qualitative/Case Study Research and the Need for Theoretical Sampling

Most conventional field research is loosely structured. There is also a common misunderstanding that field research does not employ any form of sampling decisions as they are only applicable to survey research (Burgess 1982, p. 75).

However, Miles and Huberman (1994, p. 17) argue that “loosely designed studies make good sense only when experienced researchers have plenty of time” (Miles and Huberman 1994, p. 17) and, therefore, it is not possible to study every one everywhere and do everything (Miles and Huberman 1994, p. 27). Consequently, Jick (1979, p. 604) encourages researchers using the qualitative methodology to utilize sampling techniques as they help systematic data collection as well as analysis (Miles and Huberman 1994, p. 27).

Developing a theoretical framework prior to data collection (as discussed above) enables the researcher to adopt a theoretical sampling strategy when operating in a qualitative mode, which is essential to carefully decide what groups to study, where and when to study them, what data to collect, and when to stop studying them (Burgess 1982, p. 75). Theoretically driven selection of cases ensures complete coverage of a phenomena being studied and comparability across a diverse range of groups, letting the researchers identify and categorise emergent theoretical properties (Johnson 1990, p. 27); Miles and Huberman 1994, p. 17–18; Johnson 1990, p. 42). In other words, while data collection and analysis are in progress, theoretical sampling enables the researcher to make further sampling decisions (Glaser and Strauss 1967, in Burgess 1982, p. 75; Gummesson 1991, p. 84), refining the theory if deemed necessary (Pope and Mays 1995, p. 110).

Sampling in field research usually commences with the selection of a specific research site (Burgess 1982, p. 77; Strauss et al. 1964), so that a researcher can choose to explore the life-ways of one social aggregate rather than another. Furthermore, selection of a research site is considered as a function of qualitative data (Jick 1979, p. 604) as it influences the data that will be gathered (Burgess 1982, p. 76). As a result, the researcher’s decision where to locate herself/himself and her/his studies is an important sampling decision. This aspect ideally matches with the advantage of the case study strategy that the researcher can decide on the physical/geographical and sociocultural boundaries of the case study.[1]

Furthermore, sampling decisions of qualitative studies are chosen for theoretical, not statistical, reasons (Eisenhardt 1989, p. 537); hence they are “purposive” (Kuzel 1992; Moore 1989) and theory-driven (Miles and Huberman 1994, p. 27). In theoretical sampling, the goal is to select respondents who are likely to replicate or extend the emergent theory (Eisenhardt 1989). Sampling in qualitative research, therefore, is not pre-specified and can evolve through fieldwork (Miles and Huberman 1994, p. 27). Consequently, no sampling frames are available for the researcher adopting qualitative methods requiring her/him to rely on key informants for gaining insights on regular/usual patterns of behaviours (Freeman and Romney 1987; Freeman and Romney 1987; Johnson 1990, p. 35) as well as deviations

[1]For a lucid example for selecting a geographical boundary of a case study, see Kodithuwakku (1997) and Kodithuwakku and Rosa (2002) in which the authors selected a Sri Lankan village to explore entrepreneurial behaviour of rural farmers. Similarly, Leach (1967) drew conclusions on his fieldwork in just one village to counter some interpretations from an extensive survey conducted by Sakar and Tambiah (1957) in 57 villages on land ownership in Sri Lanka.

(Kodithuwakku and Rosa 2002), which is an essential requirement for policy analysis.

According to Cambell (1955), informants should be selected based on their informedness and ability to communicate with the social scientist rather than their representativeness. Key informants can act as (a) gatekeepers to research sites (Burgess 1982, p. 77), introducing researchers to other inhabitants, and (b) a source of cross-validation/triangulation for a variety of economic (Johnson 1990, p. 73) and contextual data (Kodithuwakku and Rosa 2002). Once the respondents are introduced by the key informants, the researcher can adopt snowball (or referral) sampling through which, at the end of each interview, respondents can be requested to introduce others whom they think are in the same category (Ostrander 1980, p. 75) or in different categories. Moreover, snowball sampling procedure provides the researcher with an explicit means of moving through a given community/social entity in a methodologically and theoretically meaningful manner (Werner 1989), as it enables the researcher to gain complete coverage of actors holding different theories that shape their behaviours concerning the policies being analysed. Repeated interviews in the snowball sampling procedure lead to the emergence of patterns (Johnson 1990). The researcher can decide to end the sampling process when there is little or no marginal addition of knowledge gained by interviewing one more respondent on the phenomenon being researched (Hartley 1994, p. 36; Yin 1994; Glaser and Strauss 1967).

7.6 Data Gathering

As discussed above, the case study strategy facilitates researchers to use multiple data sources. These can be primary data sources – in-depth interviews, brief informal interviews, focus discussions, ethnography, participatory rural appraisals, direct observations, participant observation, and field notes – and secondary data sources to establish the context. Collecting information through multiple sources enables the researcher to corroborate information through triangulation (Yin 2018; Eisenhardt 1989). Figure 7.1 demonstrates evidence from different data sources converge to validate findings (Fig. 7.1).

In case study/qualitative research, interviews are used to explore behaviours in a given context (Hartley 1994, p. 210). Interviewing is the most common method adopted in qualitative data gathering (King 2004). In-depth interviewing is central to all qualitative methods, as it allows the researcher to gain an understanding of the actors' perspectives of a given situation that were not structured in advance (Smith et al. 1992). Therefore, qualitative research interviews attempt to explore the research topic from the interviewee's perspective, to understand how and why they have gained the particular perspective (King 2004). They facilitate a more interactive interviewing process, enabling the researcher to trace how different issues and situations hold different significance for different respondents/sub-cases (Stoecker 1991). Interviews can be conducted using a topic guide prepared based on a prior formulated conceptual framework.

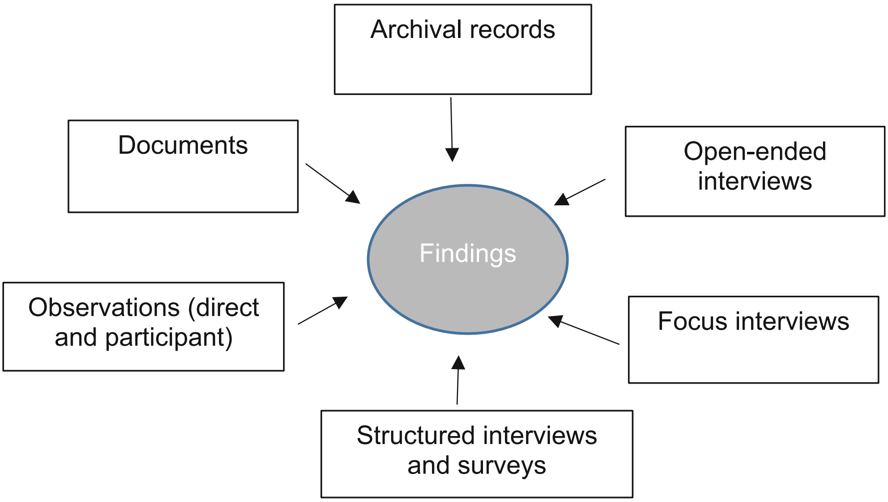

Fig. 7.1 Convergence of evidence: single case study. Source: Yin (2018)

Informants should be given freedom to choose the order of discussion, although the researcher should make a systematic attempt to fully cover the topics/areas of investigation (Tremblay 1957). The researcher may carry out repeated interviews with a given respondent if she/he deems it appropriate (Kodithuwakku and Rosa 2002). It is recommended that interviews begin with a general discussion on areas/topics that the respondents are more familiar with so that they can answer easily without embarrassment or distress, enabling the researcher to establish a better rapport.

In qualitative research, interviewees are considered participants in the research, as they actively shape the course of the interview unlike in questionnaire surveys where respondents passively respond to pre-set questions asked by the interviewer. Furthermore, allowing other interested respondents (such as family members) who wish to participate in interviews to do so enables data triangulation and further validation of findings. Researchers are advised to use audio-recording as this helps to conduct interviews in a natural discussion with minimal interruption (i.e. due to not having to take notes during the interview) (Kodithuwakku 1997). Box 7.1 illustrates the writer's experience that clearly shows the value of multiple respondents as a means of validating the findings through triangulation.

Box 7.1 Validating the Findings Through Triangulation

While this author was conducting field research on entrepreneurship among rural dry zone framers, a pattern emerged that participatory decision-making within households was one of the causes of entrepreneurial success. As I interviewed a farmer, whom key informants had identified as the household

(continued)

Box 7.1 (continued)
head of an unsuccessful farming family, the farmer stated that he always discussed with his wife before making important decisions. This left me a bit puzzled as to why the family was unsuccessful. While the interview was in progress, the farmer's wife joined the discussion. The farmer, showing his displeasure, said, "Why did you come here? You have no business here. Please go to the kitchen. It is the place you should be now". With subsequent probing, it was revealed that the farmer did not engage in participatory decision-making at all with his wife. Rather, he merely informed his wife before taking any important decision, unilaterally, to share the blame if something went wrong.

Had the researcher used a closed-ended questionnaire to collect data on participatory decision-making in a family setting, the findings would have been wrong.

Most agricultural activities are carried out in an open environment where relevant environmental conditions and resultant behaviours may be observed. Direct/participant observations on a wide array of activities (Pope and Mays 1995, p. 111) provide an opportunity to triangulate between what the respondents said during interviews and what they do (Yin 1994, p. 92). The findings from other data sources on contextual factors can be triangulated using observations (Jick 1979, p. 60) for capturing the decision makers' perceptions about their decision settings (Downey and Ireland 1979, p. 634). According to Rosa and Bowes (1990, p. 8), participant observations also can help the researcher to gain an understanding of complex social interactions. Certain observations can be captured as photographs/video recordings. Table 7.1 demonstrates different data sources and their contributions to the understanding of a given phenomenon (Kodithuwakku 1997).

7.7 Data Analysis

Yin (1994) argues that the main objective of data analysis is to produce compelling analytic conclusions by treating the evidence fairly and ruling out alternative interpretations. Data gathering and analysis in qualitative studies occur simultaneously (Bogdan and Biklen 1982; Eisenhardt 1989; Miles et al. 2014). Such a strategy enables the researcher to cycle back and forth between the existing data and generate strategies for collecting new data. Furthermore, early analysis allows production of the interim reports required in most policy studies.

In case studies, data analysis may be carried out in three simultaneous stages: within (sub-) case analysis, cross-case analysis, and comparison of findings with the theory. The within-case analysis enables the field researcher to describe, understand, and explain what has happened in a single case in a bounded context (Miles et al. 2014). After carefully describing data, a within-case analysis should be conducted in keeping with the conceptual framework that was developed before fieldwork, eventually leading to the identification of key processes (Miles and Huberman

Table 7.1 Different data sources and their contribution to the understanding of a given phenomenon

The sources and methods of data collection within the case study strategy	Main contribution of each source to the final understanding	Other contributions of each data source to the final understanding	
Key informants	Contextual	Theoretical	Triangulation
In-depth interviews (sub-cases)	Theoretical	Contextual	
Direct/participant observation	Contextual	Theoretical	
Field notes	Contextual	Theoretical	
Brief interviews (with the second parallel sample)	Confirmation of specific contextual factors and theoretically meaningful areas established from above sources	Theoretical	
Secondary data	Contextual	Theoretical	

Source: Kodithuwakku (1997)

1994, p. 33). First, data could be organised around certain topics created based on the central questions being addressed or key themes using tables to search for patterns (Hartley 2004). The topic guide developed based on the theoretical framework and used for data collection can also be used for this purpose (Kodithuwakku 1997). Then, data should be examined to see how far they fit or fail to fit into the expected categories (Hartley 2004), leading to recognition of patterns within each case/sub-case (Miles et al. 2014).

Next, a cross-case analysis could be carried out to identify similar and contrasting patterns across subcases (Eisenhardt 1989; Gummesson 1991; Yin 1981; Miles et al. 2014). The objective here is to understand if processes and outcomes across many cases are qualified by local conditions to develop more powerful explanations, enhancing the generalisability of the findings (i.e. the findings are applicable beyond a given specific case) or transferability to other contexts (Miles et al. 2014).

For this purpose, the case survey method could be used as a variable-oriented strategy (Miles et al. 2014) to instil scientific rigour into the study, provided that the number of cases is large enough to warrant cross-case tabulations (Yin 1981, p. 62). Finally, the data could be compared vis-à-vis the theoretical propositions that led to the case study investigation (Eisenhardt 1989, p. 544; Hartley 1994, p. 220; Yin 1994, p. 103) to arrive at conclusions.

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Part III

Tools to Analyse Sectoral and Global Regulations

General Equilibrium Analysis of Regional Trade Agreements

8

Sumali Dissanayake

Abstract

Quantitative analysis of the effects of trading agreements is important to answer the question, whether the gains from trade exceeds its costs. The ability to analyse such effects is essential for policymakers and other stakeholders who are at different stages of the policymaking process. Using a computable general equilibrium framework, this chapter introduces the quantitative analysis of the effects of regional trade agreements focusing on Sri Lanka as a case. Among the key modelling approaches available to analyse such effects, the standard Global Trade Analysis Project (GTAP) model is discussed with the required GTAP package and stepwise procedure of policy experiments. The chapter uses the simplest version available to carry out basic level policy experiments, the 3×3 model, to run simulations on various trade liberalization scenarios. Extracting and interpreting results of the GTAP outputs are discussed to provide meaningful insights on trade policy-related reforms, strategies, and recommendations.

Keywords

GTAP model · Computable GE · Trade liberalization · Policy experiments · Trade agreements

8.1 Introduction

As the world economy becomes more integrated, with a growing number of Regional Trading Agreements (RTAs), there is an increasing demand for quantitative analysis of the impacts of such agreements. The chapter provides an overview of

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RTAs, the policy milestones of Sri Lanka, the available tools, and a simple guide for selecting an appropriate tool for analysing the effects of RTAs. A natural way to become familiar with a model is through a simple application. This chapter uses the standard GTAP model as an application to analyse the effects of RTAs. Hence, the fundamental components of the standard GTAP model are discussed with some policy experiments and simulations using a 3×3 example. The next section focuses on extracting the results from GTAP model outputs and deriving policy recommendations.

8.2 The Context

8.2.1 Intentions of the Policy and Global Context

The formation of RTAs has become a popular trade strategy for many developing economies to regulate trade with their partner countries. According to the World Trade Organisation (WTO), 302 RTAs were in force as of September 2019 (see Fig. 8.1). In the early days, the objective in forming RTAs was to liberalise bilateral tariffs among member countries. However, in the present era the objectives of RTAs go beyond tariffs to cover multiple policy areas, including para-tariffs, behind-the-border regulations such as competition policy, government procurement rules, and intellectual property rights. Accordingly, many forms of RTAs can be identified based on the type of liberalisation. When preferential access is given to member countries by lowering bilateral tariffs, the RTA is termed a Preferential Trading Agreement (PTA). When bilateral tariffs are fully eliminated, the agreement is termed as a Free Trade Agreement (FTA). The agreements that cover tariffs and

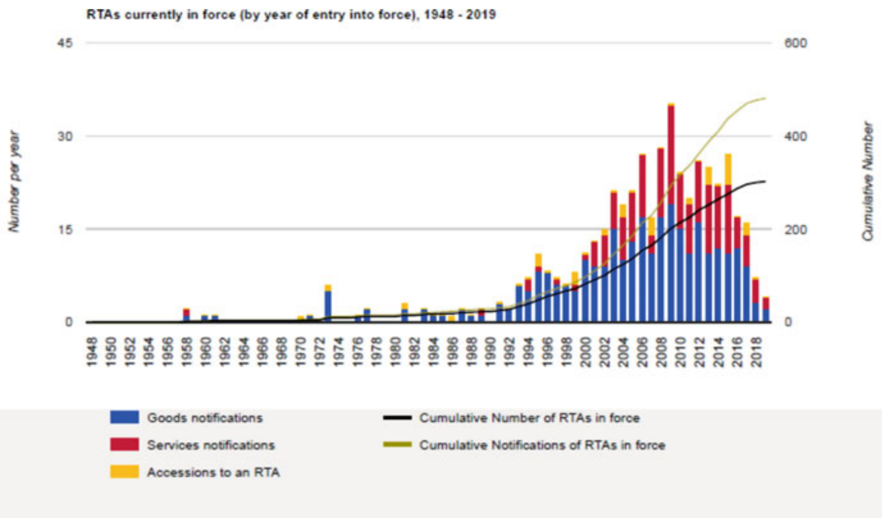


Fig. 8.1 RTAs currently in force 1948–2019. Source: World Trade Organisation (2019)

other border measures are termed as shallow agreements, and those that extend to cover behind-the-border issues are deep agreements.

The benefits of RTAs are due to the potential trade that is created among a group of countries. Economic benefits of trade creation are found to be quite large in RTAs which demonstrate trade complementarities among member countries, higher initial tariffs, and similar tariffs on non-member countries, but they however can yield welfare losses when the RTA diverts trade from efficient non-member countries to less-efficient member countries. In such situations, the member country could incur revenue losses due to preferential tariffs provided to inefficient member countries. When such losses are greater than gains due to trade creation, welfare losses occur.

The definition of Rules of Origin (ROO) criteria is an essential element in RTAs to prevent trade deflections from non-member countries. When multiple RTAs are signed by a single country, the administrative and implementation costs of ROO can be sizable.

The current move of the Sri Lankan government to negotiate with multiple countries to form FTAs needs to be assessed against the above background. The RTAs in force with respect to Sri Lanka are the Asia-Pacific Trade Agreement (APTA); Global System of Trade Preferences (GSTP); India-Sri Lanka FTA; Pakistan-Sri Lanka FTA; South Asian Free Trade Agreement (SAFTA); the South Asian Preferential Trade Agreement (SAPTA); and most recently, the Sri Lanka-Singapore FTA. The government plans to expand and deepen the existing RTAs and form FTAs under the category of deep agreements. The agreement with the government of India is a good example.

8.2.2 Sri Lanka as a Member of the South Asian Preferential Trading Agreement and South Asian Free Trade Area

The concept of SAPTA, a form of RTA, was initiated by Sri Lanka during the sixth South Asian Association for Regional Cooperation (SAARC) summit held in Sri Lanka in 1991. It was agreed that SAPTA is the first step towards higher levels of trade relations and economic cooperation among the SAARC member countries. SAPTA came into operation in December 1995 with the aim of gradual widening intraregional trade and achieve full liberalization, allowing free movement of goods, services, and other resources within the region. Afghanistan, the eighth member of the region, was added to the agreement in 2005. The SAPTA was transformed into a free trade area and a new form of the agreement called the South Asian Free Trade Area (SAFTA) established in 2006. The objective of forming SAFTA was to further promote and enhance the mutual trade among member countries. As a result of these agreements, since the early 1990s, the region has made considerable progress in the performance in the trade that enabled the region to enhance its integration with the world economy. Tables 8.1 and 8.2 show Sri Lanka's country-wise imports and exports under SAPTA and SAFTA during the last 5 years. The values indicate that India is the major export destination of the country's products as well as the main source of imports followed by Bangladesh.

Table 8.1 Sri Lanka's country-wise imports and exports under SAPTA

Value in US$ Mn

	2015		2016		2017		2018		2019	
Country	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import
India	4.09	0.68	2.67	0.17	2.89	0.07	2.86	0.18	1.54	0.07
Bangladesh	0.77	0.04	0.62	0.01	1.52	–	0.55	0.02	0.19	0.04
Nepal	0.03	–	0.00	–	–	–	0.01	–	0.01	–
Pakistan	0.36	–	0.10	0.26	0.04	0.11	0.03	0.03	0.00	–
Maldives	0.01	–	0.01	–	0.04	–	0.06	–	–	–
Total	5.26	0.72	3.40	0.44	4.49	0.18	3.52	0.23	1.75	0.11

Source: Department of Commerce Sri Lanka (2020)

Table 8.2 Sri Lanka's country-wise imports and exports under SAFTA

Value in US$ Mn										
	2015		2016		2017		2018		2019	
Country	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Afghanistan	–	–	–	–	–	–	–	–	–	–
Bangladesh	0.23	0.12	2.49	0.10	5.98	0.18	4.25	0.17	8.33	0.60
Bhutan	0.01	–	–	–	–	–	–	–	–	–
India	21.82	4.87	4.67	6.14	34.65	5.79	30.47	5.27	46.62	5.78
Maldives	0.11	–	0.02	–	0.03	–	0.03	–	0.05	–
Nepal	0.12	–	0.27	–	0.29	–	0.15	–	0.04	–
Pakistan	0.79	0.02	0.06	0.01	0.13	0.01	0.44	0.02	0.86	0.01
Total	23.08	5.00	7.51	6.24	41.08	5.97	35.34	5.46	55.89	6.39

Source: Department of Commerce Sri Lanka (2020)

8.3 An Application

8.3.1 Selection of a Tool to Analyse the Effects of an RTA

Trade policy reforms result in both direct and indirect effects with significant impacts on all economic agents. An analytical tool needs to be chosen based on the nature of impacts one needs to analyse, considering overall linkages of those relationships.

The key approaches used so far can be grouped into two broad categories based on the nature of values assigned to model parameters: econometric models and simulation models (refer to Fig. 8.2). In econometric models, the parameters are estimated statistically, while in simulation models, they are typically drawn from prior econometric studies and other simulation models, as well as being based on analysts' intuition and judgment. In between these broad categories, there are hybrid approaches which combine the features of both.

Econometric models used for measuring the effects of trade agreements can be further grouped into two general classes – models designed to predict trade flows between countries and models designed to predict the economic impacts[1] of trade. The gravity model is the most popular econometric model used to predict trade flows between countries (see Chap. 9). Two distinct variables are used in the gravity model: incomes of trading partners and distance between the countries, including physical distance as well as distance created through other ways and means.[2] The gravity equation has been used in many studies related to international trade, and many success stories can be found. The model has been used not only to estimate the effects of trade flows due to trade agreements but also relationships that can be used to formulate theories of international trade. In fact, most of the relationships estimated through the gravity model (such as longer-term effects on productivity and technological change) cannot be estimated using simulation models (Abler 2007).

Simulation models used for measuring the effects of trade agreements can be further classified according to the coverage of sectors in an economy as Partial Equilibrium (PE) models and Computable General Equilibrium (CGE) models or Applied General Equilibrium models (AGE). PE models cover a limited set of goods and services within an economy or group of economies; CGE models cover all goods and services simultaneously within an economy or group of economies.

A large number of PE and CGE models have been used to analyse agricultural and trade policies (Abler 2007). In measuring the effects of trade agreements on the food and agricultural sector, PE models consider the sector a closed system that does not have significant effects on the rest of the economy, although the latter can still

[1]Economic impacts include changes in employment and wages, productivity, competition, etc.

[2]Distance created through trade barriers, colonial ties, customs unions, common borders, quality of economic and political institutions of two partners, languages, ethnicities, religions, and so on.

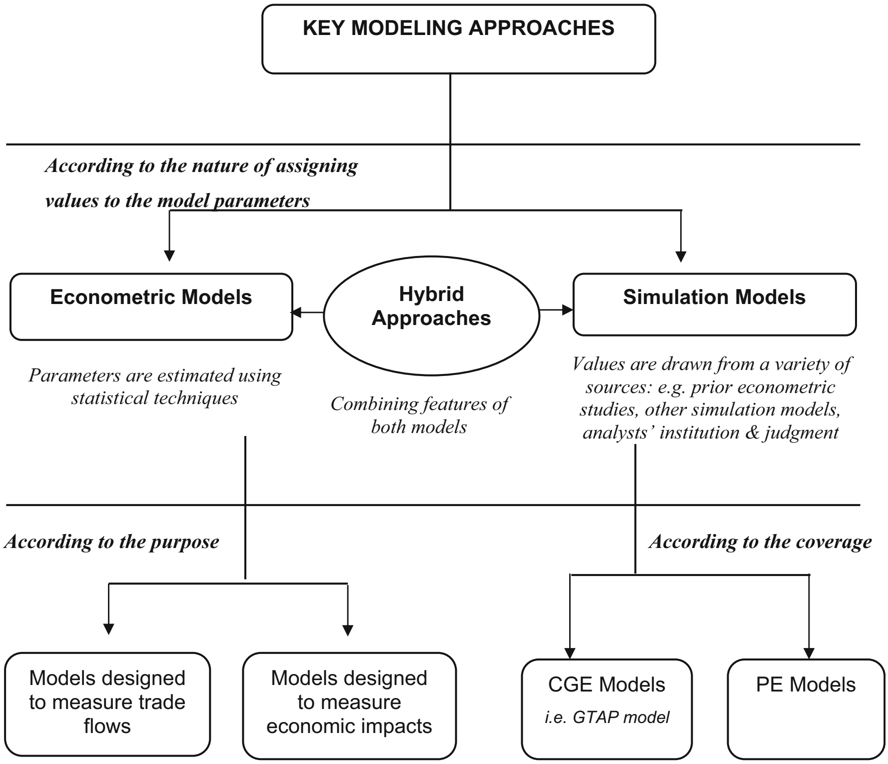


Fig. 8.2 Key modelling approaches. Source: Compiled from Abler (2007)

affect the food and agriculture sector. In contrast, CGE models consider the food and agricultural sector an open system that can potentially have significant effects on the rest of the economy. Therefore, the results attained through the two models may have significant differences.

Literature suggests that CGE models are appropriate to analyse the effects of trade agreements on employment and food processing sectors; to gauge the effects of trade agreements which involve developing countries; to determine long-run effects; and to perform aggregate social welfare calculations. The Global Trade Analysis Project (GTAP) is such a model which we are going to discuss in the next section. On the other hand, PE models are appropriate for study products at a fine level of detail and to represent complex agricultural policies accurately. These models best analyse the short-run effects when up-to date data is utilised (Abler 2007).

There are strengths as well as weaknesses in every model mentioned above. Importantly, no single model can fully capture all the possible impacts of a complex trade agreement. It is the analyst's responsibility to select the most appropriate model in line with the focus of the study.

8.3.2 Structure of the GTAP Model

The Global Trade Analysis Project is a CGE model established in 1992. The model was introduced with the objective of supporting those seeking to conduct quantitative analysis of international economic issues under an economy-wide framework. The model is comprised of several parts, including a fully documented global database, a standard modelling framework, and software for data manipulation and implementation of the standard model (Hertel 1997).

More specifically, the GTAP is a comparative-static, multisector, multiregional model which assumes perfect competition and constant returns to scale. It is based on national or regional input-output tables and fully tracks bilateral trade flows between all the countries in the database. The consumption and production of all commodities in each of the national economies are explicitly modelled and fully documented in Hertel (1997). The GTAP uses the theory and structure of Australia's ORANI model, a multisectoral model of the Australian economy. For its implementation, the GTAP uses a software called GEMPACK (General Equilibrium Modelling PACKage) developed at the Centre of Policy Studies in Australia (see Harrison and Pearson, 1996). There is wide use of this model in empirical analyses. While the GTAP model has several extensions, this chapter introduces the standard GTAP model. It describes the global economy, assuming the same model structure for each economy and following a bottom-up approach, i.e. aggregating from individual regions to the world. The economies are linked through international trade and investment flows.

For ease of understanding, assume a simplified version of the GTAP called OneGTAP model. In this model, there is only one region and hence no trade, no depreciation, and no taxes or subsidies. Specifically, it is a closed economy. Figure 8.3 shows a schematic representation of the OneGTAP model.

The model is based on the standard neo-classical assumption that consumers maximise utility. At the top of Fig. 8.3, there is a regional household which collects all the income of the region and allocates this income among three types of expenditure: (1) private expenditure, (2) government expenditure, and (3) savings. These expenditures are governed by an aggregate Cobb-Douglas utility function that allocates constant budget shares across the three types. One advantage of allocating constant shares of income among the three is the explicit, empirically more acceptable indicator of welfare offered by the aggregate utility function, a key indicator used in many analyses. Private household preferences are represented using the non-homothetic constant difference elasticity functional form.

Since there are no taxes, the only source of income for the regional household is sale of endowment commodities to firms. The income is denoted as **VOA** $_{\text{(endow)}}$ (Value of Output at Agents' prices of endowment commodities). Producers are assumed to maximise profits. Firms use five types of primary endowments: land, capital, skilled and unskilled labour, natural resources, and intermediate goods (**VDFA**, Value of Domestic purchases by Firms at Agents' prices) to produce final goods for consumption. Sales of these final goods are to (1) private households (**VDPA**, Value of Domestic purchases by Private households at Agents' prices);

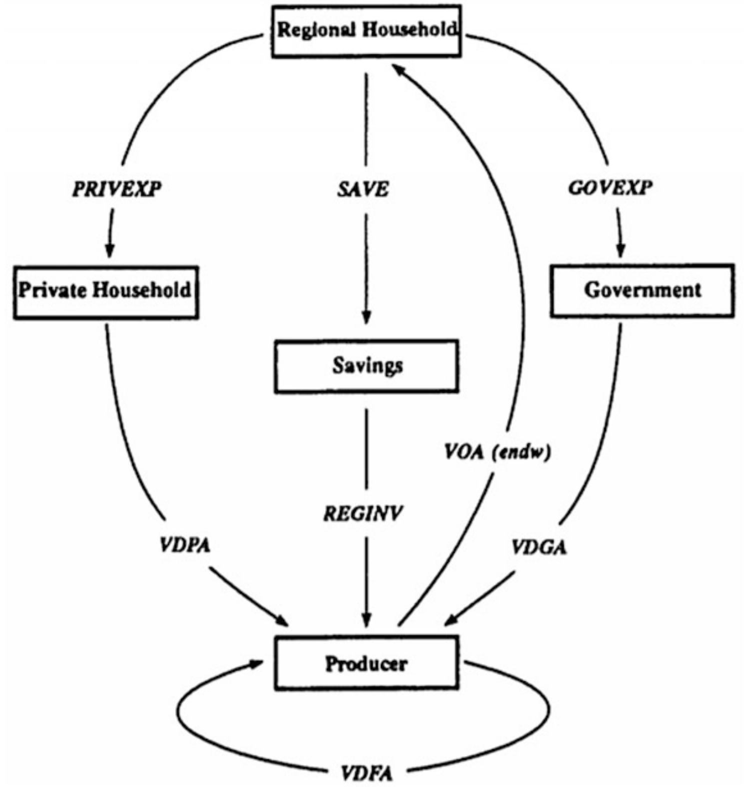


Fig. 8.3 OneGTAP model, one-region closed economy. Source: Hertel (1997)

(2) government households (**VDGA**, Value of Domestic purchases by Government households at Agents' prices); and (3) sales of Investment goods (**REGINV**) to fulfil regional household's demand for savings. The world is balanced when **Savings = Investments**. See Fig. 8.3.

Now let us assume a multiregion open economy by introducing international trade to the OneGTAP model discussed above. Hence, we add another region called "Rest of the world' to the bottom of the diagram. The new model is presented in Fig. 8.4.

The new region (Rest of the World) acts as a source of imports into the regional economy and as a destination of the region's exports. The notation **VXMD** represents Value of eXports at Market prices by Destination. Three types of specific agents in the economy trace the imports from the rest of the world. Accordingly, these agents make three types of import payments to the rest of the world, namely, (1) **VIPA** (Value of expenditure on Imports by Private household at Agent prices); (2) **VIGA** (Value of expenditure on Imports by Government household at Agent prices); and **VIFA** (Value of Imports by Firms at Agent prices).

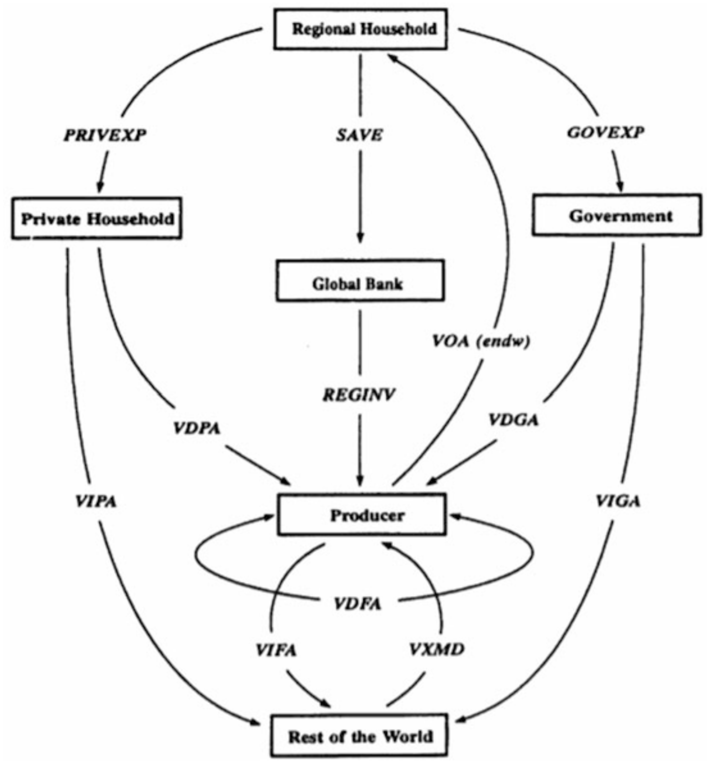


Fig. 8.4 Multiregion open economy. Source: Hertel (1997)

When the model moves to a multiregion open economy, we introduce another two global sectors: (1) global banking and (2) international trade and transport. Global investments are linked to global savings through the global bank. This sector brings savings and investments in the model into equilibrium. The explicit treatment of international trade and transport margins is another unique feature of the standard GTAP model. Bilateral trade is specified via Armington elasticity between imported and local commodities (Hertel 1997).

In the multiregion open economy model, the world is balanced when the following requirements are fulfilled.

Global savings = Global investments

Total exports = Total imports

8.3.3 Components of the GTAP Package

Here we introduce the following implementing software and database to practice policy experiments:

1. The most recent publicly available database (GTAP Database Version 8) (visit https://www.gtap.agecon.purdue.edu/databases/default.asp)
2. RunGTAP (visit https://www.gtap.agecon.purdue.edu/products/rungtap/default.asp)
3. GTAPAgg (visit https://www.gtap.agecon.purdue.edu/products/packages.asp)

The GTAP database version 8 is the main component of the GTAP package (earlier versions are also available for free download). This version includes data on bilateral trade information, transport, and protection for 129 regions of the world and 57 commodity sectors, for two reference years, 2004 and 2007. For simulation exercises, the database is used with GTAP model and RunGTAP software which are available for download using the above links.

RunGTAP is the visual interface to the GTAP model and automates the GTAP simulations. It provides easy access to many output files, such as model solutions, and updated data after the shocks have been implemented. It uses the GEMPACK software for its processes.

The GTAPagg programme is used to aggregate the data (i.e. regions, commodities, and endowments) that are appropriate for study objectives and analysis.

8.3.4 Policy Experiments

This section explores use of RunGTAP to perform policy experiments. Figure 8.5 is a screenshot of the RunGTAP home screen which can be obtained by double-clicking the RunGTAP icon on your desktop.

The steps below summarise the procedure required to view data files and set information and parameter values.

1. Open 3 × 3 Version
   Double Click *RunGTAP* | Select *Version* | Select *Change* | Select *ACORS3 × 3* in the Load Version | Click *OK*.

   These steps will open the ACORS3 × 3 model, the version we use to become familiarised with GTAP experiments.

   Loading the selected version in the version page of the RunGTAP gives summary information about the current version (for this exercise, ACORS3 × 3). The first few lines state the summary of the version and the regional and commodity aggregation used (refer to Fig. 8.6). ACORS3 × 3 aggregates GTAP regions and commodity sectors into three regions – SSA (Sub-Saharan Africa); EU (European Union); and ROW (Rest of the World) – and three goods: food (food and agriculture); mnfs (resources and manufactures); and svces (all services).

   The lower half of the version page shows the experiments, shocks, closures, and solution methods used in policy simulations carried out with this version (see Fig. 8.7).

Fig. 8.5 RunGTAP home screen. Source: Horridge (2001)

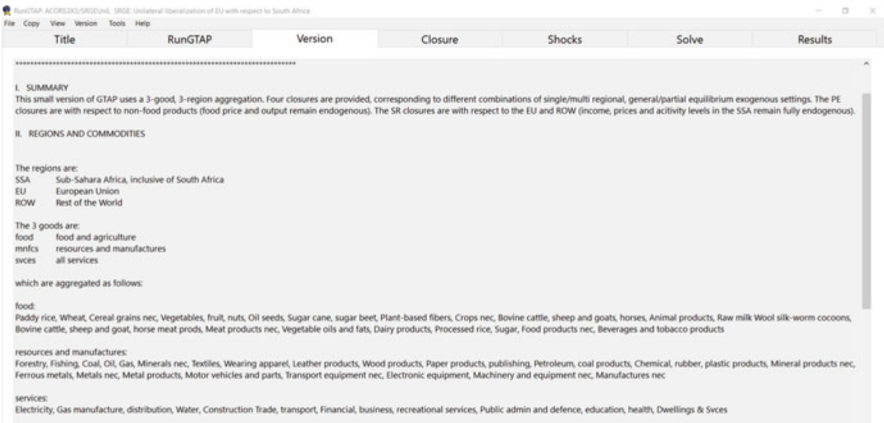


Fig. 8.6 Version summary and regional and commodity aggregation in ACORS3 × 3 model. Source: Horridge (2001)

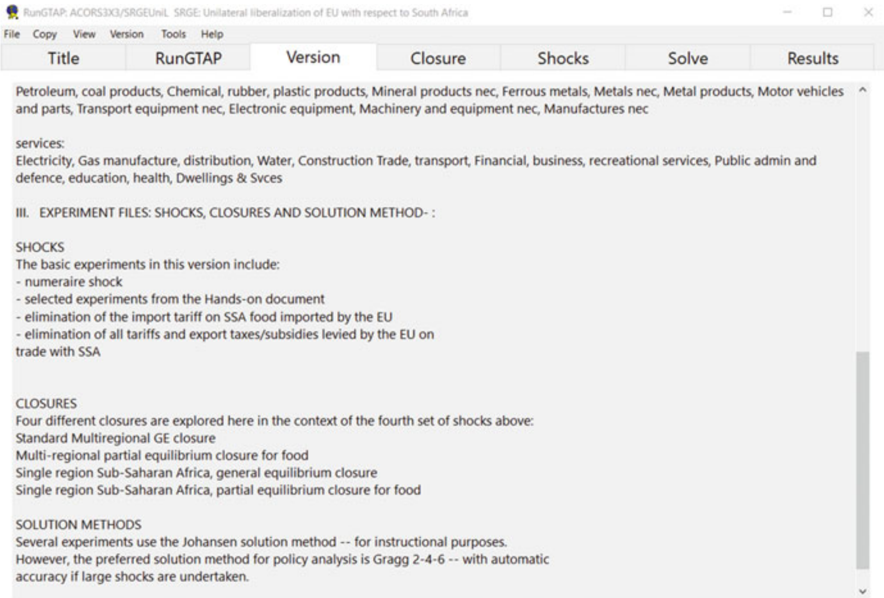


Fig. 8.7 Shocks, closures, and solution methods used in ACORS3 × 3 model. Source: Horridge (2001)

2. View Data using RunGTAP

   Each GTAP version has three main files.

1. Global dataset file: **GTAPDATA**
2. File containing information about the sets (including aggregated regions and commodity sectors appropriate for your analysis): **GTAPSETS**
3. File containing parameter values used in experiments: **GTAPPARM**

8.3.4.1 Viewing GTAPDATA

The file contains input-output data for each region and global trade data. This is base-year data (the data before the shocks have been given). Data under different headers containing 26 coefficients may be viewed on this screen. For example, bilateral exports can be seen in array number 3, at Header **VXWD**. To see the actual data, double click on the **VXWD** row. The following data (Fig. 8.8) will appear.

Figure 8.9 is a screenshot of the header **VXWD**. It shows the values for bilateral exports of three commodities by the three regions considered in this version. The values are in USD millions in 1995.

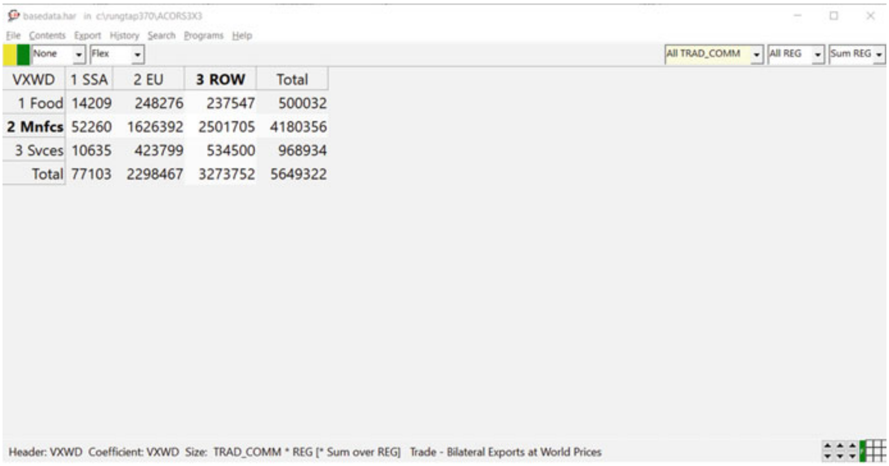
Question: What is the value of food exports by the EU to all the regions?

8.3.4.2 Viewing GTAPSETS

There are two types of main GTAP sets that can be created given the data in the ACORS3 × 3 model.

	Header	Type	Dimension	Coeff	Total	Name
1	DVER	RE	1	VERNUM	5.00	version of GTAP data
2	VTWR	RE	MARG_COMM*TRAD_COMM*REG*REG	VTWR	317195	Value of transport services at world prices, by
3	VXWD	RE	TRAD_COMM*REG*REG	VXWD	5649322	Trade - Bilateral Exports at World Prices
4	VIWS	RE	TRAD_COMM*REG*REG	VIWS	5966517	Trade - Bilateral Imports at World Prices
5	VST	RE	MARG_COMM*REG	VST5	317196	sales to trade and transport -- margins comm
6	EVFA	RE	ENDW_COMM*PROD_COMM*REG	EVFA	25917713	Endowments - Firms' Purchases at Agents' Pri
7	EVOA	RE	ENDW_COMM*REG	EVOA	25917714	Endowments - Output at Agents' Prices
8	SAVE	RE	REG	SAVE	2799012	Savings - Net Expenditure at Agents' Prices
9	VDEP	RE	REG	VDEP	3274395	Capital Stock - Value of Depreciation
10	VDFA	RE	TRAD_COMM*PROD_COMM*REG	VDFA	28172661	Intermediates - Firms' Domestic Purchases at
11	VDFM	RE	TRAD_COMM*PROD_COMM*REG	VDFM	27811951	Intermediates - Firms' Domestic Purchases at
12	VDGA	RE	TRAD_COMM*REG	VDGA	4179484	Intermediates - Government Domestic Purcha
13	VDGM	RE	TRAD_COMM*REG	VDGM	4146621	Intermediates - Government Domestic Purcha
14	VDPA	RE	TRAD_COMM*REG	VDPA	16293990	Intermediates - Household Domestic Purchas
15	VDPM	RE	TRAD_COMM*REG	VDPM	15719091	Intermediates - Household Domestic Purchas

Fig. 8.8 Base data view in ACORS3 × 3 model. Source: Horridge (2001)



VXWD	1 SSA	2 EU	3 ROW	Total
1 Food	14209	248276	237547	500032
2 Mnfcs	52260	1626392	2501705	4180356
3 Svces	10635	423799	534500	968934
Total	77103	2298467	3273752	5649322

Fig. 8.9 View of Header VXWD. Source: Horridge (2001)

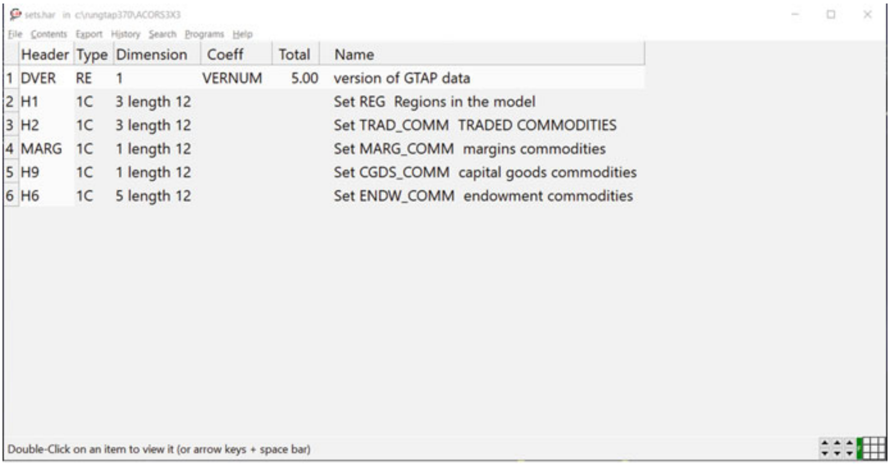
1. Regional set (called REG) – under header H1.
2. Tradable commodities set (called TRAD_COMM) – under header H2.

There are additional types of sets too.

To view the GTAPSETS, you need to return to **RunGTAP** and follow the following steps.

View | Sets

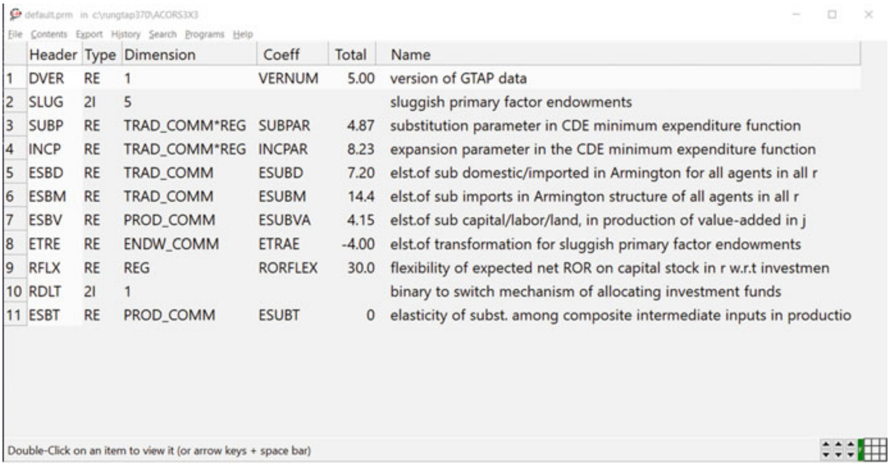
Figure 8.10 displays a view of GTAPSETS.



	Header	Type	Dimension	Coeff	Total	Name
1	DVER	RE	1	VERNUM	5.00	version of GTAP data
2	H1	1C	3 length 12			Set REG Regions in the model
3	H2	1C	3 length 12			Set TRAD_COMM TRADED COMMODITIES
4	MARG	1C	1 length 12			Set MARG_COMM margins commodities
5	H9	1C	1 length 12			Set CGDS_COMM capital goods commodities
6	H6	1C	5 length 12			Set ENDW_COMM endowment commodities

Double-Click on an item to view it (or arrow keys + space bar)

Fig. 8.10 View of GTAPSETS. Source: Horridge (2001)



	Header	Type	Dimension	Coeff	Total	Name
1	DVER	RE	1	VERNUM	5.00	version of GTAP data
2	SLUG	2I	5			sluggish primary factor endowments
3	SUBP	RE	TRAD_COMM*REG	SUBPAR	4.87	substitution parameter in CDE minimum expenditure function
4	INCP	RE	TRAD_COMM*REG	INCPAR	8.23	expansion parameter in the CDE minimum expenditure function
5	ESBD	RE	TRAD_COMM	ESUBD	7.20	elst.of sub domestic/imported in Armington for all agents in all r
6	ESBM	RE	TRAD_COMM	ESUBM	14.4	elst.of sub imports in Armington structure of all agents in all r
7	ESBV	RE	PROD_COMM	ESUBVA	4.15	elst.of sub capital/labor/land, in production of value-added in j
8	ETRE	RE	ENDW_COMM	ETRAE	-4.00	elst.of transformation for sluggish primary factor endowments
9	RFLX	RE	REG	RORFLEX	30.0	flexibility of expected net ROR on capital stock in r w.r.t investmen
10	RDLT	2I	1			binary to switch mechanism of allocating investment funds
11	ESBT	RE	PROD_COMM	ESUBT	0	elasticity of subst. among composite intermediate inputs in productio

Double-Click on an item to view it (or arrow keys + space bar)

Fig. 8.11 View of parameters. Source: Horridge (2001)

8.3.4.3 Viewing GTAPPARM

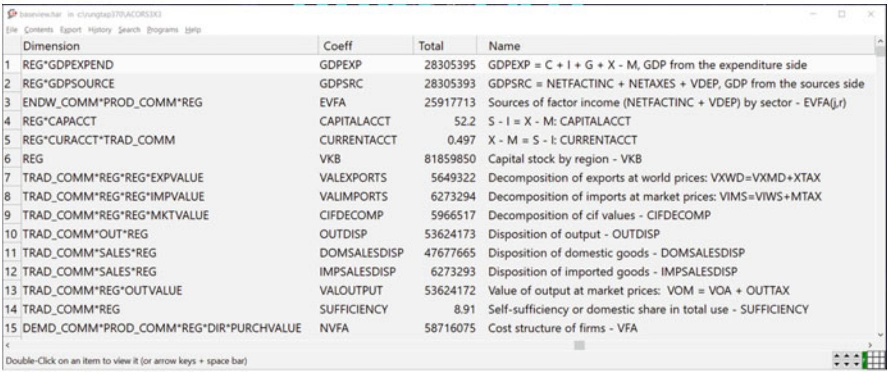
The parameter values used in GTAP simulations can be seen in RunGTAP by clicking on the following.

View* | *Parameters

The header ESBV (see Fig. 8.11) gives the parameter value, "Elasticity of substitution between endowments".

8.3.4.4 Viewing ACORS3 × 3 Data Using GTAPVIEW

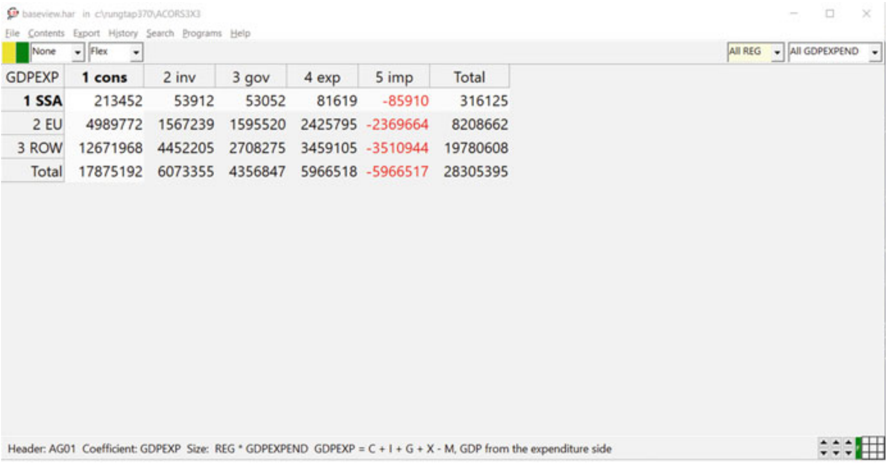
Go to RunGTAP and complete the following step. You can view the base data using GTAPVIEW (see Fig. 8.12).



	Dimension	Coeff	Total	Name
1	REG*GDPEXPEND	GDPEXP	28305395	GDPEXP = C + I + G + X - M, GDP from the expenditure side
2	REG*GDPSOURCE	GDPSRC	28305393	GDPSRC = NETFACTINC + NETAXES + VDEP, GDP from the sources side
3	ENDW_COMM*PROD_COMM*REG	EVFA	25917713	Sources of factor income (NETFACTINC + VDEP) by sector - EVFA(j,r)
4	REG*CAPACCT	CAPITALACCT	52.2	S - I = X - M: CAPITALACCT
5	REG*CURACCT*TRAD_COMM	CURRENTACCT	0.497	X - M = S - I: CURRENTACCT
6	REG	VKB	81859850	Capital stock by region - VKB
7	TRAD_COMM*REG*REG*EXPVALUE	VALEXPORTS	5649322	Decomposition of exports at world prices: VXWD=VXMD+XTAX
8	TRAD_COMM*REG*REG*IMPVALUE	VALIMPORTS	6273294	Decomposition of imports at market prices: VIMS=VIWS+MTAX
9	TRAD_COMM*REG*REG*MKTVALUE	CIFDECOMP	5966517	Decomposition of cif values - CIFDECOMP
10	TRAD_COMM*OUT*REG	OUTDISP	53624173	Disposition of output - OUTDISP
11	TRAD_COMM*SALES*REG	DOMSALESDISP	47677665	Disposition of domestic goods - DOMSALESDISP
12	TRAD_COMM*SALES*REG	IMPSALESDISP	6273293	Disposition of imported goods - IMPSALESDISP
13	TRAD_COMM*REG*OUTVALUE	VALOUTPUT	53624172	Value of output at market prices: VOM = VOA + OUTTAX
14	TRAD_COMM*REG	SUFFICIENCY	8.91	Self-sufficiency or domestic share in total use - SUFFICIENCY
15	DEMD_COMM*PROD_COMM*REG*DIR*PURCHVALUE	NVFA	58716075	Cost structure of firms - VFA

Double-Click on an item to view it (or arrow keys + space bar)

Fig. 8.12 View of base data using GTAPView. Source: Horridge (2001)



GDPEXP	1 cons	2 inv	3 gov	4 exp	5 imp	Total
1 SSA	213452	53912	53052	81619	-85910	316125
2 EU	4989772	1567239	1595520	2425795	-2369664	8208662
3 ROW	12671968	4452205	2708275	3459105	-3510944	19780608
Total	17875192	6073355	4356847	5966518	-5966517	28305395

Header: AG01 Coefficient: GDPEXP Size: REG * GDPEXPEND GDPEXP = C + I + G + X - M, GDP from the expenditure side

Fig. 8.13 GDP Decomposition of ACORS3 × 3 model using GTAPView. Source: Horridge (2001)

View | Base Data | GTAPView Output

Macroeconomic data, such as GDP in the base year, can be obtained in GTAPView. The header REG*GDPEXPEND (see Fig. 8.9) gives GDP of expenditure side. Click twice on the header AG01 to return to a page where you can see the decomposition of GDP in the base year (Fig. 8.13).

Question 1:

What is the value of GDP on the expenditure side in the EU?

Question 2:

How much of the EU's GDP comes from household consumption?

Question 3:

How much of the EU's GDP comes from exports?

8.3.5 Policy Simulations

Now let's do a simple simulation using RunGTAP following the steps given below. We use the same version discussed above, ACORS3 × 3 (Horridge 2001).

Simulation: Import liberalization
Introduce 15% reduction in EU's tariff on food products imported from SSA

1. Start with RunGTAP and select ACORS3 × 3 version (see Fig. 8.14).
   In the simulation exercise we access Closure, Shocks, Solve, and Results in RunGTAP in that order, left to right.
2. Click on the **Closure** page (see Fig. 8.15). You will see the list of exogenous variables considered in the simulation. You have the option to change the closure shown on the closure page and save the edited closure.

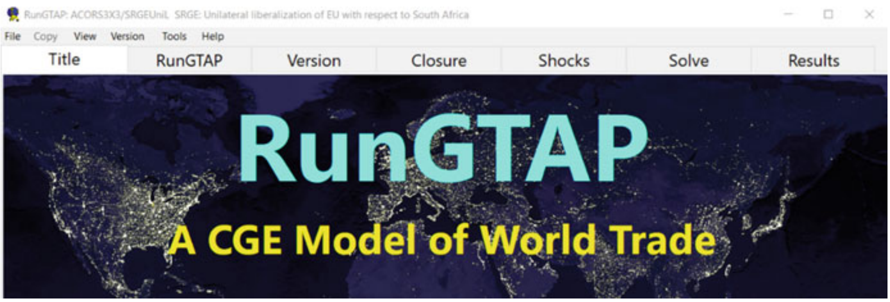


Fig. 8.14 Title page of RunGTAP. Source: Horridge (2001)

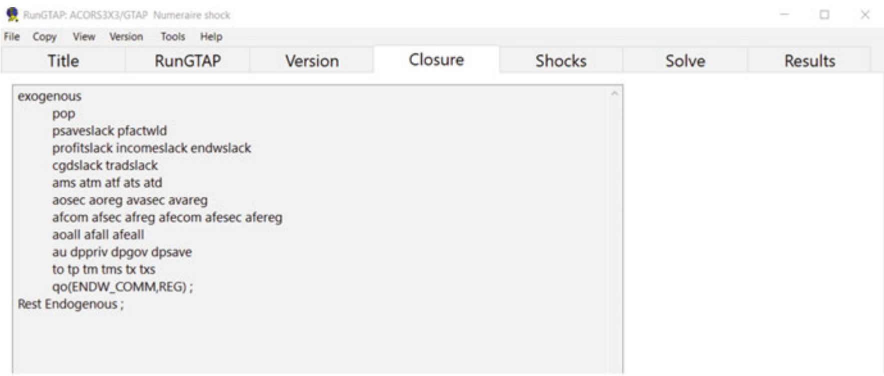


Fig. 8.15 The view of model closure in RunGTAP. Source: Horridge (2001)

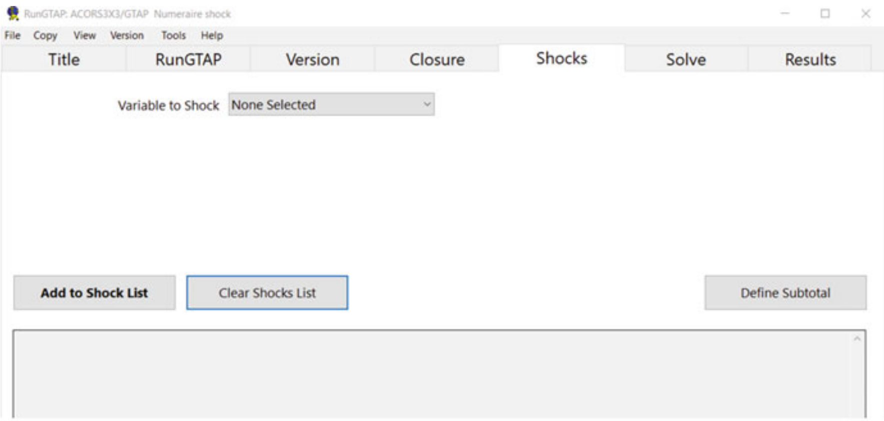


Fig. 8.16 The Shocks page of RunGTAP. Source: Horridge (2001)

3. Click on the **Shocks** page. The shock is to introduce a 15 per cent tariff cut for food products imported from SSA into the EU. See Fig. 8.16.
   First, clear the existing shocks by clicking on: **Clear Shocks List**. This option enables you to delete the default shocks already given in the shock list.
4. Select Variable to Shock **tms.** Use the first combo box on the top-left corner to select the variable you need to shock. Here, our simulation is import liberalisation which directly says the variable to shock is source specific tariff. Selecting the variable tms on the right provides the variable definition as source specific change in tax on imports of I from r into s.
5. Select Elements to Shock **All TRAD_COMM** from **SSA** from **EU**. On selecting the variable to shock, a second combo box will appear: elements to shock from where (exporter) to where (destination/importer). Click on the arrow of the first box which currently says ALL TRAD_COMM (all trade commodities) and change this to Food, as our simulation is for food commodities.
   Next, click on the second box which currently says **ALL REG**, showing you the disaggregated regions considered in the ACORS3 × 3 version. Choose the origin of the food commodities given for the simulation exercise by selecting **SSA** from the list. Also, in the next box, select the importer **EU** from the list.
6. Type of Shock % - **%change rate.**
7. Shock Value. Go to the third row of boxes. The exercise calls for a "15% reduction in tariff". There are three options to specify the shock value: (1) % change rate; (2) % change power; and (3) % target rate. Select % change rate and give the shock value as −15. This will enable the existing tariff rate to be reduced by 15 per cent.
   Note that once you fill these boxes, RunGTAP indicates the initial ad valorem rate as 13.0422 per cent and the final ad valorem rate as 11.0859 per cent. The latter is the tariff rate after the shock has been applied (a 15 per cent cut from the initial level).

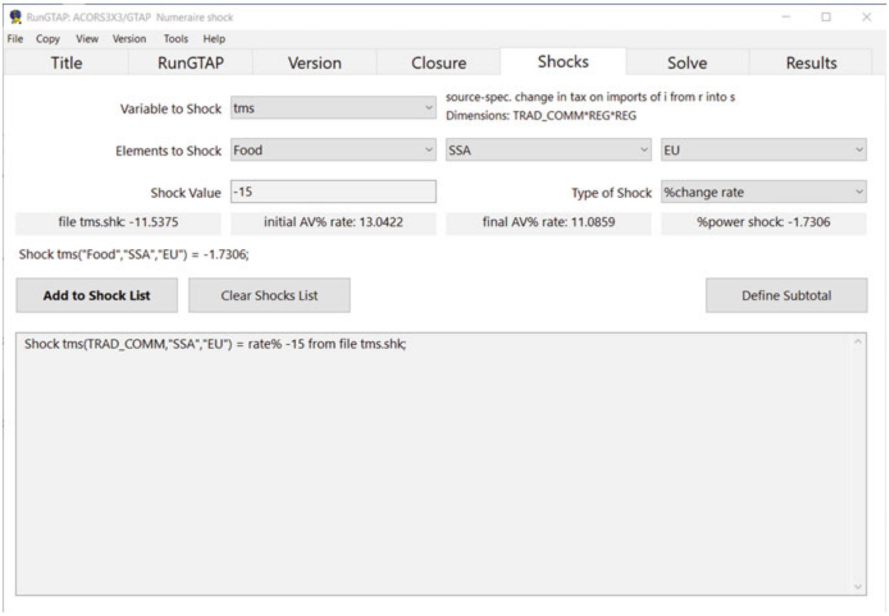


Fig. 8.17 The completed shock page of the simulation "Import Liberalisation". Source: Author's applications in RunGTAP Ver. 3.7

8. Click **Add to Shock List**. Add the shock described above by clicking the box **Add to Shock List**.
   The completed shock of this experiment can be seen in Fig. 8.17.
9. Now go to the **Solve** page. See Fig. 8.18.
10. The solution method appears at the top right-hand corner as **Johansen**. There are alternative solution methods which you can read via the link https://www.copsmodels.com/webhelp/rungtap/index.html?hc_solmethod.htm.
    For this experiment, we will leave the solution method as **Johansen** and the **default parameter file**.
11. Edit the experiment description summarising the current simulation as "Import Liberalisation of Food from SSA to EU by 15%".
12. Click **Save Experiment** and create a file name, e.g. IMLIBSE, and click **OK**.
13. Go ahead and click **Solve**. An output file will be generated in a few seconds (Fig. 8.18).

8.3.6 Extraction of Results from the GTAP Model

Once the Solve is completed, the software will generate a box giving the amount of time it took to produce a solution file. Click **OK** in the box, opening the **Results** page with the output of the simulation (Fig. 8.19).

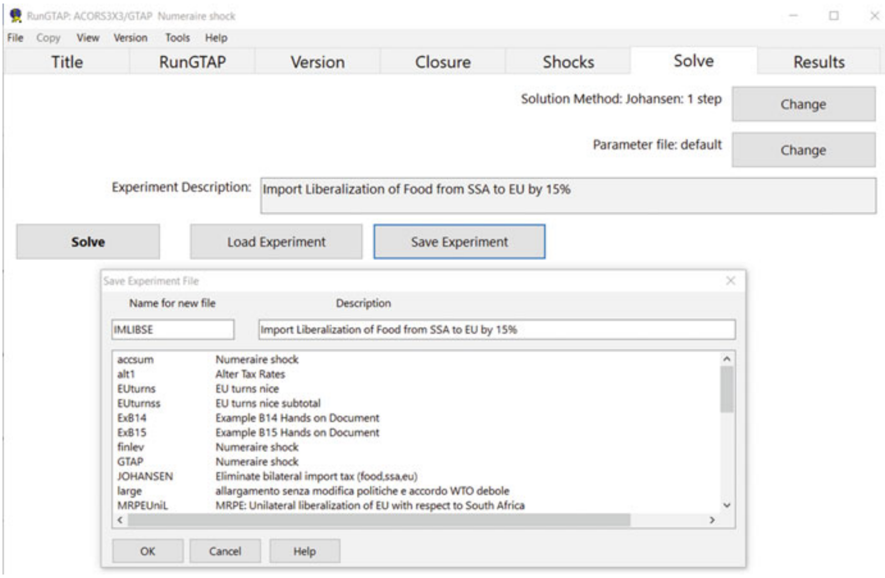


Fig. 8.18 The solve page of the simulation "Import Liberalisation". Source: Author's applications in RunGTAP Ver. 3.7

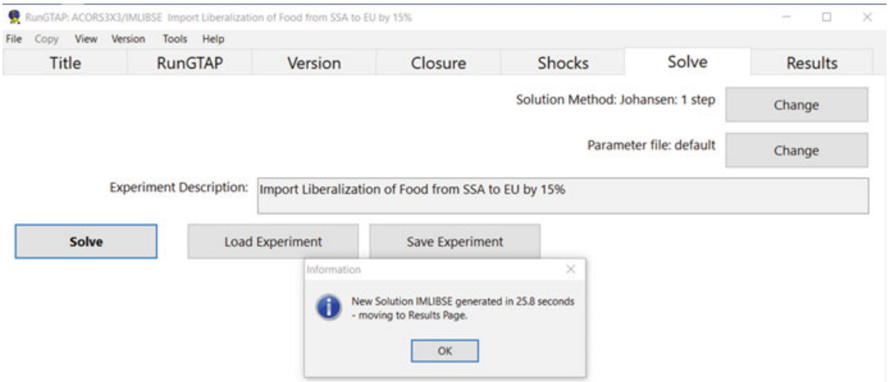


Fig. 8.19 Directing to the Results of the Experiment. Source: Author's applications in RunGTAP Ver. 3.7

A copy of the Results page is provided in Fig. 8.20. It identifies all the variables considered in separate arrays including the size (dimensions) of the variable and name. You can view the results of each variable by double-clicking the row containing a specific variable. For example, double clicking the variable **qo** (Industry output of commodity i in region r) provides details on the volume changes due to import liberalisation.

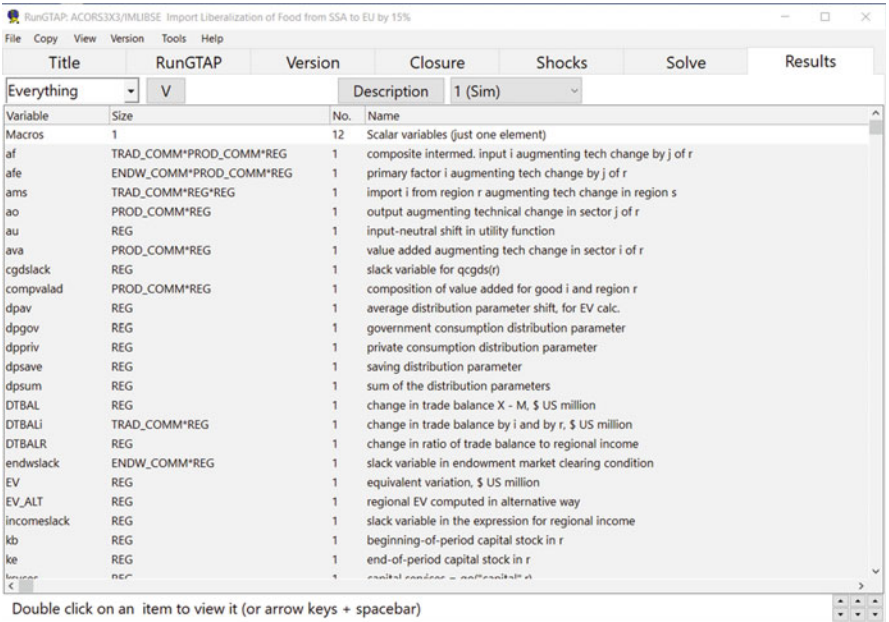


Fig. 8.20 Results page of the experiment _ Import Liberalisation. Source: Author's applications using RunGTAP Ver. 3.7

Question 1: What is the percentage change in industry output of food in SSA due to the 15 percentage reduction in tariff on food by the EU?

Question 2: What happened to the manufacturing output of SSA?

Likewise, you can check the results of the other variables to assess the impact of the import liberalisation policy adopted by the EU in this simulation.

Note that some of the results may be expressed in terms of percentage change as a result of the shock, while some may be expressed as a change in value of the USD million. For example, the variable **DTBAL** gives the change in trade balance (exports-imports) in USD million.

Question 3: What is the change in the trade balance in the SSA as a result of the policy change?

Note that a positive sign indicates an improvement in trade balance. In this example, due to the reduction of the EU tariff for SSA food products, exports of food products by SSA will be enhanced, with a positive impact on the trade balance of SSA.

Question 4: What is the change in trade balance for the EU subsequent to implementing an import liberalisation policy towards SSA food products?

You will notice that the EU shows a negative value for the changes in trade balance. This indicates that the change in value of imports is greater than that for exports. The EU's reduction of the source-specific tariff on SSA's food products results in more imports of food products and, hence, the value of imports rising, resulting in a negative value for the change in trade balance.

The results of the experiment can be presented in many ways. However, the variables of interest will depend on the basis of your analysis. In the case of trade policy, for a basic level of analysis, one may present the following variables.

1. **Macroeconomic impacts** – GDP (qgdp – GDP quantity index); output changes (qo); price changes (pm); trade balance (DTBAL); regional imports (qiwreg); regional exports (qxwrwg); etc.
2. **Sectoral impacts** – You need to use other ways on viewing results; you may follow View | Results using ViewSol / ViewHAR / AnalyseGE.
3. **Welfare effects** (EV).

The welfare measurement used in GTAP is given by the equivalent variation (EV) method. The EV, expressed in USD millions, is the money metric measure of the regional household's income at constant prices which is equivalent to the impact of policy change we used as the shock.

Go to the variable EV and examine the welfare impact on SSA due to the proposed import liberalisation policy. You will notice that there is a positive effect on welfare of SSA.

The resulting EV can be decomposed into six components: changes in allocative efficiency (AE); technical efficiency (TE); terms of trade (TOT); population change welfare contribution (POP), domestic endowment welfare contribution (ENDW), and investments-savings (IS) effects (Huff and Hertel, 2001).

8.3.7 Policy Recommendations

In the above simulation, the GTAP model was used to analyse the impacts of a trade policy liberalising imports of food and other products to a country or region. The policy was analysed by applying a tariff cut (i.e. using the variable **tms** as discussed above). The GTAP model allows the reduction of import tariffs to be applied to one commodity or to a group of commodities. It can also be used to analyse a trade agreement which focuses on step-wise reduction of import tariffs. Ex ante analysis can be performed to see whether such a proposed trade agreement would be beneficial if implemented. The welfare of both participating regions or countries can be checked, together with other macroeconomic and sectoral variables to draw a conclusion. If a trade agreement, existing or proposed, will improve the country's (or countries') welfare as given by the EV, we can recommend the policy as effective in terms of welfare improvement.

Another area where this model can be utilised is in the analysis of technological change or productivity. This examination may require some advanced economics knowledge but will be rewarding.

8.4 Assignment

Use the data in 3 × 3 aggregation available free in the GTAP website. This aggregation recognises three regions, Sub-Saharan Africa (SSA), European Union (EU), and Rest of the World (ROW), and three commodities as food, manufactures (mnfes), and services (svces).

Question1: Analyse the effects of complete elimination of tariffs on food from SSA to EU.

Question 2: Perform welfare analysis and decomposition of welfare.

Question 3: Would you recommend this policy to a developing region like SSA? Justify your answer.

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Policy Documents
Use the Following Links

National Policy Frameworke: Vistas of Prosperity and Splendour - http://www.doc.gov.lk/images/pdf/NationalPolicyframeworkEN/FinalDovVer02-English.pdf

Overview of South Asian Free Trade Area (SAFTA) - http://www.doc.gov.lk/index.php?option=com_content&view=article&id=32&Itemid=157&lang=en#

Policy and Regulation Documents - https://www.srilankabusiness.com/buyers/policy-regulations/policy-and-regulation-documents.html

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Analysing Trade Facilitation Using Gravity Models

9

Senal A. Weerasooriya

Abstract

Trade facilitation is an important aspect of promoting international trade. Hence, international organisations in collaboration with many countries have taken steps to improve trade facilitation. To make this effective, one needs to understand how trade facilitation influences trade. In this context, the knowledge and application of gravity models are substantial. This chapter attempts to provide the reader with what is trade facilitation and its important components. Afterward, the gravity intuition and how trade facilitation can be included in a gravity model is introduced. Finally, the readers are exposed to an actual application of the gravity model using a statistical package.

Keywords

Trade facilitation · Non-tariff measures · Trade policy analysis · Estimating a gravity model

9.1 Introduction

Often bureaucratic delays and 'red tape' pose a burden for moving goods across borders for traders. Hence, in the context of international trade, the concept of trade facilitation has been brought to the forefront as a measure to reduce trade costs. Currently, trade costs account for an equivalent of 219 per cent ad valorem tariff on a product in developing countries (World Trade Organisation 2015). The World Trade Organisation (WTO) members forged the Trade Facilitation Agreement (TFA)

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which came into force in 2017 to combat this issue. According to the WTO, improving trade facilitation includes simplifying paperwork, modernising procedures, and harmonising customs requirements. In other words, it seeks to improve procedures and controls governing the movement of goods across national borders to reduce trade costs while safeguarding legitimate regulatory objectives. Trade facilitation is often associated with trade policies as policies set the tone for better or worse facilitation. Hence an understanding of trade policy analysis is of great importance to address the issues of trade facilitation.

Before readers try to analyse trade policies, it is imperative that we understand what trade policy is and how it is classified. Trade policy is generally defined as a set of standards, goals, rules, and regulations that pertain to trade relations between countries. Usually, these policies are country-specific and often can be product- or market-specific too. The overarching authority for formulating, implementing, and regulating these policies is bestowed on public officials. In international trade literature, trade policies are broadly categorised into two sections, namely, tariff and non-tariff measures. Tariffs are a tax or duty to be paid on a particular class of imports or exports, whereas non-tariff measures are defined as any trade policy instruments used to regulate international trade other than ordinary tariffs (United Nations Conference on Trade and Development 2015). As readers have been exposed to tariff measures in a previous chapter, this chapter focuses more on Non-Tariff Measures (NTM) and how to analyse their impacts as NTMs are often linked to trade facilitation. For example, many have highlighted the importance of NTMs in changing trade costs and thereby improving (or worsening) trade facilitation (De Melo and Nicita 2018).

Within this milieu, the quantitative analysis of trade policy impacts focused on trade facilitation is one of the major issues researched in applied international trade literature. This is vital due to the integral versatility of trade in shaping trade facilitation and ultimately the development of many nations. In this context, the gravity model has garnered global interest and attraction for analysing trade policies.

The gravity model was first proposed by the Nobel laureate Jan Tinbergen in 1962 to explain international bilateral trade.[1] Named for its analogy with Newton's law of universal gravitation, the gravity model proposes that bilateral trade can be explained by the size of the economies and distance/proximity. Just as planets are attracted to each other in proportion to their sizes and distance, so too are countries. Relative size is determined by current GDP, and economic distance is determined by trade costs, i.e. the more economically 'distant', the larger the trade costs. Tinbergen's explanation initially lacked theoretical foundations and was intuitively driven. However, the gravity model has provided some of the clearest and most robust findings in empirical economics (Leamer and Levinsohn 1995) and remains the workhorse of the applied international trade literature[2] (Shepherd 2012). For

[1]Bilateral trade is the exchange of goods between two nations promoting trade and investment.

[2]See De Benedictis and Taglioni (2011) for a review of the development of the gravity model and its early implementations.

example, Disdier and Head (2008), in their meta-analysis of the effect of distance on trade, cover 1052 separate estimates in 78 papers. Hence, it is important for policy analysts to understand and apply the gravity model appropriately. This chapter provides an elementary understanding of the gravity model and how it can be applied in trade policies that are related to trade facilitation. More specifically, the focus will be on how to analyse the impact of NTMs on trade.[3] The chapter provides an overview of NTMs and the gravity model, data sources, and estimation techniques using real-world data. In addition, the chapter provides STATA[4] codes to run various regression models used under gravity modelling. More specifically, this chapter (i) describes what is meant by trade facilitation, trade facilitation agreement, and its role in reducing trade costs; (ii) describes the role of NTMs within the context of trade facilitation; (iii) defines NTMs, how they are classified, and what type of measures are included under each classification; (iv) explains the logical intuition of the gravity model and its theoretical explanation; (v) identifies and finds the data needed to estimate a gravity model; (vi) lists the main measurement issues associated with gravity models; and (vii) describes the main econometric estimation techniques available to counter various issues in estimating a gravity model.

9.2 The Context

9.2.1 Intentions of the Policy and Global Context

Trade policy today is increasingly integrated with NTMs that are not necessarily designed to restrict or integrate trade but address non-trade regulatory objectives, such as product safety, environmental protection, and national security or intellectual property rights (De Melo and Nicita 2018). Extensive research has shown that from a development viewpoint and regardless of what trade policies a country implements, it is in the national interest of all countries to minimise trade costs (Moise and Le Bris 2013). Reducing trade transaction costs incurred in enforcing NTMs is a major objective and rationale for TFAs. The economic cost of NTMs, in terms of sanitary and phytosanitary and technical barriers to trade measures, is estimated to be around 1.6 per cent of global gross domestic product amounting to USD 1.4 trillion (United Nations Conference on Trade and Development 2019); NTMs have become an important concern for traders as well as for trade policymakers aiming to reduce trade costs.

[3]Note that gravity model can be used to analyse not only NTMs but tariff measures too.

[4]STATA is a statistical software package.

9.2.2 Trade Facilitation Agreement

Traders from both developing and developed countries have frequently highlighted the vast amount of 'red tape' that exists in moving goods across borders. To address this, WTO members forged the Trade Facilitation Agreement. Negotiations of the TFA were concluded in December 2013 at the Ninth Ministerial Conference of the WTO held in Bali, Indonesia. The protocol of amendment that inserted the TFA into the WTO agreement was officially adopted and opened for ratification by WTO member states in November 2014. The TFA aims to streamline and expedite import and export procedures and customs requirements and enhance co-operation and transparency on cross-border trade rules and regulations (World Trade Organisation 2014, 2015). The TFA contains three sections: Section I on the expected commitments of member states; Section II on 'special and differential treatment' for developing nations and least developed countries; and Sect. III, which calls for the creation of committees on trade facilitation and includes provisions related to definitions and special circumstances.

The TFA entered into force on 22 February 2017, upon ratification by two-thirds of WTO member states, including Sri Lanka (Malith and De Zylva 2017). It includes 12 articles which are:

1. Quickly publishing information in a non-discriminatory and easily accessible manner
2. Allowing interested parties to comment on the application of trade-related regulations
3. Issuing advance rulings on the treatment of imported goods in a reasonable and timely manner
4. Improving procedures to appeal or review decisions made by customs officials
5. Developing a system that efficiently notifies concerned parties of enhanced border controls or inspections, detention of goods, and test procedures for imported goods
6. Regulating and reviewing fees imposed in connection with imports, exports, and penalties
7. Expediting the release and clearance of goods
8. Establishing coordination and cooperation between border control authorities
9. Allowing imported goods to be moved under customs control from the customs office of entry to another office in that state's territory for release or clearance
10. Streamlining formalities connected to the import, export, and transit of goods
11. Facilitating and improving the transit of goods
12. Improving customs cooperation between traders and customs officers and between customs officers of member states (World Trade Organisation 2014; Malith and De Zylva 2017)

The TFA further declared that member states should also establish a National Committee on Trade Facilitation or designate an existing entity to develop national roadmaps and align domestic policy with the TFA. In addition, the TFA allows provision of assistance, in the form of soft and hard infrastructure, for implementing the TFA. The assistance is available through the TFA, WTO, and external organisations (World Trade Organisation 2014).

According to WTO estimates, the TFA is expected to reduce trade costs by an average of 14.5 per cent (World Trade Organisation 2014). Also, the TFA is expected to reduce the average time to import goods by approximately 1.5 days and the average time to export by approximately 2 days. Moreover, the WTO estimates that the TFA could potentially add in the range of USD 345–USD 555 billion to global GDP each year. Developing countries are expected to reap larger gains than developed countries if the TFA is fully implemented: the TFA is anticipated to increase average GDP growth in developing countries by 0.9 per cent, compared to 0.25 per cent in developed countries. Similarly, exports of developing countries are projected to increase by 3.5 per cent per year, compared to a 1.8 per cent increase in developed countries (World Trade Organisation 2014).

9.2.3 Non-tariff Measures

As mentioned above, NTMs are defined as any trade policy instruments, other than ordinary customs tariffs, used to regulate international trade that can potentially have an economic effect on international trade in goods, changing quantities traded or prices or both (United Nations Conference Trade and Development 2015). In general, governments use NTMs for two main purposes: to align trade policy with their economic policies and development objectives and to pursue public policy objectives.

NTMs include a very diverse set of policy measures that can be quite different from each other. As a result, a coherent and proper classification is needed to understand the scope of NTMs. For example, issues related to the implementation of government regulations or enforcement are not defined as NTMs but referred to as procedural obstacles[5] (De Melo and Nicita 2018). The United Nations Conference on Trade and Development (UNCTAD), in collaboration with other international organisations, has developed a detailed classification of policies that can be considered as NTMs. Here, NTMs are broadly classified into technical measures, non-technical measures, and export measures. The non-technical measures are further classified into hard measures, threat measures, and other measures. Within the three broad categories, 16 chapters from A to P are defined by the UNCTAD (2015). These are given in Table 9.1 with the UNCTAD (2015) descriptions of each chapter.

Chapter A which includes Sanitary and Phytosanitary (also known as SPS) measures are applied to protect human or animal life from risks arising from additives, contaminants, toxins or disease-causing organisms; to prevent or limit

[5]For example, lengthy procedures at custom clearance due to inefficiencies at the border are not to be considered NTMs although these may affect trade costs.

Table 9.1 International classification of non-tariff measures

	A	Sanitary and phytosanitary measures (SPS)
	B	Technical barriers to trade (TBT)
Non-technical measures	C	Pre-shipment inspection and other formalities
	D	Contingent trade-protective measures
	E	Non-automatic licensing, quotas, prohibitions, and quantity-control measures other than for SPS or TBT
	F	Price control measures, including additional taxes and charges
	G	Finance measures
	H	Measures affecting competition
	I	Trade-related investment measures
	J	Distribution restrictions
	K	Restrictions on post-sales services
	L	Subsidies (excluding export subsidies under chapter P)
	M	Government procurement restrictions
	N	Intellectual property
	O	Rules of origin
Export measures	P	Export related measures

Source: De Melo and Nicita (2018), United Nations Conference Trade and Development (2015)

other damage to a country from the entry, establishment or spread of pests; and to protect biodiversity. These include measures taken to protect the health of fish and wild fauna, as well as of forests and wild flora. Prohibitions or restrictions for imports under SPS reasons, tolerance limits for residues and restricted use of substances, labelling, marketing and packaging requirements, hygienic requirements, treatment of plant and animal pest and disease-causing organisms, other requirements and conformity assessments related to SPS are some of the measures under chapter A.

Chapter B which includes Barriers to Trade (also known as TBT) refers to technical regulations, and procedures for assessment of conformity with technical regulations and standards, excluding measures covered by the SPS agreement. More specifically, a technical regulation is a document which lays down product characteristics or their related processes and production methods, including administrative provisions, where compliance is compulsory. It can include or deal exclusively with terminology, symbols, packaging, marking or labelling requirements as they apply to a product, process or production method. Prohibitions or restrictions of imports under TBT reasons, tolerance limits for residues and restricted use of substances, labelling, marketing, and packaging requirements, production or post-production requirements, product identity requirement, product-quality or performance requirement and conformity assessment[6] *related to TBT are some of the measures under chapter B.*

[6]A conformity assessment procedure is any procedure used, directly or indirectly, to determine that relevant requirements (under SPS or TBT) are met. It may include, inter alia, procedures for

Chapter C includes pre-shipment inspection and other formalities which refers to requirements and formalities to be performed in the exporting country prior to shipment. Pre-shipment inspection by an independent inspecting agency, direct consignment requirement (goods must be shipped directly from the country of origin without stopping anywhere), the requirement to pass through the specified port of customs, import monitoring and surveillance and other automatic licensing measures are some of the measures under chapter C.

Chapter D includes contingent trade-protective measures that are implemented to counteract certain adverse effects stemming from imports in the market of the importing country, including measures aimed at unfair trade practices, contingent upon the fulfilment of certain procedural and substantive requirements. Antidumping measures (measure applied to imports which are dumped and are causing adverse effects to the importing country), countervailing measures (measure applied to imports to counter any subsidy granted by authorities in an exporting country where subsidised imports of that product are causing injury to the domestic industry producing a similar product), and safeguard measures are some of the measures under chapter D.

Chapter E includes non-automatic licensing, quotas, prohibitions and quantity-control measures other than for SPS or TBT. These are control measures generally aimed at restraining the quantity of goods that can be imported, regardless of whether they come from different sources or one specific supplier. Non-automatic licensing, fixing of a predetermined quota, or through prohibitions other than SPS and TBT reasons, and tariff-rate quotas are some of the measures under chapter E.

Chapter F includes price control measures, including additional taxes and charges. These are measures implemented to control or affect the prices of imported goods in order to, inter alia*, support the domestic price of certain products when the import prices of these goods are lower; establish the domestic price of certain products because of price fluctuation in domestic markets, or price instability in a foreign market; or to increase or preserve tax revenue. They are also known as para-tariffs. Administrative measures affecting customs value, voluntary export-price restraints, variable charges, custom surcharges, seasonal duties, additional taxes, and charges levied in connection to services provided by the government, internal taxes and charges levied on imports, and decreed customs valuations are some of the measures under chapter F.*

Chapter G includes finance measures that are intended to regulate the access to and cost of foreign exchange for imports and define the terms of payment. They may increase import costs in the same manner as tariff measures. Advance payment requirements, multiple exchange rates, regulation on official foreign exchange allocation, and regulations concerning terms of payments for imports are some of the measures under chapter G.

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sampling, testing, and inspection; evaluation, verification, and assurance of conformity; and registration, accreditation, and approval as well as their combinations.

Chapter H includes measures affecting competition which are used to grant exclusive or special preferences or privileges to one or more limited groups of economic operators. State-trading enterprises, for importing and other importing channels, and compulsory use of national services are some of the measures under chapter H.

Chapter K includes restrictions on post-sales services where such measures are used to restrict producers of exported goods to provide post-sales services in the importing country. For example, any after-sales service on exported TV sets should be provided by a local service company in the importing country.

Chapter L includes subsidies excluding export subsidies under chapter P. These include a financial contribution by a government, or via *government entrustment or direction of a private body, or income or price support, which confers a benefit and is specific to an industry, group or a geographical region. For example, the government can provide producers of chemicals a one-time cash grant to replace outdated production equipment.*

Chapter M includes government procurement restrictions. These measures attempt to control the purchase of goods by government agencies, generally by preferring national providers. For example, a government office may have a traditional supplier of its office equipment despite a higher price than similar foreign suppliers.

Chapter N includes intellectual property which is related to intellectual property rights in trade. Intellectual property legislation encompasses patents, trademarks, industrial designs, layout designs of integrated circuits, copyright, geographical indications and trade secrets. For example, there might be a prohibition for importing clothing with unauthorized use of the trademark at a much lower price than the authentic product.

Chapter O includes rules of origin. Rules of origin cover laws, regulations and administrative determinations of general application applied by the government of importing countries to determine the country of origin of goods. Rules of origin are important in implementing trade policy instruments such as antidumping and countervailing duties, origin marking and safeguard measures.

Chapter P includes export-related measures. These are measures that are applied by the government of the exporting country on exporting goods. Export-license, -quota, -prohibition and other quantity restrictions, state-trading enterprises, for exporting and other selected channels, export price-control measures, measures on re-export, export taxes and charges, export technical measures, export subsidies, and export credits are some of the measures under chapter P. (United Nations Conference Trade and Development 2015)

Several interesting patterns or issues may be observed. Firstly, the majority of NTMs are Sanitary and Phytosanitary Measures (SPS) and Technical Barriers to Trade (TBT) measures (see Figs. 9.1 and 9.2). Globally, 41 per cent of the measures are SPS (30 per cent in the Asia Pacific region), and 40 per cent are TBTs (48 per cent in the Asia Pacific), followed by export measures (9 per cent globally and 13 per cent in the Asia Pacific) (United Nations Conference Trade and Development 2019). The case in Sri Lanka is no different (Fig. 9.3).

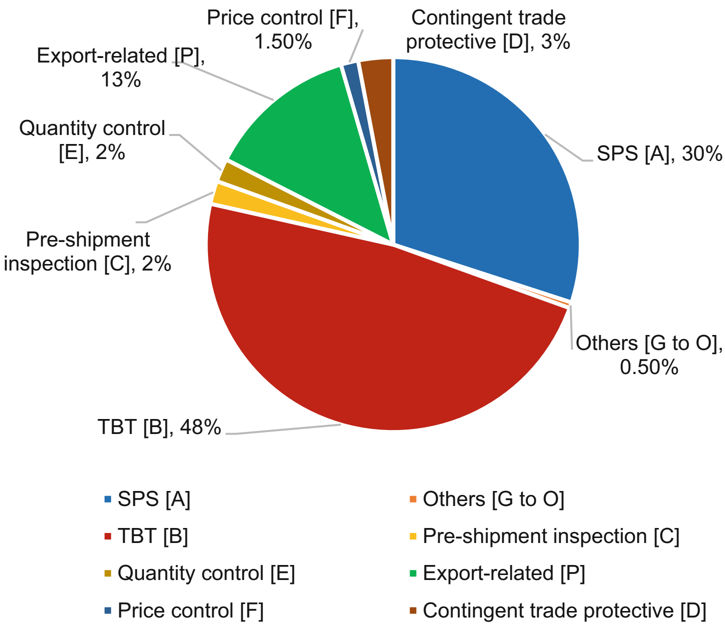

Fig. 9.1 Percentage of NTMs in the Asia-Pacific region, by type. Source: United Nations Conference on Trade and Development (2019)

As heterogeneous SPS and TBT measures account for a major portion of NTMs, the WTO has streamlined these measures in the form of international standards in trying to overcome challenges related to the heterogeneity of regulations. International standards are accepted as the benchmarks against which national measures are evaluated. According to the WTO SPS agreement, unless there is a scientific justification for a more stringent SPS protection, members must base their SPS measures on international standards in order to achieve broad harmonisation (United Nations Conference Trade and Development 2019). Similarly, the WTO TBT agreement places an obligation on member states to use international standards wherever they exist as a basis for their technical regulations and standards, unless the existing international standards or their parts are ineffective or inappropriate to fulfilling the respective legitimate objectives (United Nations Conference Trade and Development 2019).

Secondly, in terms of individual economies, the highest number of NTMs are imposed by developed countries, meaning more developed countries have stronger legislative frameworks (United Nations Conference Trade and Development 2019; Sandaruwan et al. 2020).

Thirdly, over the past two decades, with the rise of multilateral and regional trade agreements and unilateral efforts, tariff measures in the Asia-Pacific region have been halved. However, NTMs have risen dramatically. This is shown in Fig. 9.4.

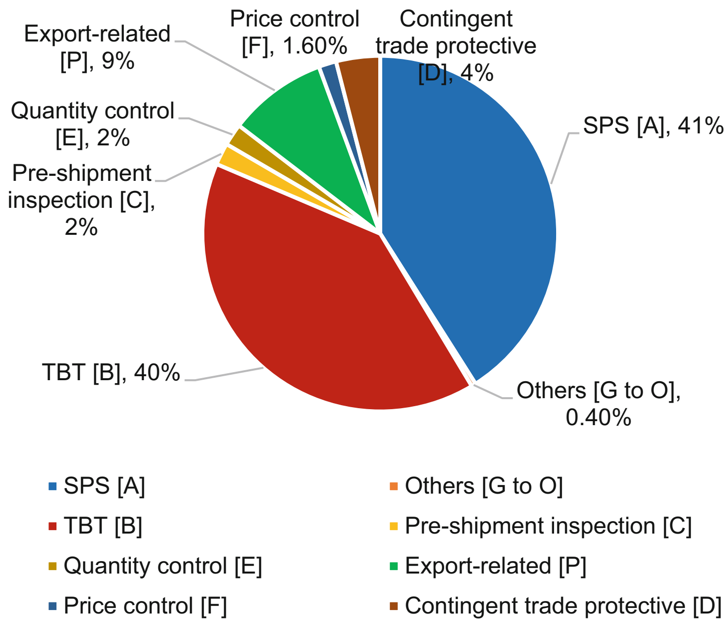

Fig. 9.2 Percentage of NTMs in the world, by type. Source: United Nations Conference on Trade and Development (2019)

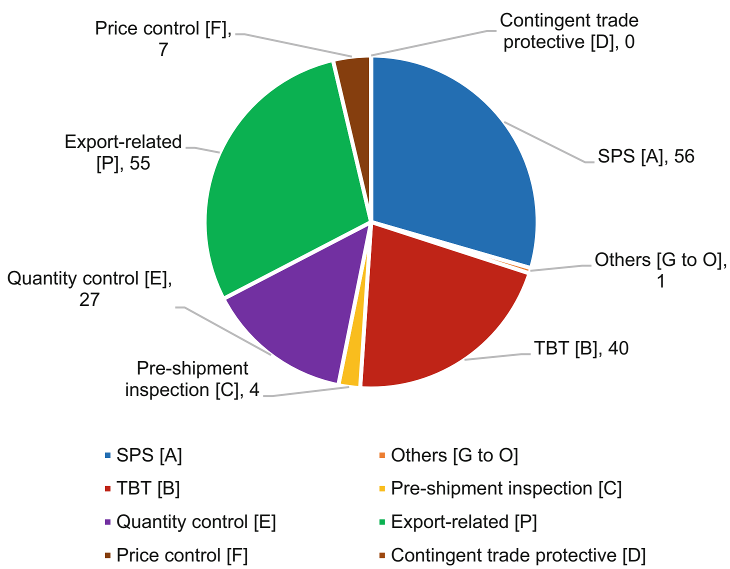

Fig. 9.3 Number of NTMs in Sri Lanka, by type. Source: United Nations Conference on Trade and Development (2020)

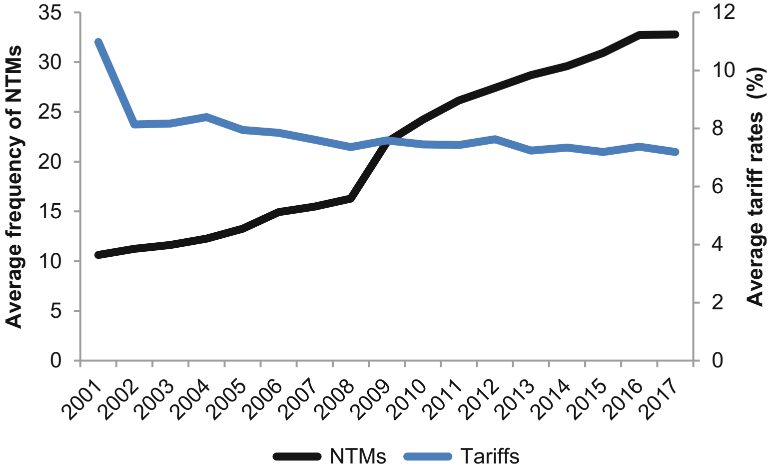

Fig. 9.4 The average frequency of NTMs and average tariff rates from 2001 to 2017. Source: Sandaruwan et al. (2020)

A term that is often associated with trade cost is Non-Tariff Barriers (NTBs). UNCTAD (2019) defines NTBs as policies that induce an adverse impact on trade due to the specific discriminatory and protectionist intent. Unlike for NTMs, there is no widely accepted definition of NTBs. Whether an NTM is an NTB largely depends on the intent of the regulation. In general, NTMs are implemented to serve the public interest and would not necessarily cause a negative impact. In fact, many studies have found a positive impact of NTMs on many related issues (Sandaruwan and Weerasooriya 2019; De Melo and Nicita 2018; Flaaten and Schulz 2010; United Nations Conference Trade and Development 2010). Classifying an NTM as an NTB is contentious as trading partners are most likely to disagree on whether a particular NTM contains a discriminatory or protectionist intent. In de facto terms, technical NTMs are not NTBs unless they have been challenged successfully through the WTO's (lengthy and expensive) dispute settlement process. Nevertheless, some technical NTMs can be viewed as discriminatory rather than necessary, tilting towards NTBs (United Nations Conference Trade and Development 2019). Hence, in some instances, the distinction between NTMs and NTBs can be difficult and contentious.

Another term that is associated with NTMs is procedural obstacles, practical challenges such as long delays in testing or certification, poor or inadequate facilities, lack of information on regulations, or infrastructure challenges. While not NTMs, they are in existence because there are NTMs (United Nations Conference Trade and Development 2019). These procedural obstacles are often an acute issue in the least developed or developing countries where facilities necessary to achieve NTMs are often lacking or inadequate. As a result, these countries have to resort to outsourcing which drives costs up and negatively influences any cost advantage they initially had. Most notably affected are the agricultural and food sectors. This is greatly disadvantageous for countries, with comparative advantage and a large portion of their populations that depend on income generated from the agricultural and food sectors (United Nations Conference Trade and Development 2019).

9.2.4 Policy Milestones of Sri Lanka

Where does Sri Lanka stand in terms of trade facilitation? According to Malith and De Zylva (2017), Sri Lanka takes 5 days to export and 5.4 days to import, respectively; Sri Lanka fares better than emerging economies in South Asia like India and Bangladesh, although it lags far behind Southeast Asian economies like Singapore, Thailand, and Malaysia, especially in terms of time taken to export. Sri Lanka submitted its instrument of ratification in May 2016, becoming the 81st member of the WTO to ratify the agreement. To improve trade facilitation, Sri Lanka pledged towards the TFA in 2017. Sri Lanka was also one of 32 countries to have received support from the World Bank's trade facilitation support programme and one of the first countries to engage with the global alliance for trade facilitation.

Under the TFA, one of the major initiatives taken by Sri Lanka was to establish a National Trade Facilitation Committee, a public-private body headed by the Director-General of Customs and co-chaired by the Director-General of Commerce. Other major initiatives included the creation of a Trade Information Portal and a National Single Window. The Trade Information Portal, hosted by the Department of Commerce in collaboration with the National Trade Facilitation Committee, was launched in July 2018. It provides a one-stop point for information relating to import into and export from Sri Lanka. The National Single Window, involving a collaboration of Sri Lanka Customs and the National Trade Facilitation Committee, was launched in January 2016. It facilitates access to a number of online systems developed for regulatory agencies involved in imports and exports. WTO estimates suggest that Sri Lanka can expect trade cost reductions ranging from 13.9 to 15.8 per cent, following full implementation of the TFA (World Trade Organisation 2015). In addition, the TFA is expected to improve and streamline cross-border procedures, thereby reducing time and cost to export which could allow for greater participation in trade by small- and medium-sized enterprises (SMEs) (Malith and De Zylva 2017).

As of September 2019, Sri Lanka has achieved 52 per cent of the overall implementation of trade facilitation measures in the following aspects: transparency (13 per cent), formalities (14 per cent), institutional arrangements (4 per cent), paperless trade (17 per cent), and cross-border paperless trade account (4 per cent) (United Nations Economic and Social Commission for Asia and the Pacific and Asian Development Bank 2019).

How well has Sri Lanka fared in terms of NTMs? Figure 9.5 shows the number of NTMs by type for selected Asian countries. As shown in Fig. 9.5, Sri Lanka had a total of 191 measures which constituted 56 SPS, 40 TBT, 55 export-related, 27 quantity control, 7 price control, 4 pre-shipment inspections, and 1 other measure

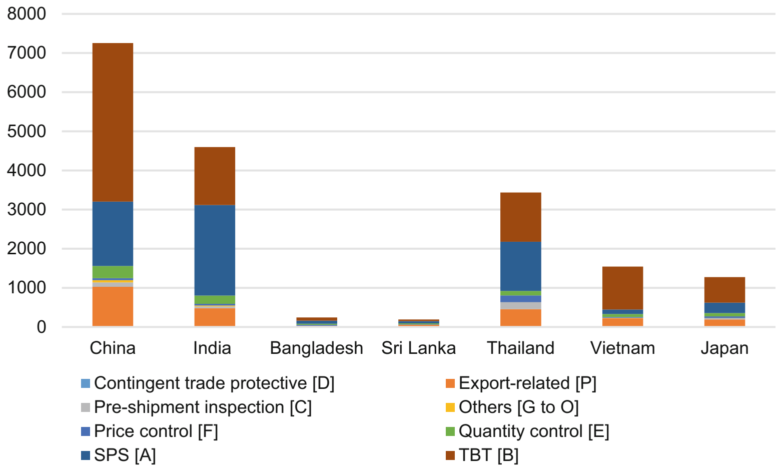

Fig. 9.5 NTMs in selected Asian economies. Source: United Nations Conference on Trade and Development (2020)

(United Nations Conference on Trade and Development 2020). In general, NTMs are already prevalent and are becoming more so as developing countries like Sri Lanka enhance their technical regulatory frameworks (United Nations Conference on Trade and Development 2019).

9.3 An Application

9.3.1 The Gravity Model: Intuitive

As mentioned earlier, Tinbergen's initial idea of using a gravity-like explanation for international trade was intuitive. In other words, it lacked economic theory. The extraordinary stability of the gravity equation and its power to explain bilateral trade flows using the size of the economies and the distance prompted the search for a theoretical explanation for it (Bacchetta et al. 2012). The gravity model specification is similar to Newton's law of universal gravitation and is presented in Eq. (9.1).

$$X_{ij} = \frac{AY_i^{\beta_1} Y_j^{\beta_2}}{T_{ij}^{\theta}} \tag{9.1}$$

where X_{ij} denotes exports (can be imports or net exports) from country i to j, Y denotes the economic size (in terms of GDP), and T denotes trade costs which are approximated by many factors, such as distance, tariffs, and non-tariffs between country i and j. In its most basic form, the gravity model can be written as an empirical equation as given in Eq. (9.2a) which is also known as the intuitive gravity model.

$$lnX_{ij} = \alpha + \beta_1 \, ln\, GDP_i + \beta_2 \, ln\, GDP_j + \theta lnT_{ij} + e_{ij} \tag{9.2a}$$

$$ln\, T_{ij} = \, ln\,(\text{distance})_{ij} + \,\ln\,(1 + \text{Tariff})_{ij} + \,\ln\,(1 + NTM)_{ij} \tag{9.2b}$$

$$\begin{aligned} lnX_{ij} = \alpha & \\ & + \beta_1 \, ln\, GDP_i \\ & + \beta_2 \, ln\, GDP_j \\ & + \beta_3 \, ln\,(\text{distance})_{ij} \\ & + \beta_4 \ln\,(1 + \text{Tariff})_{ij} \\ & + \beta_5 \ln\,(1 + NTM)_{ij} \\ & + e_{ij} \end{aligned} \tag{9.2c}$$

Equation (9.2a) is simply the log-linear form of Eq. (9.1). Here the α term acts as a regression constant, and $\beta's$ and θ are the coefficients to be estimated. A slightly more detailed equation is given in Eq. (9.2c)[7] where trade cost is broken into components.

According to the gravity model, we would expect the $\beta's$ to be positive and θ to be negative. A first sensible place to start would be to use Ordinary Least Squares (OLS) to show the relationship between trade and GDP and trade and distance. OLS typically minimises the sum of squares error and gives the parameters of interests. OLS parameters are intuitively appealing and possess useful statistical properties to conduct hypothesis tests and draw inferences. Under econometric theory, OLS estimates are rendered useful if the following three conditions are met[8]:

- The errors e_{ij} have a mean zero and must be uncorrelated with each of the explanatory variables (exogeneity).
- The errors e_{ij} are independently drawn from a normal distribution with a given constant variance (homoscedasticity).
- None of the explanatory variables is a linear combination of other explanatory variables (no perfect multicollinearity).

If all three assumptions are satisfied, then the OLS estimates are consistent, unbiased, and efficient. Consistency implies that the OLS coefficients converge to the true population values as the sample size increases. Unbiased implies that the

[7]Note that in equation (9.2c), 1 has been added before tariffs and NTMs. Since the equation is estimated in logs, this is to avoid taking the log of zero where tariffs/NTMs are not applied. Zero tariffs/NTMs would send the log to negative infinity while the log of 1 would be equal to zero.

[8]For more details on OLS and other econometric estimation techniques (which will be discussed later), please refer to Wooldridge (2012).

coefficients are not different from the true population values. Efficiency implies that there exists no other estimator that results in a smaller standard error than the standard error produced by the OLS estimators. If these assumptions are violated (which is most common), then OLS would not give accurate results.

9.3.2 Ad Valorem Tariff Equivalent

A common issue in trade policy analysis is that policy interventions take many different forms. A simple question is how can one compare a 10 per cent tariff, a 1000 metric ton quota, a complex licensing procedure, and an LKR ten million-worth subsidy? A frequently used approach in the trade literature is to bring the different types of trade policy instruments into a common metric by estimating ad valorem equivalents (AVEs). Hence, in the context of NTMs and gravity modelling, it is important to understand how this is done. Although there are many approaches,[9] Eq. (9.3) is a common approach proposed by Kalaba and Kirsten (2012) and Sandaruwan et al. (2020)).

$$ln\,\widehat{X}_{ij} = \beta_A \Psi_{ij} + \beta_4 \ln\left(1 + \text{Tariff}\right)_{ij} + \beta_5 \ln\left(1 + \text{NTM}\right)_{ij} \tag{9.3}$$

where Ψ represents all other explanatory variables except tariff rates and NTMs. Predicted difference between a country pair with a tariff and the same country pair without the tariff would be ($\widehat{X}^a$ – export value with tariff, $\widehat{X}^b$ - export value without tariff) as shown in Eq. (9.4).

$$ln\,\widehat{X}^a_{ij} - \ ln\,\widehat{X}^b_{ij} = \widehat{\beta}_4 ln(1 + \text{Tariff})_{ij} - \widehat{\beta}_4\, ln\,(1) \tag{9.4}$$

Predicted difference between a country pair with NTMs and the same country pair without the NTMs would be ($\widehat{X}^c$ – export value with NTM, $\widehat{X}^d$ –export value without NTM) as shown in Eq. (9.5).

$$ln\,\widehat{X}^c_{ij} - \ ln\,\widehat{X}^d_{ij} = \widehat{\beta}_5 \ln\left(1 + NTM\right)_{ij} - \widehat{\beta}_5\, ln\,(1) \tag{9.5}$$

A tariff equivalent or AVE of NTMs is the tariff that has the same effect on trade flows. This implies that the left-hand sides of Eqs. (9.4) and (9.5) are equal. Consequently, the right-hand sides of Eqs. (9.4) and (9.5) also should be equal. This is given in Eq. (9.6). By solving for Tariffs, we get Eq. (9.7) which gives the tariff equivalent or AVE of the corresponding NTM for the country pair i and j.

$$\widehat{\beta}_4 ln(1 + \text{Tariff})_{ij} = \widehat{\beta}_5 \ln\left(1 + \text{NTM}\right)_{ij} \tag{9.6}$$

[9] See Kee et al. (2009).

$$\mathrm{AVE} = (1 + \mathrm{NTM})_{ij}^{\left(\widehat{\beta}_5/\widehat{\beta}_4\right)} - 1 \tag{9.7}$$

Note that the AVE changes according to the way you specify NTMs. If you specify the NTMs as a dummy variable, Eq. 9.7 reduces to $\exp\left(\widehat{\beta}_5/\widehat{\beta}_4\right) - 1$ (for more details on how to do this when NTMs are specified as dummy variables, see Kalaba and Kirsten 2012; and Sandaruwan et al. 2020).

9.3.3 Example

Let's try to run an OLS using the intuitive gravity model and calculate AVE. The dataset is from Sandaruwan et al. (2020) on seafood exports from Sri Lanka to other countries from 2001 to 2017. The database included bilateral data from 107 countries on 144 seafood-related products at the Harmonised System (HS) 6-digit level. Altogether, 26,093 observations were included in the database. Data for this study originated from several sources which are described under Sect. 9.3.4. The following regression Eq. (9.8) will be estimated using OLS.

$$\begin{aligned} lnX_{ijt}^{k} = \beta_0 + \beta_1\, ln\, \mathrm{GDP}_{it} \\ + \beta_2\, ln\, \mathrm{GDP}_{jt} + \beta_3\, ln\, \mathrm{DIS}_{ij} \\ + \beta_4\, ln\, \mathrm{POP}_{it} + \beta_5\, ln\, \mathrm{POP}_{jt} \\ + \beta_6\, ln\left(1 + \mathrm{Tariff}_{ijt}^{k}\right) \\ + \beta_7\, ln\, (1 + \mathrm{SPS})_{ijt}^{k} \\ + \beta_8\, ln\, (1 + \mathrm{TBT})_{ijt}^{k} \\ + \beta_9\, \ln\, (1 + \mathrm{OTHNTM})_{ijt}^{k} \\ + \beta_{10}\mathrm{landlock}_{it} + \varepsilon_{ijt}^{k} \end{aligned} \tag{9.8}$$

where X_{ijt}^{k} is the export value of product k to the i^{th} importing country from Sri Lanka at time t, GDP_{it} is the gross domestic product of i^{th} import country at time t, GDP_{jt} is the gross domestic product of Sri Lanka at time t, DIS_{ij} is the distance between the capital of the i^{th} import country and capital of Sri Lanka, $\mathrm{Tariff}_{ijt}^{k}$ is the tariff rate imposed by country i for exported product k from Sri Lanka, SPS_{ijt}^{k} is the number of SPS measures country i has imposed on the exported product k from Sri Lanka, TBT_{ijt}^{k} is the number of TBT measures country i has imposed on the exported product k from Sri Lanka, $\mathrm{OTHNTM}_{ijt}^{k}$ is the number of other NTMs excluding SPS and TBT country i has imposed on the exported product k from Sri Lanka, $\mathrm{landlock}_{it}$ is a dummy variable where 1 is for landlocked and 0 otherwise, and ε_{ijt}^{k} is the error

Table 9.2 OLS estimates of Eq. (9.8) using STATA

```
. regress lnexport lngdpi lngdpj lndist lnpopi lnpopj lntariff lnsps lntbt lnothntm landlock, robust

Linear regression                               Number of obs     =     26,093
                                                F(10, 26082)      =      94.27
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0272
                                                Root MSE          =     4.0836
```

lnexport	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lngdpi	.4520636	.0259471	17.42	0.000	.4012058	.5029215
lngdpj	.1184052	.4344835	0.27	0.785	-.7332063	.9700168
lndist	-.4690078	.0478748	-9.80	0.000	-.562845	-.3751706
lnpopi	-.274703	.0260562	-10.54	0.000	-.3257746	-.2236313
lnpopj	14.22719	3.96477	3.59	0.000	6.456024	21.99836
lntariff	1.123672	.4108558	2.73	0.006	.3183725	1.928972
lnsps	-.1789728	.0431157	-4.15	0.000	-.263482	-.0944636
lntbt	.2026716	.0469719	4.31	0.000	.1106041	.294739
lnothntm	.0364642	.0409085	0.89	0.373	-.0437187	.1166471
landlock	-.1738641	.0963734	-1.80	0.071	-.3627612	.015033
_cons	-22.42951	2.057051	-10.90	0.000	-26.46144	-18.39758

term.[10] The average AVE for SPS, TBT, and other NTMs per country for all seafood products are given by $(1 + \text{Avg\#SPS})^{\left(\widehat{\beta_7}/\widehat{\beta_6}\right)} - 1$, $(1 + \text{Avg\#TBT})^{\left(\widehat{\beta_8}/\widehat{\beta_6}\right)} - 1$, and $(1 + \text{Avg\#OTHNTM})^{\left(\widehat{\beta_9}/\widehat{\beta_6}\right)} - 1$. This can be done for different products or for different countries/regions too.

STATA (version 13 or higher) is used to estimate the above equation. OLS in STATA can be done by using the 'regress' command. It takes the following format:

Regress dependent_variable independent_variable1 independent_variable2 … [if …], [options]

The 'if' statement can be used to limit the estimation sample to a particular set of observations. If it is not specified, the entire set of observations will be used in the estimation. Although there are many options, one of them is of particular interest in a gravity context (Shepherd 2012). This is the 'robust' option which produces standard errors that are robust to heteroscedasticity in the data.[11] Not accounting for this issue might result in incorrect standard errors. The results of the OLS regression are given in Table 9.2.

[10]Please note that this equation is estimated for demonstration only. Do not assume that this is the best equation to be used at all times.

[11]Another common option is *cluster(variable)* which allows for correlation of the error terms within groups defined by *variable*. For example, errors may be correlated by country pair. To do this, it is necessary to specify a clustering variable that separately identifies each country pair independently of the direction of trade (Shepherd 2012). An example would be distance which is unique to each country pair but is identical for both directions of trade. In this example, we will not use this. Please see Shepherd (2012) for more information.

Table 9.3 A test of the hypothesis that both GDPs are equal to unity

```
. test (lngdpi=lngdpj=1)

 ( 1)  lngdpi - lngdpj = 0
 ( 2)  lngdpi = 1

       F(  2, 26082) =  226.76
            Prob > F =    0.0000
```

Several things can be observed here. First, the R^2 is somewhat low at 0.027. This figure will increase if more independent variables are added to the model and, in particular, once panel data techniques are applied (see Sect. 9.3.5). However, the overall model significance is high with a high F-statistic (with a low p-value) which rejects the null hypothesis that all coefficients are jointly zero at the 0.05 level. To interpret the model closer, we need to look at the estimated coefficients and their corresponding t-statistic and the p-value. Looking at the GDP terms, both influence exports positively. But only the GDP in the importing country is statistically significant (a low p-value). According to the results, a 1 per cent increase in importer GDP tends to increase the export of seafood from Sri Lanka by 0.45 per cent, ceteris paribus. In addition, as distance increases, exports decrease. A 1 per cent increase in distance will result in a 0.47 per cent decrease in seafood exports from Sri Lanka to the importing country, ceteris paribus. Likewise, the population of Sri Lanka and the importing country also are statistically significant with expected signs. A 1 per cent increase in population in Sri Lanka and in the importing country will decrease and increase seafood exports by 0.25 per cent and 14 per cent, respectively, ceteris paribus.

How do we interpret the tariffs and the NTMs? Coefficient estimates obtained for tariffs, SPS, and TBT are statistically significant, whereas the coefficient obtained for other NTMs is not statistically significant. According to the results, a 1 per cent increase in tariffs increases exports by 1.12 per cent, ceteris paribus, which is a surprising result. Similarly, a 1 per cent increase in TBTs increases exports from Sri Lanka by 0.20 per cent, ceteris paribus. Both these results do not conform to the gravity intuition as we would expect these to be negative. Nevertheless, we obtain the expected sign for SPS measures. A 1 per cent increase in SPS measures decreases exports by 0.18 per cent, ceteris paribus. Finally, when the importing country is landlocked, seafood exports decrease, but this is not statistically significant. Please note that we considered $\alpha = 0.05$ for the level of significance.

$$lnX_{ijt}^{k} = \beta_0 + \beta_1\, ln\,\mathrm{GDP}_{it} + \beta_2\, ln\,\mathrm{GDP}_{jt} + \beta_3\, ln\,\mathrm{DIS}_{ij} + \beta_4\, ln\,\mathrm{POP}_{it} + \beta_5\, ln\,\mathrm{POP}_{jt} + \beta_6\, ln\left(1 + \mathrm{Tariff}_{ijt}^{k}\right) + \beta_7 \mathrm{bnt}_{ijt}^{k} + \beta_8 \mathrm{landlock}_{it} + \varepsilon_{ijt}^{k} \quad (9.9)$$

By interpreting the coefficient t-statistics for the corresponding coefficients, a number of simple and compound hypotheses may be tested. For example, GDP

Table 9.4 A test of the hypothesis that lntariff is equal to unity

```
. lincom lntariff-1

 ( 1)  lntariff = 1
```

lnexport	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
(1)	.1236724	.4108558	0.30	0.763	-.6816275	.9289722

Table 9.5 OLS estimates of Eq. (9.9) using STATA

```
. regress lnexport lngdpi lngdpj lndist lnpopi lnpopj lntariff bntm landlock, robust

Linear regression                                    Number of obs   =   26,093
                                                     F(8, 26084)     =   116.28
                                                     Prob > F        =   0.0000
                                                     R-squared       =   0.0268
                                                     Root MSE        =   4.0842
```

lnexport	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lngdpi	.4635908	.0252922	18.33	0.000	.4140168	.5131649
lngdpj	.0767628	.432572	0.18	0.859	-.7711021	.9246277
lndist	-.4766793	.0461087	-10.34	0.000	-.5670549	-.3863038
lnpopi	-.2708954	.0257122	-10.54	0.000	-.3212928	-.2204981
lnpopj	15.29274	3.953658	3.87	0.000	7.543351	23.04212
lntariff	1.157427	.3986554	2.90	0.004	.3760407	1.938814
bntm	-.274645	.0806744	-3.40	0.001	-.4327712	-.1165189
landlock	-.0897253	.0953355	-0.94	0.347	-.2765881	.0971374
_cons	-23.0951	2.041382	-11.31	0.000	-27.09632	-19.09388

coefficients in the goods trade literature are frequently found to be close to one. We can test whether that is also the case for the seafood data from Sri Lanka. In STATA, we use the command ‘test’. The results are shown in Table 9.3.

Here, we reject the null hypothesis that the coefficients of both GDPs are equal to one, since the p-value is less than 0.05. In addition, we can use the command ‘lincom’ in STATA to test for linear combinations of the coefficients. For example, we can test if the coefficient for lntariff is, in fact, equal to one. The results are shown in Table 9.4. Both ‘test’ and ‘lincom’ are post estimation commands in STATA; they can be done only after running the regression.

According to the results in Table 9.4, we fail to reject the null hypothesis that the coefficient for lntariff is equal to one since the p-value is greater than 0.05.

To look at another way of specifying NTMs, we will use a slightly different specification to Eq. (9.8) as given in Eq. (9.9). Here, instead of the types of NTMs, a dummy variable for the total number of NTMs is defined where $bntm = 1$ if NTMs are present and 0 otherwise. The results are given in Table 9.5.

Similar to the results in Table 9.2, we observe a low R^2. However, the overall model significance is high with a high F-statistic which rejects the null hypothesis that all coefficients are jointly zero at the 0.05 level. Looking at the GDP terms, we can see that only GDP in the importing country is statistically significant with a positive coefficient. A 1 per cent increase in importer GDP tends to increase the export of seafood in Sri Lanka by 0.46 per cent, ceteris paribus. As the distance increases, exports decrease. A 1 per cent increase in distance will result in a 0.47 per cent decrease in seafood exports from Sri Lanka to the importing country, ceteris paribus. We can see that the population of Sri Lanka and the importing country also are statistically significant with expected signs. A 1 per cent increase in population in Sri Lanka and the importing country will decrease and increase seafood exports by 0.27 per cent and 15 per cent, respectively, ceteris paribus. Coefficient estimates obtained for tariffs are again positive and statistically significant. According to the results, a 1 per cent increase in tariffs increases exports by 1.16 per cent, ceteris paribus. We obtain the expected sign for the dummy variable for NTMs which is negative and statistically significant. Compared to no NTMs, when there are NTMs imposed, seafood exports decrease by 24 per cent, ceteris paribus ($e^{-0.27} - 1 = -0.24$). Note that similar hypothesis testing can be carried out as in the earlier example.

9.3.4 Gravity Model: Structural

The gravity model depicted in Eqs. (9.2a, 9.2b, 9.2c) is collectively known as the intuitive gravity model (Shepherd 2012). This is due to the fact that there is no underlying economic theory behind it. This model has certain limitations as described by Shepherd (2012). For example, consider the impact on exports (or imports) between countries i and j due to a change in trade costs between countries i and k. Such change might be a result of a preferential trade agreement that lowers tariffs on their respective goods (think of Sri Lanka as country i, Pakistan as country j, and India as country k). Economic theory implies that such a move may impact the trade of country j although it is not part of the agreement.[12] The intuitive model described above doesn't incorporate this issue as it forces $\frac{\partial logX_{ij}}{\partial logT_{ik}} = 0$. So reducing trade costs on one bilateral trade route does not affect trade on other routes in the intuitive model. This is one of the major weaknesses in the intuitive model as it depicts omitted variable bias (Wooldridge 2012).

As mentioned before, the stability and robustness of the gravity equation and its power to explain bilateral trade flow prompted the search for a theoretical explanation. While many authors have made significant strides, one study by Anderson and Van Wincoop (2003) has received serious attention from a viewpoint of applied trade literature. Eqs. (9.10b, 9.10c, and 9.10d) collectively are the final equation. Please note that you can obtain Eq. 9.10b by taking the logarithm of Eq. 9.10a.

[12] Concepts such as trade creation and trade diversion are classical examples for this.

$$X_{ij}^{k} = \frac{Y_i^k E_j^k}{Y^k} \left\{ \frac{T_{ij}^k}{\pi_i^k P_j^k} \right\}^{1-\sigma_k} \tag{9.10a}$$

$$\begin{aligned} log\, X_{ij}^k = \; & log\, Y_i^k + log\, E_j^k - log\, Y^k + (1 - \sigma_k) \\ & \times \left[\log T_{ij}^k - \log \pi_i^k - \log P_j^k \right] \end{aligned} \tag{9.10b}$$

$$\pi_i^k = \sum_{j=1}^{C} \left\{ \frac{T_{ij}^k}{P_j^k} \right\}^{1-\sigma_k} \frac{E_j^k}{Y^k} \tag{9.10c}$$

$$P_j^k = \sum_{j=1}^{C} \left\{ \frac{T_{ij}^k}{\pi_i^k} \right\}^{1-\sigma_k} \frac{Y_i^k}{Y^k} \tag{9.10d}$$

where X is the exports indexed over countries i and j for sector k; Y is GDP; E is an expenditure; $Y^k = \sum_{i=1}^{C} Y_i^k$, i.e. world GDP; σ_k is the intra-sectoral elasticity of substitution; and T_{ij}^k is the trade costs. The unique feature of this model is the inclusion of two additional variables π_i^k and P_j^k. The first is called the outward multilateral resistance and captures the fact that exports from country i to j depend on trade costs across all possible export markets. The second term known as inward multilateral resistance captures the dependence of imports into country i to j on trade costs across all possible suppliers (Shepherd 2012). Together these two terms overcome the limitation described above in the intuitive model. The final term T_{ij}^k is defined as follows in Eq. (9.10e).[13]

$$\begin{aligned} \log T_{ij}^k = \; & \varphi_1 \ln\left(\text{distance}\right)_{ij} + \varphi_2\, ln\, \text{Tariff}_{ij} + \varphi_3\, ln\, \text{NTM}_{ij} \\ & + \varphi_4 \text{contig} + \varphi_5 \text{comlan} + \varphi_6 \text{colony} + \varphi_7 \text{comcol} \end{aligned} \tag{9.10e}$$

where distance is the geographical length between countries i and j, contig is a dummy variable that equals one for countries which share a common border, comlan is a dummy variable that equals one for country pairs that share a common official language, colony is a dummy variable that equals one if country i and j were once in a colonial relationship, and comcol is a dummy variable that equals one for country pairs which were colonised by the same country. We will not cover the estimation of this structural gravity model in this chapter. For more details on how to estimate, please refer to the excellent description found in Shepherd (2012).

[13]There are many ways of specifying this which would depend on the research context.

9.3.5 Potential Issues and Other Estimation Techniques

It should be apparent by now that the results in Tables 9.2 and 9.5 are not ideal. In both cases, a very low R^2 is observed and some of the coefficients do not have the expected sign. All in all, it appears that OLS is not the most appropriate regression model. A variety of estimation techniques aimed at overcoming many issues associated with the gravity model have been highlighted in a plethora of studies.

One of the main issues not addressed in the intuitive model is that it omits the multilateral trade resistance term from the model. In addition, these are unobserved because they do not correspond to any price indices collected by national statistical agencies. Therefore, a procedure is needed to account for the multilateral resistance without directly including them in the mode as data points. Fixed-effect (FE) estimation provides a way out if you have a panel dataset. Panel data contains observations of multiple phenomena obtained over multiple time periods for the same individuals. In the gravity context, this individual can be a country pair. Using panel data allows the researcher to use a fixed-effect model to control for the time and/or country fixed-effects. The country fixed-effects proxy the unobserved multilateral resistance terms, while country and year fixed-effects control for correlation between omitted and observed variables (Lopez, Philippidis, and Ezcaray 2013). This is known as endogeneity. However, a drawback of the fixed-effects estimation is that it eliminates variables that are collinear with the fixed-effects. This implies that it is not possible to estimate an FE model that includes data that vary by the exporter (constant across all importers) or by the importer (constant across all exporters). If the policy variable under consideration falls under one of these categories, it would be eliminated during FE estimation.

Another potential issue is zero trade flows. One of the main drawbacks of the OLS is that it cannot take into account the information contained in zero trade flows because these are simply dropped out of the sample while taking the logarithm. To address this, one approach suggested by researchers is the use of a Tobit model which accounts for zero trade flows (Yotov et al. 2016). Most of the time, the bilateral trade matrix is filled with zeros. Dropping these observations as in OLS would immediately give rise to concerns about sample selection bias. One way to see this problem is that the probability of being selected for the estimation sample is an omitted variable in the gravity model. One way of dealing with this problem is to use the sample selection model or the Heckman model (Helpman, Melitz, and Rubinstein 2008).

One of the biggest challenges in obtaining reliable estimates of the effects of trade policy within a gravity model is that, for the most part, trade policy variables are endogenous. In other words, it is possible that trade policy may be correlated with unobservable trade costs. A country's trade policies are often determined based on the extent of trade it does. This creates a circular causal chain between policies and trade, i.e. a situation of reverse causality. The issue of endogeneity can be addressed by using an instrumental variable and a 2-stage least square (2SLS) technique. However, finding an instrumental variable (or an IV variable) that satisfies the conditions for picking a suitable instrument has proven to be challenging.

Another potential issue is the heteroscedasticity of trade data. If the error in Eq. (9.2a) is highly heteroskedastic, which is highly possible in practice, then the expected value of the error term depends on one or more of the independent variables (Shepherd 2012). This type of heteroscedasticity is different from what is explained in Sect. 9.3.3 and cannot be corrected by simply applying a robust standard error. This warrants the adoption of a completely different methodology. The Poisson Pseudo-Maximum Likelihood (PPML) estimator provides consistent estimators for the gravity equation (Santos Silva and Tenreyro 2006). It also effectively handles the presence of zero trade flows, making it a very attractive choice for empirical gravity analysis (Yotov et al. 2016).

Each of these has its own pros and cons. It is the policy analyst's responsibility to understand the data well enough and conduct a thorough literature review before adopting an estimation technique that s/he can justify. For more details on how to estimate these econometric models in STATA, please refer to Baum (2006), Cameron and Trivedi (2009), and Shepherd (2012).

9.3.6 Data and Data Sources

Here is a comprehensive account of the data needed to conduct all the estimations given above, as well as their sources. Ultimately, the quality of the findings depends on the quality of the data. Hence, it is vital to ensure that the data is up to par. For the analysis of the gravity model (intuitive or theoretical), we need:

- Bilateral trade flows
- Bilateral tariff data
- Bilateral non-tariff data
- Bilateral distances
- GDP and population data
- Other sources

Bilateral trade flows can be obtained from the WTO Integrated Data Base provided by World Integrated Trade Solutions (WITS[14]) which allows data to be extracted from the United Nations Commodity Trade Statistics Database (COMTRADE[15]). In addition, trade-map[16] from the International Trade Centre (ITC) is a useful data source. Bilateral tariff data can be obtained from WITS which allows data to be extracted from the databases of the Inter-America Development Bank (IDB[17]) and Trade Analysis Information System (TRAINS[18]) of

[14] https://wits.worldbank.org/

[15] https://comtrade.un.org/

[16] https://www.trademap.org/

[17] https://data.iadb.org/

[18] https://databank.worldbank.org/source/unctad-%5E-trade-analysis-information-system-(trains)

UNCTAD. Similarly, bilateral non-tariff data can be obtained from the TRAINS[19] database. If more details are required about NTMs, they can be found on the WTO Integrated Trade Intelligence Portal (i-TIP[20]). Bilateral distances, along with information on common border, language, common coloniser, and other related variables can be obtained from the Centre for Prospective Studies and International Information (CEPII[21]). GDP and population data can be obtained from the World Bank's World Development Indicators (WDI[22]). After collecting the data, ensure that the data is in the same unit of measure. In addition, log-transformation is required, and along with that, you may want to think of approaches to overcome the zero problems which are prevalent in bilateral trade data.

9.3.7 Policy Experiments

It is important to conceptually understand how the policy works in order to carry out experiments. One of the justifications of using policy experiments is we sometimes do not observe the counterfactual, i.e. there might not be a case where such a policy exists/not exists. In this case, either the policy should be simulated or some experiments must be performed. Before we do this, it is important to understand how NTMs are measured. In the example above, we used the number of NTMs and simply added one to overcome the issue of taking the logarithm of a zero. Another approach was to define it as a binary variable. However, in this, we lose information on the types as well as the number. In addition, there are other ways of quantifying NTMs. Examples include Coverage Ratio, Frequency Index (FI), Prevalence Score (PI), Regulatory Intensity (RI), and Regulatory Distance (RD) (De Melo and Nicita 2018).

9.4 Conclusion

Trade facilitation has been brought into the limelight as a means of combating the negative implications of trade costs. It is widely accepted that NTMs play a pivotal role in influencing trade costs. Hence, analysis of the impacts of NTMs on trade is important for future policy considerations for better trade facilitation. NTMs are increasingly used in global trade; understanding them in a universally accepted classification is important to avoid ambiguity. In addition, it is important to understand the ways by which NTMs can be quantified which have important implications for policy experiments.

[19] https://trains.unctad.org/

[20] https://www.wto.org/english/res_e/statis_e/itip_e.htm

[21] http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp

[22] https://databank.worldbank.org/source/world-development-indicators

Gravity modelling is quite a useful tool in the context of international trade especially when the user is trying to estimate the factors influencing trade. Various versions of the gravity model have been used widely in applied international trade literature for a long time. Gravity literature has undergone a series of major changes in the last 15 years or so (Shepherd 2012). Therefore, research that does not use the latest models and techniques does not represent a sound basis for drawing policy conclusions. This chapter starts with the simplest of econometric models (OLS) and then goes on to talk about other econometric tools available to counter many issues often associated with trade-related data. The readers should note that this chapter provides an introduction, not provide a comprehensive list of tools used in gravity estimation.

In the context of evidence-based policy-making, it is crucial for researchers to focus on gravity modelling on questions where it has a comparative advantage. In particular, the gravity model describes the behaviour of trade flows, but not economic welfare. For applications that focus on economic welfare, it would be more appropriate to use other methodologies, such as computable general equilibrium modelling (Shepherd 2012). It is the reader's responsibility to look into all aspects and avoid falling into the pitfalls of estimating a gravity model. If such pitfalls are avoided, the gravity model can be a very useful tool for trade policy analysis.

9.5 Assignment[23]

We shall continue with the Sandaruwan et al. (2020) dataset and the OLS estimations given in Tables 9.2 and 9.5. The necessary data and do-files are included for you to proceed with this assignment. Although we discussed the results, we did not calculate the AVE of NTMs from the results in Tables 9.2 and 9.5.

1. First, let's consider Eq. 9.8 which yielded Table 9.2. Average AVE for SPS, TBT, and other NTMs for Sri Lanka for all seafood products are given by $(1 + Avg\#SPS)^{\left(\widehat{\beta_7}/\widehat{\beta_6}\right)} - 1$, $(1 + Avg\#TBT)^{\left(\widehat{\beta_8}/\widehat{\beta_6}\right)} - 1$, and $(1 + Avg\#OTHNTM)^{\left(\widehat{\beta_9}/\widehat{\beta_6}\right)} - 1$. If the average number of SPS and TBT is 13.32 and 6.19, respectively, calculate the average AVE for SPS, and TBT using the above formulas (we will not do this for other NTMs as the coefficient for other NTMs is not statistically significant).
2. Let's consider Eq. 9.9 which yielded Table 9.5. Here a binary variable is specified to indicate whether NTMs are present or not. The AVE is now given by $AVE_{NTM} = \exp\left(\widehat{\beta_7}/\widehat{\beta_6}\right) - 1$. Using this formula, calculate the AVE for NTMs.

[23]This take-home assignment is designed for demonstration purposes only. Do not assume that the methods outlined here are the most appropriate. It would depend on your research question and the nature of your data among many other things.

3. OLS estimation of Eqs. 9.8 and 9.9 doesn't include the multilateral trade resistance term. As explained in Sect. 9.3.5, this may give rise to endogeneity. As a remedy, the FE model can be used where we include year and/or country-specific fixed-effects. In order to do this, first, you have to tell STATA that this is a panel dataset. For that, we use 'xtset' and specify both *year* and *bilateralid* variables (*xtset bilateralid year*). Here we are specifically including country fixed-effects and not year fixed-effects[24]. Now use the 'xtreg' command to estimate FE models for Eqs. 9.8 and 9.9 [25]. Interpret the results in both cases. Are the results different from the OLS results? Also comment on the signs obtained for SPS and TBT. Also, comment on why the variable landlock is omitted from the results.
4. As explained in Sect. 9.3.5, a PPML estimation counters the heteroscedasticity and zero trade value problem. Let's try to estimate a PPML for the following equation[26].

$$X_{ijt}^{k} = \beta_0 + \beta_1\, ln\, \mathrm{GDP}_{it} + \beta_2\, ln\, \mathrm{GDP}_{jt} + \beta_3\, ln\, \mathrm{DIS}_{ij} + \beta_4\, ln\left(1 + \mathrm{Tariff}_{ijt}^{k}\right) + \beta_5\, ln\,(1 + \mathrm{SPS})_{ijt}^{k} + \beta_6\, ln\,(1 + \mathrm{TBT})_{ijt}^{k} + \beta_7 \ln(1 + \mathrm{OTHNTM})_{ijt}^{k} + \varepsilon_{ijt}^{k}$$

   (a) First, you will have to install the PPML package in STATA. For that, use 'ssc install ppml'. You may need connectivity to install the PPML package on STATA. Once this is done, use the following line of code.
   (b) 'ppml export lngdpi lngdpj lndist lntariff lnsps lntbt lnothntm'
   (c) Interpret the results. Can you try to calculate the average AVE for SPS, TBT, and other NTMs? (Average number of SPS, TBT, and other NTMs are 13.32, 6.19, and 2.14, respectively. Average AVE for SPS, TBT, and other NTMs for Sri Lanka for all seafood products are given by $(1 + Avg\#SPS)^{\left(\widehat{\beta_5}/\widehat{\beta_4}\right)} - 1$, $(1 + Avg\#TBT)^{\left(\widehat{\beta_6}/\widehat{\beta_4}\right)} - 1$, and $(1 + Avg\#OTHNTM)^{\left(\widehat{\beta_7}/\widehat{\beta_4}\right)} - 1$.)
5. Now try estimating a PPML for the following equation where NTMs are specified as a dummy variable.

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[24] For more details on how to set up a panel dataset using *xtset*, refer to STATA documentation available at https://www.stata.com/manuals13/xtxtset.pdf.

[25] You can use the following codes for this purpose.

xtreg lnexport lngdpi lngdpj lndist lnpopi lnpopj lntariff lnsps lntbt lnothntm landlock, fe vce (robust)

xtreg lnexport lngdpi lngdpj lndist lnpopi lnpopj lntariff bntm landlock, fe vce(robust)

[26] PPML is applied on the levels of exports, i.e. the dependent variable is exports, not log(exports). However, the explanatory variables can still remain in the log form.

$$X_{ijt}^{k} = \beta_0 + \beta_1\, ln\, \mathrm{GDP}_{it} + \beta_2\, ln\, \mathrm{GDP}_{jt} + \beta_3\, ln\, \mathrm{DIS}_{ij} + \beta_4\, ln\left(1 + \mathrm{Tariff}_{ijt}^{k}\right) + \beta_5 \mathrm{bnt}_{ijt}^{k} + \varepsilon_{ijt}^{k}$$

(a) You can use the following code 'ppml export lngdpi lngdpj lndist lntariff bntm'. Interpret the results and calculate the AVE for bntm using $exp\left(\widehat{\beta}_5/\widehat{\beta}_4\right) - 1$.

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10 Analysing Marketing Policies Using Market Integration Models

Pradeepa Korale-Gedara

Abstract

The objective of this chapter is to equip policy analysts with the knowledge to conduct ex-post evaluation of marketing policy. While there are many tools to evaluate marketing policies, this chapter describes one tool used to test marketing policy, market integration. Market integration testing goes beyond testing the physical connection between markets. It tests the price responsiveness of one market to the changes in prices in the other market. Tools used to assess the presence of market integration evolved since the 1970s from simple correlation tests to advanced threshold models. Cointegration test is one such test, which is used to assess market integration, when price series of the two markets are non-stationary during the study period. In this chapter we used Gregory-Hansen cointegration test, a modified cointegration test, to test a possible change to market integration associated with government intervention. The Gregory-Hansen cointegration test assesses the cointegration with one structural break. If the occurrence of the structural break in the cointegration and the timing of the policy intervention coincide with each other, then it can be concluded that the policy intervention has changed the price transmission process. Depending on the sign and the magnitude of the structural dummy, the exact effect is interpreted.

Keywords

Marketing policy · Market integration · Time series analysis · Gregory-Hansen cointegration test

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10.1 Introduction

The role of agriculture markets goes beyond the primary function of delivering products from producers to consumers. Efficient agriculture markets transmit macroeconomic signals to producers, provide incentives, balance demand and supply, and most importantly, promote efficient resource allocation (Jasdanwalla 1977; Chang 2012). Prices and the price transmission process between markets are the facilitators of these functions. Although it is widely believed that "market prices cannot fail" (Williams 2012, p. 18), there are numerous instances where prices and the price transmission process are found to be deficient facilitators. In these instances of market failure, governments may intervene with public policies to make markets more efficient.

Governments also face much criticism for intervening in markets. One of the main criticisms is that often the link between the rationale for government intervention and the actual intervention is weak. However, even as these criticisms take issue with the manner of intervention, they do not eliminate the need for such intervention: rather, they highlight the need for a prudent selection of the correct instrument to intervene with and a better understanding about the market under consideration.

Since policymakers are responsible for public money, the effect of interventions needs to be analysed. In fact, it is imperative to conduct both ex-ante and ex-post evaluation of marketing policies for better interventions.

10.2 The Context

10.2.1 Intentions of the Policy and Global Context

There are legitimate reasons for governments to intervene in agricultural markets. Reasons for intervention include use of public goods as inputs in production; imperfect information; externalities associated with adoption of new technology which require promotion through subsidy; unequal income distribution; and the presence of incomplete markets in insurance, futures, and credit.

Considering the history of government intervention in agriculture markets, immediately after World War II, there was a global trend towards more state-led economic models of development (Chang 2012). It was a widely held belief that market mechanisms would be unable to supply socially optimal quantities of agriculture inputs, such as irrigation, seed, and fertiliser. Consequently, many countries pursued government-financed research, irrigation, and extension programmes and provided fertiliser and agriculture loans at subsidised prices. Apart from this, many countries started to regulate the marketing of key agricultural products through marketing boards or co-operatives. While these policies brought significant positive changes, they had unintended effects, such as increased inefficiencies and burdens to government finances, that led to a shift in social expectations at the beginning of the 1970s about the role of governments in agriculture markets. This shift resulted in remarkable changes in policies during the 1980s and 1990s. In many instances, countries adopted market-oriented agricultural policies in which subsidies were curtailed and the role of marketing boards was reduced (Barrett 2008).

Marketing boards, statutory bodies that act as compulsory marketing agents controlling or performing market functions, are the long-standing instrument of agriculture marketing policies in both developed and developing countries (Veeman 1997). Based on the functions they perform, six types of marketing boards may be identified (Abdulai 2002): advisory and promotional boards (Abbott 1967); regulatory boards (Alexander and Wyeth 1994); boards stabilising prices without being engaged in trading (Ali 1966); boards stabilising prices by trading alongside other enterprises (Bandara and Jayasuriya 2007); export-monopoly marketing boards (Barrett 1996); and domestic-monopoly marketing boards (Abbott 1967). The Indonesia Logistics Bureau is a good example of a marketing board which handles food distribution and price control of rice; the organisation implements a procurement programme to stabilise produce prices and a distribution programme to stabilise consumer prices and acts as a buffer stock authority (Ismet et al. 1998).

Agriculture price policy is another commonly used instrument. Price policy intervention in agriculture produce markets aims to influence fluctuations in prices and price spreads from farm gate to the retail level. Governments attempted to stabilise producer prices in Europe as early as the 1930s through maintenance of buffer stocks (Ali 1966). Further, quota or licensing schemes have been frequently used to control supply and stabilise local market prices. Also, input subsidies are used to increase the supply of a commodity and, in turn, decrease prices in the domestic market and increase the competitiveness of local producers.

Apart from this, guaranteed prices and obligatory procurement have been used to stabilise farm gate price in many countries; on the consumption side, price ceilings on essential food commodities are used to protect consumers from price surges.

10.2.2 Policy Milestones of Sri Lanka

Sri Lanka has a long record of government intervention in agriculture markets, for export agriculture crops and import-substitution crops. At independence, Sri Lanka had a well-developed plantation crop sector. The objective of government intervention during this period was to tax the exports and, thereby, earn income from the agriculture sector. Part of the revenue collected was reinvested in the sector by means of research and extension and replanting. During the 1950s, taxes on plantation crop exports accounted for 30 per cent of the total tax revenue (Bandara and Jayasuriya 2007). However, after independence, the agriculture economy started to diversify, further supported by the country's import substitution policy during the 1960s. There was a trend of greater government involvement in agriculture markets through subsidies and investment in infrastructure. During this era, the government made huge investments in irrigation and introduced a fertiliser subsidy programme in 1962 (Bandara and Jayasuriya 2007). Since then, with some modification and temporary termination between 1990 and 1994, a fertiliser subsidy has been in effect and continues even today.

In addition to initiatives aimed at increasing production to reduce food imports into the country, there were restrictions on imports through licensing requirements for imports and greater government control in trade and marketing (Lakshman and Tisdell 2000). At the same time, certain initiatives were taken to strengthen the domestic market: one good example is the establishment of the Paddy Marketing Board (PMB) in 1971 to procure paddy from the domestic market, provide a better price for farmers, and distribute rice efficiently to rice-deficit areas (Bogahawatta 1982). At the beginning, the PMB had monopoly power to purchase paddy. Paddy brought by the Multi-Purpose Co-operative Societies (MPCS) were milled by PMB mills, co-operative mills, and government-contracted private mills. Then this rice was issued to the Food Commissioners Department to be distributed to the MPCS retail outlets.

However, in 1977 a change in government saw a radical policy change involving deregulation of control over imports and liberalisation of markets. Except for a few food crops, trade of most commodities was liberalised. After 1978, private traders were also allowed to purchase paddy from farmers: as a result, the share of paddy purchased by the PMB fell sharply to around 5 per cent. PMB operations were temporarily halted in 2002 and recommenced in 2008 with the change in government. However, due to the shortage of funds to purchase paddy at the correct time, the share of paddy procured by PMB is minimal even today.

The National Livestock Development Board (NLDB) was established in 1973 under the State Agricultural Cooperation Act No. 11 of 1972. However, NLDB's focus is limited to upgrading cattle breeds and farming. It plays a minimal role in the dairy market.

Interventions since 2000 have included the establishment of Dedicated Economic Centres which facilitate vegetable marketing and shorten the length of the marketing channel, thus strengthening the linkage between producers and consumers. One ill-fated government intervention was the 2011 directive from the Consumer Affairs Authority making it compulsory for plastic crates or hard boxes to be used to transport vegetables and fruits. This intervention failed as it did not take into account the many small-scale farmers. Since there is no way to return the plastic crates to farmers, this measure increased the cost to farmers and in turn farmers protested against it.

10.3 Theoretical Model to Assess the Effect of Marketing Policy

The objectives of policies, as well as the mechanisms by which policies work, are diverse and numerous. The social objectives of policies fall into the two main categories of efficiency and equity. Efficiency refers to the optimal usage of national resources; equity, to fair distribution of the total output between individuals or social groups (Ellis 1992). Measuring efficiency is challenging, although there are several measures for market efficiency.

One method of testing for market efficiency is to measure the presence of integration between two markets. Testing for market integration is a measure of the optimal allocation of resources and enables policymakers to examine whether an intervention has improved or weakened the linkage between two markets. The tests focus on price transmission between two markets. In an efficient market, prices act as signals of demand or supply, shortage or surplus. Markets that transmit prices well will see responses in production or consumption in response to these price changes; responsive markets are capable of allocating resources in an optimal manner. However, market integration is neither a necessary nor sufficient condition for market efficiency.

Several empirical studies have examined the influence of interventions on market integration. Ismet et al. (1998) assess the impact of government intervention in rice procurement on rice market integration in Indonesia during 1985–1995; their results indicate a positive influence from government intervention. Srinivasan (2003) examined the effect of market liberalisation on integration of the wheat, paddy/rice, mustard seed, Sorghum, and groundnut markets in India: findings confirmed that the degree of market integration was high for wheat, paddy/rice, and mustard seed during the post-liberalisation period (as compared to before liberalisation), without such indications for Sorghum and groundnut. Moreover, Baylis et al. (2013) studied the impact of an export ban on wheat and rice to safeguard domestic consumers in India from adverse world market price changes in 2007. They found that states which produced and consumed wheat were fully integrated after the ban, while states which exported rice and the world market were fully integrated prior to the ban (Baylis et al. 2013). Goletti and Babu (1994) found that after liberalisation of the maize market in Malawi in 1987, there was an increase in the number of markets integrated. Jayasuriya et al. (2007) found that for rice, integration between India and the world market was significantly improved after a policy of liberalising rice exports. Several other studies (Goletti and Babu 1994, for Malawi; Dercon 1995, for Ethiopia; Alexander and Wyeth 1994, for Indonesia) determined that market liberalisation increased domestic market integration.

10.3.1 Tools to Assess the Presence of Market Integration

In testing market integration, co-movement of prices between two markets is assessed. If two markets are integrated, then price changes in one market are transmitted to the other market where prices change in response. This efficient transmission of price changes between markets will ensure that prices in two markets do not drift apart in the long run.

Figure 10.1 shows price movements in two markets. Assume Markets A and B are trading with each other; Market A is a farmers' market, and B, a wholesale market. Since the two markets trade with each other, a change in demand or supply in one market should be conveyed to the other market immediately or within a short period of time. Assume a situation in which (marked with a circle) the price in Market A decreases due to a high supply. Ideally, this price change in Market A should be transmitted to the wholesale market and reflected in lower wholesale prices and increased demand for this commodity. The lower price and increased

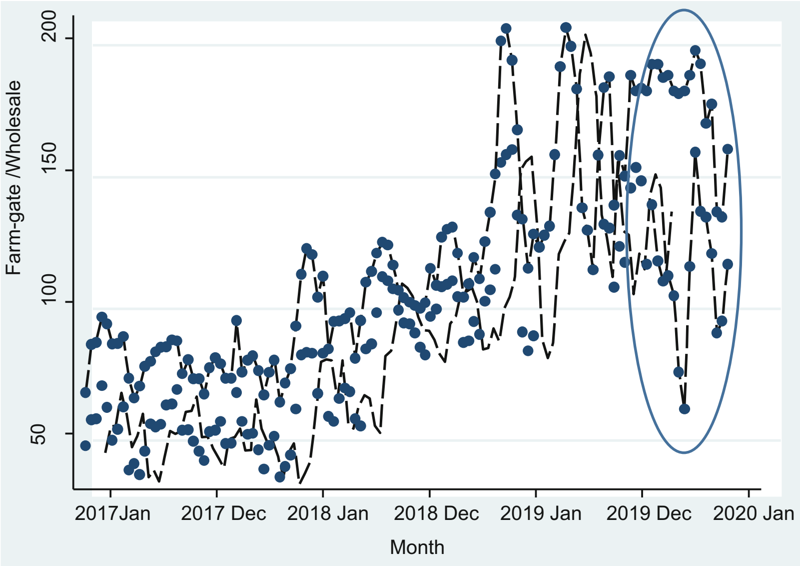

Fig. 10.1 Price movement in two segmented markets. *Source:* Drawn using the data obtained from Hector Kobbekaduwa Agrarian and Research Training Institute

wholesale demand should clear the market surplus. However, if the markets are not well integrated, then prices in the wholesale market will not adjust or adjust very slowly in response to changes in price in the farmers' market.

Time series data is used to test for market integration between two markets. Time series data is a sequence of observations of a defined variable at a uniform interval (frequency) over a period of time (Shrestha and Bhatta 2018). The frequency of data could be annual, quarterly, monthly, weekly, or daily.

Econometric tools used to test relationships between cross-section data may not be appropriate due to unique features, such as clear trend, high degree of persistence on shocks, high volatility, etc. Therefore, different econometric tools have evolved to test time series data. However, the appropriate time series model will depend on data availability, the nature of the data which will be discussed later. In selecting an appropriate methodological framework for time series data analysis, a researcher should be informed about the properties of the data. Box 10.1 presents a description of stationary properties of data.

Box 10.1 Stationary Properties of Time Series Data

If a variable's value tends to revert to its long-run average value, and properties of the data series are not affected by the change in time, that time series data will be called stationary (see Fig. 10.2). On the contrary, if the values do not revert to the long-run value, and mean, variance, and covariance of the series

(continued)

Box 10.1 (continued)
change over the time, this time series data is referred to as non-stationary (see Fig. 10.3; Shrestha and Bhatta 2018). If the time series is non-stationary, it is said to have a unit root.

In deciding on the appropriate technique to analyse data, a primary focus is given to stationarity. A unit root test is used to detect the stationary [stationarity] of a given series. Based on the results of the unit root test, the appropriate econometric tool to assess data will be determined. If both the variables are stationary, then ordinary least square (OLS) or vector autoregressive models can be used to assess the relationship between the two variables. If both variables are non-stationary, then cointegration, vector-error correction models, etc. can be used. If one variable is stationary and the other is non-stationary, then an autoregressive distributed lag (ARDL) cointegration technique will be used (Shrestha and Bhatta 2018). An ARDL cointegration

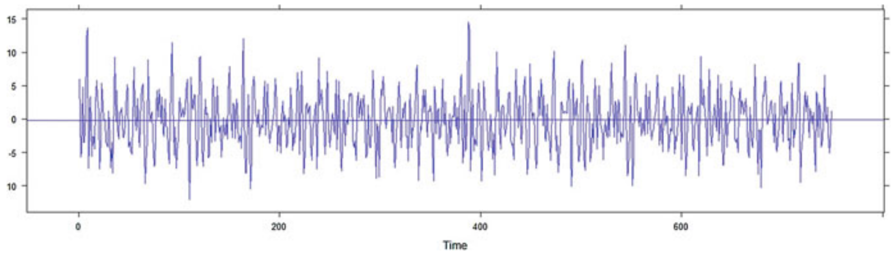

Fig. 10.2 Stationary time series. Source: Palachy (2019)

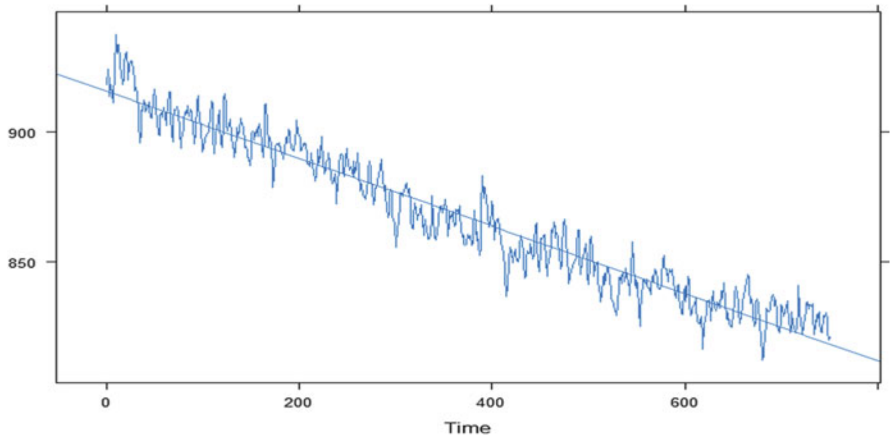

Fig. 10.3 Non-stationary time series. Source: Palachy (2019)

technique can be used when the data series is non-stationary and has mixed order of integration.

Econometric techniques to test for market integration have evolved over five decades. These techniques can be divided into three categories: pre-cointegration, cointegration, and other (von Cramon-Taubadel 2017).

Pre-cointegration techniques: Early researchers have used correlation techniques to test market integration. These techniques test the co-movement of prices in two markets connected with trade. The assumption is that when prices in one market change, prices in the other market also change, so that they move in the same direction. If the markets are integrated, this will hold true. However, the problem is even though the markets are not integrated, it is possible that two price series will co-move due to common periodicity (seasonality in agricultural production, influence of weather, etc.) and/or a common exogenous trend (inflation or pan-territorial pricing by a monopolist; Ravallion 1986; Alexander and Wyeth 1994; Barrett 1996). This problem associated with time series data is known as the non-stationarity of prices.

The other econometric problem occurs because correlation does not take into account the prices of the previous time period; therefore, it underestimates market integration. It is quite possible that prices will not adjust immediately. For example, if we consider daily prices, it is possible that prices in the integrated market will not adjust on the same day as the price change in the corresponding market. The adjustment in prices, for instance, can occur on the next day. But since the previous time period's prices are not considered in correlation analysis, even though the markets are integrated, the erroneous conclusion will be drawn that the markets are not integrated based on the correlation coefficient. Regression models with lag variables are used to overcome the stationarity issue in the time series. If the level of nominal prices is used, it could lead to an erroneous conclusion about the integration as the regression could be a spurious regression (see Box 10.2).

Box 10.2 Spurious Regression

Spurious regression implies that even though there is no relationship between variables, if the two variables are non-stationary, then regression will indicate that there is a relationship. For example, assume that a researcher estimates the relationship between population in Sri Lanka and consumption in India. While there is no relationship between these two, due to the effect of other variables, both these variables will show an upward trend (see Fig. 10.4). Thus, the estimated regression will have a higher R^2 as well. In reality, consumption in India may have changed due to income increases in India.

Even if this very same data is used to examine correlations between these variables, it will indicate that the two variables are highly correlated.

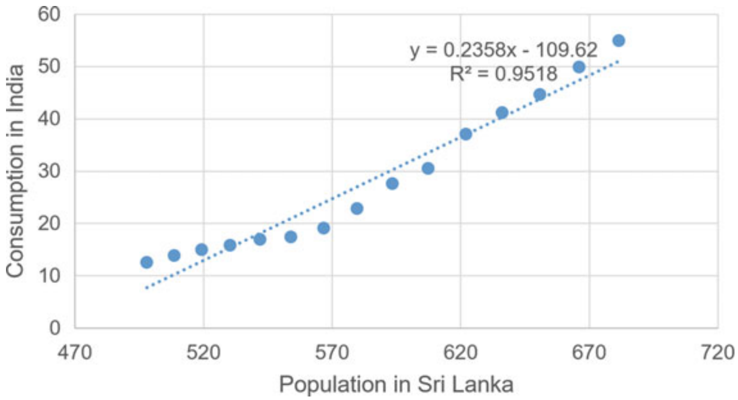

Fig. 10.4 Spurious regression

To overcome the problem of non-stationarity, Richardson (1978) used change in price instead of price levels. This model is the famous *law of one price* in which the following equation is tested.

$$\Delta P_i = \alpha + \beta_1 \Delta P_j + \varepsilon_t \tag{10.1}$$

ΔP_i and ΔP_j are prices of a commodity at market i and j. According to Richardian model, markets to be integrated α and β_1 need to take the value of zero and one, respectively (Baulch 1997). Since the model includes only one period, it assumes perfect price adjustment within one time period: the major flaw of the Richardian model.

Subsequently, Ravallion (1986) introduced a model in testing market integration which successfully addressed the problem of non-stationarity through an error correction model. To allow price adjustment to take time, he incorporated time lags into the model. The basic Ravalian model assumes that there is a central market, and prices in the peripheral markets adjust to the changes in the central market.

Both these models assume that if two markets are integrated, then price changes in one market will be transmitted on a one-to-one basis to the other market, either instantaneously or after a time lag (Baulch 1997). However, unless trade flows occur continuously between the two markets under consideration, this perfect co-movement of prices will not be valid.

Cointegration techniques: Cointegration techniques have been used by many researchers in testing market integration (Alexander and Wyeth 1994; Ghosh 2003; Van Campenhout 2007). The cointegration test does not assume that prices will transmit immediately: it allows prices to adjust with a time lag and prices to be simultaneously determined. More importantly, it does not assume perfect price adjustment. As with correlation techniques, cointegration tests also test for the co-movement of price series. But instead of testing whether the two price series

Fig. 10.5 An illustration of cointegration and short-run deviations

move together, cointegration tests examine the existence of a long-run equilibrium relationship between the two price series.

Consider two markets, i and j, which trade together. The long-run relationship between these two markets can be expressed as Eq. 10.2.

$$P_{it} = \beta_0 + \beta_1 P_{jt} + \varepsilon_t \tag{10.2}$$

where P_{it} is the price at the i^{th} market at time t, and P_{jt} is the price at the j^{th} market at time t. β_1 is the long-run price transmission coefficient. A significant β_1 coefficient indicates that change in price level in one market will be transmitted to the other market. Now, assume that P_{jt} has changed. To maintain the relationship, P_{it} needs to adjust. This means that prices in market i adjust in response to price changes in market j. Thus, even though prices deviate from their levels, the two price series do not drift apart as prices in one market adjust in response to the other market.

To better understand the concept, assume there is a man holding a dog with a rope as shown in Fig. 10.5. Both man and dog can move but cannot drift apart from each other because of the rope. The length of the rope will determine the maximum distance one can move away from the other. If they want to walk together, then when the dog moves, the man also must move. If the rope breaks, then they can move independently.

It is noteworthy that long-run equilibrium (or existence of co-integration between two markets) does not deny the existence of short-run deviations of prices. An external shock to the system which leads to deviation of prices from their long-run equilibrium triggers the systems to adjust the prices in the other market, so that the equilibrium will be restored. The dynamic of this adjustment can be tested using the Error Correction Model (ECM).

The Error Correction Model

$$\Delta P_{it} = -\rho u_{t-1} + \sum_{i=1}^{m} \varphi_i \Delta P_{i(t-n)} + \sum_{i=1}^{m} \beta_j P_{j(t-i)} + \lambda_1 ECT_{t-1} + \upsilon_{1t} \quad (10.3)$$

$$\Delta P_{jt} = -\rho u_{t-1} + \sum_{i=1}^{m} \beta_j P_{j(t-i)} + \sum_{i=1}^{m} \varphi_i \Delta P_{j(t-n)} + \lambda_2 ECT_{(t-1)} + \upsilon_{2t} \quad (10.4)$$

where Δ is defined as the change or difference in a variable from one period to the next, $u_{t-1}$is the error correction term, and υ_t is a stationary series.

If the system adjusts to short run deviations, then $\rho > 0$. This condition is tested in the ECM. The term ρ gives the proportion of the earlier error term corrected by the system within a unit period of time. In other words, the magnitude of ($1/\rho$), known as the adjustment speed, indicates the average time taken by the system to restore the long-run equilibrium after an external shock to the system.

Other models: There are two problems in using the cointegration test to test the presence of market integration. The first is that the cointegration test assumes the relationship between the two prices is linear. The linear vector error correction model also assumes that the dependent variable reacts linearly to changes in independent variables; this is not always true. For example, in the ECM, although it is assumed that both price increases and decreases are adjusted at the same speed, on many occasions, there is an asymmetry in price adjustment. Many researchers have witnessed this (Peltzman 2000; Sanogo and Amadou 2010; Abdulai 2002; Ghoshray 2007, 2008). If there is asymmetry in price adjustment, then the relationship between the dependent and independent variables could be non-linear or piecewise linear. Thus the relationship is more appropriately modelled as a non-linear (piecewise linear) conditional expectation function rather than a linear function (Barrett 1996). With this realisation, different sets of models were introduced to test the presence of market integration. The asymmetric threshold autoregressive model and asymmetric error correction models are capable of testing the piecewise linear relationship between two price series.

The second weakness is that cointegration tests ignore the transfer cost of moving products between two markets. Transfer cost comprises the transportation cost, loading and unloading cost, and normal profit of the trader. If the transfer cost is higher than the price disparity between two markets, then trade will not happen. Two markets trade with each other only when transfer cost is equal or less than the price disparity; otherwise the trade flow between two markets will be discontinuous and markets will not be integrated in those instances. The parity bound model, developed by Baulch (1997), addresses this problem. This model takes into account the transfer cost of moving products between markets. It defines three regimes: regime 1, price parity is equal to the transfer cost; regime 2, price parity is above the transfer cost; and regime 3, price parity is below the transfer cost. When production and consumption are specialised (production and consumption areas are different), then only regime 1 is consistence with market integration. If both markets produce and consume, then both regimes 1 and 2 are consistent with market integration. Regime 3 is inconsistent with market integration (Baulch 1997). To estimate the parity bound model, data on transfer cost needs to be available.

The decision to use cointegration or other advanced techniques will be determined based on the nature of the trade between markets and the data availability. If two markets have continuous flow of trade, cointegration technique can be used to assess the presence of market integration. Threshold cointegration can be estimated if time series data on transfer cost is available. However, this chapter does not intend to explain in any significant detail estimation techniques of PMB or threshold autoregression models. Instead the chapter provides guidance for a researcher to use cointegration technique in measuring market integration.

10.3.2 Testing for Cointegration

This section will explain the empirical testing of market integration using the cointegration technique.

10.3.2.1 Step 1: Verify Both Variables are Integrated of the Same Order

Empirical testing of market integration starts with testing for the presence of unit root in the price series, as the correct technique to use will be determined by the nature of the data. If both price series are stationary, then the OLS regression and Vector Autoregression model (VAR) will be estimated. If the two price series are non-stationary in their level form and stationary in the same order I(d), then a cointegration test can be performed. If the two price series have a different order of integration, an autoregressive distributed lag model (ARDL) will be used to test the presence of market integration (see Fig. 10.6). However, ARDL model cannot be used when either of series is integrated of order 2.

Unit root test: The statistical procedure employed to determine the stationarity of a series is called a unit root test. There are different tests available to test the presence of unit root (e.g. Augmented Dicky Fuller test (ADF), Dicky Fuller-Generalised Least Squares test (DF-GLS), Phillips-Perron test, etc.). The ADF test is the most widely used test. The null hypothesis of the ADF test is that the price series are non-stationary.

10.3.2.2 Step 2: Carry Out an Engle-Granger Causality Test

To understand the direction of price movement between the two markets, an Engle-Granger causality test is performed. This is a statistical test for determining whether one time series is useful in forecasting others. It can be used to test the direction of causality between two price series.

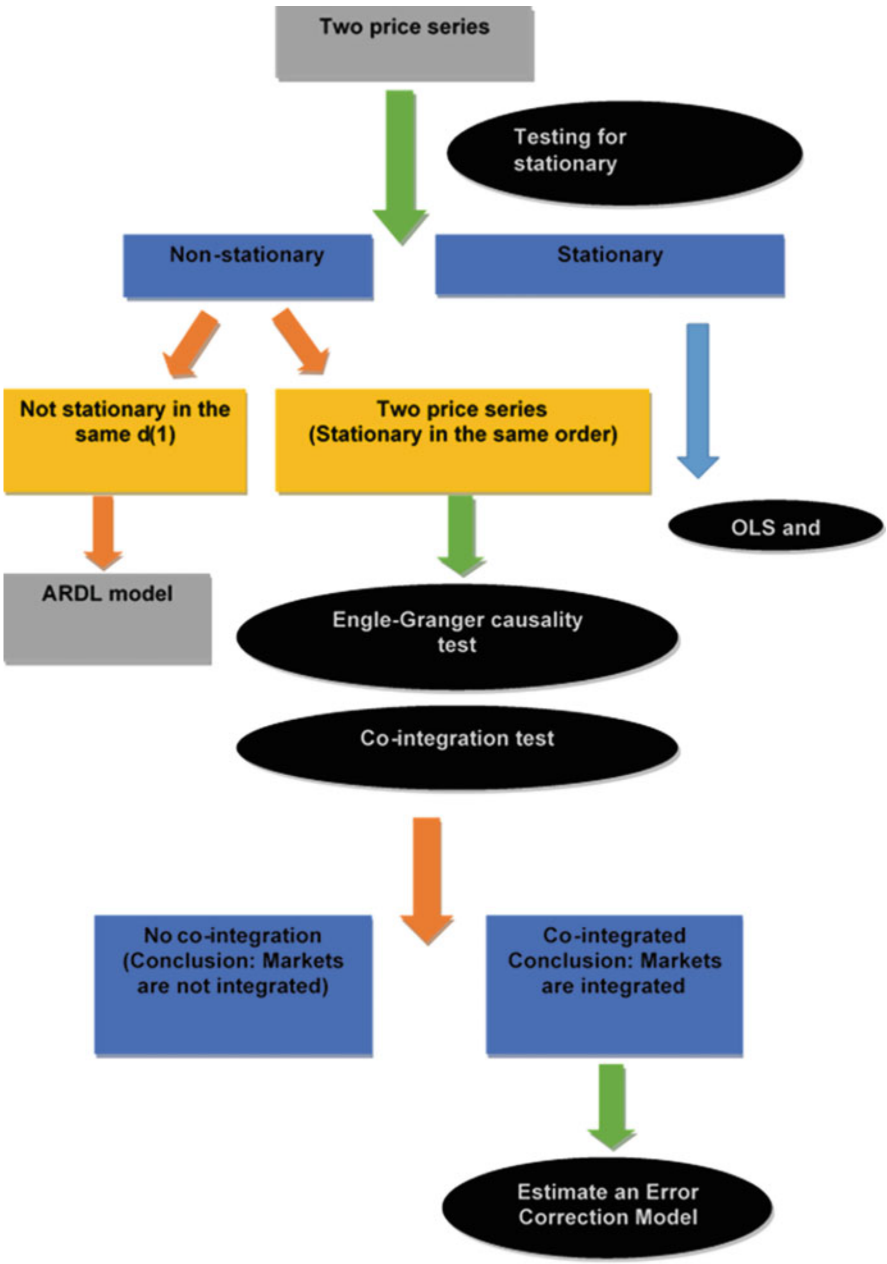

Fig. 10.6 Guild to select the most appropriate technique to test market integration

The null hypothesis is that the price in the i^{th}/j^{th} market does not Granger cause prices in the j^{th} / i^{th} market. There are three possible outcomes regarding causal relationships: uni-directional causality, bi-directional causality, and lack of any causal relationship. If there is a lack of causality between two markets, then it may be concluded that markets are not integrated.

10.3.2.3 Step 3: Carry Out a Cointegration Test

This is similar to the estimation of a linear regression model between the two price series. In this procedure, first the cointegration equation (regression equation) is estimated using a regression. The dependent and the independent variables are identified through the Granger causality test. Once the regression is estimated, then extract the error term (residual of the regression) and test the stationarity of the error terms. The test statistics of the unit root test will be compared against the critical values of the Engle-Granger critical test statistics. If the error terms are found to be stationary, then it can be concluded that the two price series are cointegrated and markets are integrated. Following this, the error correction model is estimated to understand the dynamics of price linkage between the two markets in the short run.

10.3.2.4 Step 4: Estimate and Interpret the Error Correction Model

If two price series are cointegrated, an error correction model is estimated to understand the dynamics of price linkage between the two markets in the short run. Using the coefficients of the error correction term, the time taken to restore the long-run equilibrium after a shock to the system is estimated.

10.4 Application

10.4.1 The Effects of Dedicated Economic Centres

This section applies the methodology discussed in the previous section to a hypothetical study aimed at assessing the impact of the policy measure establishing Dedicated Economic Centres in integrating the wholesale and retail markets for vegetables. Dedicated Economic Centres (wholesale markets) were introduced in 2007 in order to create an efficient vegetable marketing system by removing or minimising the number of intermediaries in the vegetable marketing system. If this objective has been achieved, then both the farm gate market and retail market would be well integrated with the Economic Centres. One way of assessing the effectiveness of the policy establishing the Economic Centres is to design a research to test whether the intervention has improved the market linkage between the Economic Centres and retail markets. Two scenarios could have resulted from implementation of the policy:

- Scenario 1: No impact. The policy intervention has no impact on the price transmission process between the wholesale and the retail market.

- Scenario 2: With the intervention, the price transmission process between the wholesale and retail markets has changed.

Since the objective is to explore the impact of a policy intervention on a price transmission process, the hypothetical study expects a change to the long-run equilibrium relationship between price series of the two markets. Consequently, if there is an impact of the intervention, a statistical test would provide evidence for the presence of a structural break in the long-run equilibrium. To capture this change in the long-run equilibrium, the Gregory-Hansen cointegration test is employed in this study. The Gregory-Hansen cointegration test is an extension to the Engle-Granger cointegration test. The null hypothesis here is the same as in the normal cointegration test, but the alternative hypothesis is different. The alternative hypothesis of the Gregory-Hansen method of cointegration is that: markets are integrated and there is one structural break. If the null hypothesis of the Gregory-Hansen method of cointegration is rejected and the time of the structural break is identified, examine whether the occurrence of the structural break coincided with the timing of policy intervention in the market. If the two events coincide with each other, it may be concluded that government intervention had an impact on the markets. The exact impact can be estimated through an ECM.

10.4.2 Data and Data Sources

Given the objective of this study to assess vertical market integration, time series data on prices of one vegetable at the two markets, the Economic Centre and the Colombo retail market, is the only data required to estimate the model. A data set of annual wholesale and retail prices for pumpkin for the period 1994–2016 can be used here (this would of course be a hypothetical dataset). The data set must have a consistent time interval (monthly, daily, or weekly data is preferable over annual data) between consecutive data points. Price data may be obtained from national data sources, such as the Central Bank, the Hector Kobbekaduwa Agrarian Research Institute, and the Department of Census and Statistics.

10.4.3 Policy Simulation

Figure 10.7 indicates the movement of the two price series. The first step is to establish the presence of unit root in the two time series price data set using the ADF test. The critical values and the estimated values of the ADF test for the two price variables (in level form as well as difference (D)) are presented in Table 10.1.

The results in Table 10.1 indicate that prices are non-stationary in their level form and stationary when the first difference was taken. Since both price series are integrated in the same order, the next step would be to test for the existence of cointegration relationship between the two price series using cointegration

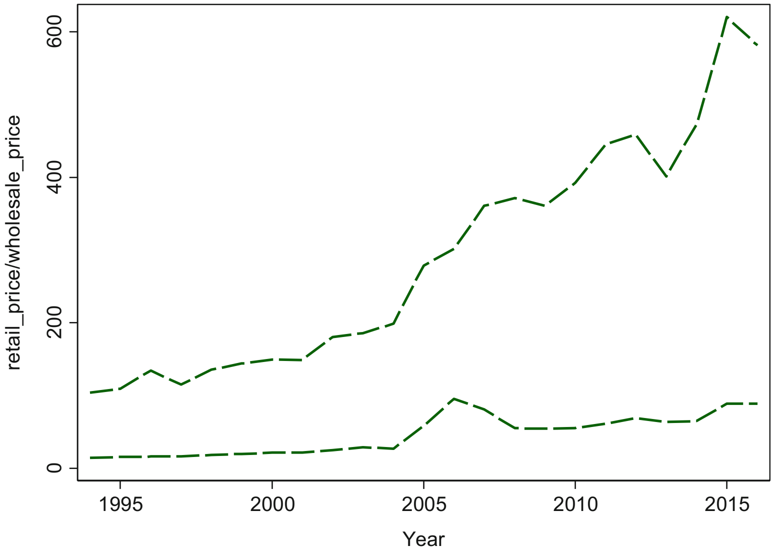

Fig. 10.7 Movement of wholesale and retail prices

Table 10.1 Test statistics of the Augmented Dickey-Fuller Test

	Including constant	Including trend	Including drift
1% critical value	*-3.750*	*-4.380*	*-2.528*
5% critical value	*-3.000*	*-3.600*	*-1.725*
10% critical value	*-2.630*	*-3.240*	*-1.325*
Wholesale price	-0.886	-2.337	-0.886
Retail price	0.244	-2.632	0.244
D (wholesale price)	-3.554 ***	..	
D (retail price)	-4.817 ***	..	

[a]Null hypothesis is rejected at 1% significance level

Table 10.2 The results of the Granger causality test

Direction of the causality	Chi square value	*P*-value
Wholesale prices do not Granger cause retail prices	0.3025	0.860
Retail prices do not Granger cause wholesale prices	5.8848	0.053[a]

[a]Significance at 10% level

technique. Therefore, first, Engle-Granger causality test is performed, and the results obtained are recorded in Table 10.2.

Table 10.3 Test statistics of the Gregory-Hansen test

	Test statistics	Critical values (5% significance level)	Breakeven point
Level			
ADF	−4.88	−4.61	2009
Zt	−4.01	−4.61	
Za	−19.46	−40.48	
Trend			
ADF	−5.04	−4.99	2009
Zt	−3.99	−4.99	
Za	−19.25	−47.96	
Regime			
ADF	−5.45	−4.95	2008
Zt	−5.47	−4.95	2007
Za	−26.29	−47.04	

Table 10.4 Cointegration equation

	Dummy (z)	Retail	Z*Retail	Z*wholesale	Constant
Cointegration equation with dummy variable	−32.5848*** (−5.82)	−0.1501*** (−20.63)	0.2169*** (3.72)	−0.9141** (−2.26)	17.69652 (2.5)

As the results in Table 10.2 indicate, retail prices Granger cause wholesale prices. Therefore, in estimating the cointegration equation, the wholesale price is taken as the dependent variable. Once the regression is estimated, the resulting error term is tested for stationarity and found to be non-stationary (ADF test statistics: - 0.244 *p*-value: 0.9746). This indicates that the two price series are not cointegrated.

Thus using the Gregory-Hansen cointegration test, the presence of cointegration with a structural break is tested. The Gregory-Hansen cointegration test examines for the existence of only one structural break in the cointegration vector. The test confirms the presence of a structural break in the data set (refer Table 10.3).

The ADF and Zt and Za statistics are above the critical value in the regime model. Here the model with lower value is preferred over higher value. So 2008 emerges as the break point (1 year after the intervention).

The next step is to create a dummy variable (z) to distinguish the period before 2008 and after 2008. Then two additional variables, Z*$z* P_{rt}$ and Z*$z* P_{wt}$, are created and a vector error correction model (VECM) run with these additional variables and dummy variable. The results of the model are presented in Tables 10.4 (long-run relationship) and 10.5 (short-run dynamics).

As Table 10.4 indicates, the dummy variable of the cointegration equation is less than zero and statistically significant. This indicates that the policy intervention has negatively affected price transmission between the two (wholesale and retail) markets. The result of the Error Correction Model is specified in Table 10.5.

Table 10.5 Error Correction Model with and without structural dummies

Models	Dependent variable (ΔP_w)						
	C	ΔP_w	ΔP_r	Z	z* retail price	z* wholesale price	EC $_{t-1}$
Without the dummy variables	13.6511 (2.47)**	0.4213* (1.71)	0.0370 (0.51)	..	..	..	−0.5693 (−2.56)**
With the dummy variables	18.3210 *** (3.35)	0.79580** (2.86)	0.0299 (0.42)	−12.0143 (−0.87)	0.2655* (1.86)	−1.9176** (−2.04)	−0.8401*** (−3.44)

* indicates the significance at 10% level, ** indicates the significance at 5% level, *** indicates the significance at 1% level

10.4.4 Policy Recommendations

Based on the results of the earlier section, we may conclude that the introduction of the Dedicated Economic Centres as wholesale centres has weakened the wholesale-retail market linkage even though the markets are still integrated.

10.5 Assignment

Design a policy research study to examine the effect of tea auctions on market integration between farm gate and wholesale market.

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Partial Equilibrium Analysis of Agricultural Price Policies

11

Jeevika Weerahewa

Abstract

This chapter is designed to help policy analysts learn how a simple market model introduced in lessons on principles of economics can be used to analyse the effects of price policies. The chapter intends to describe the nature of price policies implemented by developing countries with special reference to the agricultural and food price policies implemented by the government of Sri Lanka. It demonstrates the theoretical effects of a floor price scheme, a price ceiling, and an input price subsidy when implemented in a perfectly competitive market and describes the steps to be undertaken in performing a simulation exercise to analyse a price policy using an econometrically estimated model and a synthetically calibrated model.

Keywords

Partial equilibrium · Price ceiling · Price floor · Estimation · Simulation

11.1 The Context

11.1.1 Intentions of the Policy and Global Context

The focus in this chapter is on domestic price policies affecting output and input markets. This section provides information on different agricultural pricing policies implemented by some notable developing countries.

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11.1.1.1 Output Price Policies

Output price policies have been common policy instruments in many developing countries. A few examples can be cited from Bangladesh, Korea and Pakistan. Bangladesh operated a variable paddy rice tariff and an output price support. The level of the tariff varies on an ad hoc basis depending on the harvest. For example, when domestic production suffered substantial shortfalls as a result of the 'flood of the century' in 1998, import tariffs were eliminated and large private sector imports were allowed to flow into the country from India, thus stabilising domestic prices (Timmer and Dawe 2007). Output price support in Bangladesh has stimulated increasing investments in storage capacity to facilitate the increase of domestic grain production (Food and Agriculture Organisation 2016). Korea achieved self-sufficiency in rice paddy partially through output price controls. During the harvest period, the government purchased rice to support farm prices and released stocks to reduce consumer prices. Most of the time, the release price was less than the purchase price, plus storage and processing costs. The financial losses were borne by the government. Korea achieved self-sufficiency, well in advance of Bangladesh, where rates of population increase are much higher and lands limited (Krueger et al. 1991). In Pakistan, seasonal price stabilisation schemes, including government procurement and price ceilings, are common in wheat, which is the staple food (Krueger et al. 1991).

11.1.1.2 Input Subsidies

Input subsidies are incentives intended to increase productivity and production of farm outputs. Input subsidies include governmental support that reduces the cost of fertiliser, planting materials, and other farm inputs and technologies. Korea sought to circumvent the limitations on land for agriculture by increasing land productivity through measures such as increased application of fertilisers. Price subsidies and credits for fertilisers were provided. The government purchased fertilisers from producers and distributed them at a lower price to farmers while exporting the excess (Krueger et al. 1991). This led to a doubling of fertiliser usage between 1965 and 1986, and domestic fertiliser manufacturing plants were established. Thailand and the Philippines invested in irrigation, which facilitated two cultivations per year, and introduced an insurance scheme for rice farmers to address risks from natural disasters (Food and Agriculture Organisation 2018). Also, since 2016, Thailand has replaced its price stabilisation scheme with cash subsidies for rice farmers (Laiprakobsup 2019). Indonesia provided farmers with fertiliser at 50–75 per cent subsidised rates, along with an insurance scheme for rice farmers to cover natural calamities (Food and Agriculture Organisation 2017a). However, the effectiveness of these subsidies is highly context specific. For example, a study conducted on the fertiliser subsidy scheme in Bangladesh found that it was not as effective as expected because the supply of fertiliser was inelastic and the benefits accrued mainly to large-scale farmers. Small-scale farmers experienced a disadvantage as they purchased from large-scale farmers at unsubsidised rates. Further, limitations in irrigation facilities hampered the effectiveness of the introduced fertiliser subsidy scheme (Krueger et al. 1991). Malaysia implemented several assistance schemes, including a 100 per cent fertiliser subsidy and irrigation facilities for paddy farmers. Government distribution of fertilisers went through the main farmer organisations. Although the programme targeted mainly small-scale farmers, large-scale farmers also benefitted through multiple ownership, which is common in Malaysia (Krueger et al. 1991). Despite these incentives, production levels declined. As a remedy, the government introduced a land consolidation scheme called *estatization*, consolidating small lands into economically manageable land parcels, which successfully increased production through planting intensity and productivity improvements (Najim et al. 2007).

11.1.1.3 Food Subsidy

The majority of the world's poorest people depend on agriculture as their main source of income. The poor spend a relatively large portion of their income on food. Thus, food prices are major determinants of poverty level and income distribution (Anderson et al. 2010). Policies that raise the output price of food products hurt consumers, particularly those not engaged in farming. Food subsidies are one means of compensating consumers for real income decline, by effectively reducing expenditure on food consumption or increasing the level of food consumption by increasing affordability.

Since food subsidy schemes for the general population can be costly, implementation often includes aspects of targeting and rationing. For example, India provides food subsides through a minimum support price (MSP) scheme for which there was a threefold increase in cost between 2006 and 2012 (Sharma 2012). Indonesia implemented a subsidy scheme, a 'prosperity card', permitting the poor to purchase rice and sugar at concessionary rates. In addition, Indonesia provided cash transfers for children going to school and pregnant women attending regular clinics, targeting ten million households (Food and Agriculture Organisation 2017b).

11.1.2 Policy Milestones of Sri Lanka

11.1.2.1 Guaranteed Prices and Government Procurement

Since its independence in 1948, the government of Sri Lanka has been heavily involved in procuring paddy under a guaranteed price scheme. Between 1948 and 1971, paddy procurement was done through the Department of Agrarian Services. The Paddy Marketing Board (PMB) was established under the Paddy Marketing Board Act (No. 14 of 1971) primarily to (a) carry on the business of purchasing, selling, supplying, and distributing paddy and rice and (b) carry on the business and process of milling of paddy (Government of Sri Lanka 1971).

During the period 1972–1978, co-operatives collected paddy from farmers on behalf of the PMB, which hired private millers to process the paddy. The millers handed over the rice to the Food Commissioner's Department, which in turn issued it to the co-operatives for distribution to the consumers on ration. Also, the PMB was involved in maintaining a buffer-stock scheme for rice, using its regional warehouses.

With the opening up of the economy in 1977, the PMB Act was amended to permit the private sector to market rice. With this policy change, the share of PMB in purchasing paddy declined, and by 1990, the PMB became inactive.

In 2006, the Sri Lanka Agricultural Products Marketing Authority was established under the Companies Registration Act to purchase paddy through Co-operative Wholesale Establishments, the Co-operative Network, and farmer organisations. The PMB was re-established in 2007 and recommenced paddy purchasing in the 2008 *Yala* season. In 2018, the guaranteed price for Samba and Nadu rice were LKR 41 and LKR 38 per kg, respectively.

Proposals to introduce guaranteed prices for other food crops, specifically for potato, maize, raw milk, etc. have been made on a number of occasions. Such programmes, however, have not proved as long lasting as programmes for rice paddy.

11.1.2.2 Fertiliser Subsidy Programme

The government established a price subsidy for fertilisers in 1962, at the onset of the green revolution: the goal was to make fertiliser available to rice farmers at a low cost in order to maximise the benefits from high-yielding varieties introduced with the green revolution. It was expected that low fertiliser prices would increase the rate of adoption of high-yielding varieties, enhance land productivity, and reduce the cost of production, resulting in more profitable paddy farming. The increased paddy production was then expected to lower the prices of paddy and rice, thereby making rice affordable to the urban poor. Box 11.1 provides a timeline of important events in the fertiliser subsidy programmes in Sri Lanka.

Box 11.1 Timeline of fertiliser policy interventions

1962:	A fertiliser subsidy programme for paddy was introduced with a fixed subsidy rate.
1971:	Importation of fertiliser became a monopoly of the Ceylon Fertiliser corporation; importation of fertiliser by the private sector was banned.
1975:	The fertiliser subsidy programme was expanded to cover all crops.
1977:	Private sector companies were allowed to import fertiliser.
1978:	A uniform subsidy rate was introduced; the responsibility for administering the subsidy programme was given to the National Fertiliser Secretariat.
1979:	Subsidy rates were revised to 85 per cent for urea and 75 per cent for other fertilisers.
1988:	Subsidy rates were reduced, and the subsidy for sulphate of ammonia and rock phosphate was eliminated.
1990:	The subsidy was completely removed.
1994:	The subsidy for urea, sulphate of ammonia, muriate of potash, and triple super phosphate was reintroduced with a fixed fertiliser price.
1996:	The subsidy for sulphate of ammonia was eliminated.

(continued)

Box 11.1 (continued)

1997:	The subsidy was limited to urea.
2005:	The subsidy was limited to the main fertilisers for paddy (nitrogen, phosphate, and phosphorus) in their straight form but not as mixtures.
2006:	Tea, rubber, and coconut smallholder farmers (with less than five acres of land) became eligible for the fertiliser subsidy.
2009:	The fertiliser subsidy policy was coupled with a paddy procurement policy that required famers to supply a fixed portion of paddy to the government at a pre-specified price below the market price.
2016:	A programme, *A Wholesome Agriculture – A Healthy Populace – A Toxin-Free Nation* (2016 to 2019), was introduced under which it was suggested that the use of chemical fertilisers be phased out and organic agriculture be promoted. Tea smallholders continued to receive the subsidy of LKR15,000 per ha for fertilisers, which was implemented by the Tea Smallholder Development Authority.
2020:	Fertilisers were provided free of charge
2021:	Importation of chemical fertilisers was banned

Sources: Ekanayake (2009), Wickramasinghe et al. (2009), National Fertiliser Secretariat (2010–2020), Ministry of Finance (2010–2021)

11.1.2.3 Food Subsidy Programme

Interventions in Sri Lanka to increase the availability and accessibility of food date back to 1942, when a universal food subsidy scheme was implemented. Along with the introduction of more open trade and economic policies, a targeted food stamp programme was introduced in 1977 (refer to Table 11.1). While such programmes enhanced the availability and accessibility of energy and protein overall, successive governments improved food utilisation by targeting the specific nutritional needs of vulnerable segments of the populations, such as pregnant and lactating mothers and preschool children, through direct food provision, including school meal programmes, the Thriposha programme, and the nutrition bag programme.

The political objectives of the governing parties largely shaped the design of food policies in the early years after independence. Compared to policies in the present era, the policies implemented in the past had some profound effects on food price levels (Weerahewa et al. 2018).

11.2 Theoretical Model to Assess the Effects of Price Policies

The theoretical models presented in this section focus on closed markets (i.e. absence of international trade).

Table 11.1 Evolution of food assistance programmes 1942–2019

Period	Name of the programme	Objective of the programme	Approximate number of beneficiaries
1942–1979	Food subsidy programme	To protect consumers from rising prices and ensure equitable distribution of basic food items	Entire population of the country until 1970 From 1978, entire population except for income tax payers
1977–2002	Food stamp programme	To minimise hardships faced by communities in the country	In 1977, 50 per cent of the population In 1996, 10 per cent of the population
1989–1994	*Janasaviya* programme	To alleviate poverty in the country	1994: 265,000 families
1995–2019	*Samurdhi* programme	To improve the socioeconomic conditions of youth, women, and disadvantaged groups	1995: 2.2 million families 2006: 1.9 million families 2012: 1.5 million families 2015: 1.4 million families

Source: Adopted from Weerahewa et al. (2017)

11.2.1 Baseline Equilibrium: Competitive Market

The effects of price policies can easily be demonstrated using a market model developed using a partial equilibrium framework. The basic partial equilibrium model is comprised of a demand curve, a supply curve and a market closure condition.

Consider the demand curve, the supply curve, and the equilibrium condition given below:

$$D = D(P, M)$$

$$S = S(P, W)$$

$$D = S$$

where:

D = quantity demanded
S = quantity supplied
P = price
M = vector of demand shifters
W = vector of supply shifters

The above model can be extended to assess the well-being of consumers and producers, as well as the expenditures to be incurred by the government with the implementation of a price policy.

Figure 11.1 depicts the equilibrium in a closed market. The supply curve slopes upwards, the demand curve slopes downwards, and the intersection of the supply and demand curves determines the equilibrium price (P*) and the equilibrium

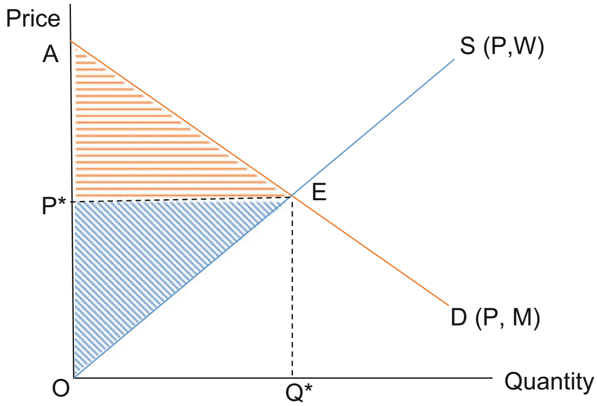

Fig. 11.1 Baseline equilibrium

quantity (Q^*) in this market. The area below the demand curve and above the price level, i.e. triangle AEP*, represents the consumer surplus (CS); the area above the supply curve and below the price level, i.e. triangle OEP*, represents the producer surplus (PS).

11.2.2 Application of the PE Model: Counterfactual Equilibrium with a Producer Price Subsidy

The equilibrium in this market after the imposition of a price floor, i.e. the minimum price that can prevail in this market, is depicted in Fig. 11.2. The quantity demanded under the controlled price (P_F) is given by (D_F), and in the absence of a government procurement scheme, the quantity demanded becomes the limiting factor and hence the equilibrium quantity supplied. This creates a deadweight efficiency loss in the market (BCE). PS increases from OEP* to OCBP$_F$. CS decreases from AEP* to ABP$_F$. Producers gain at the expense of the consumers, and society as a whole will lose as the gain in PS is not adequate to cover the loss in CS.

If the government has a parastatal to purchase the harvest at this given minimum price (P_F), then there will be a divergence in the quantity demanded (D_F) and the quantity supplied (S_F). Figure 11.3 shows the impacts of such a policy. In this situation, the PS would be much larger (shown by area OFP$_F$). CS will remain at ABP$_F$. However, the government will have to incur expenditure on procurement equivalent in value to the area P$_F$FS$_F$O (if the entire stock is purchased). Local consumers will purchase a value equivalent to the area P$_F$BD$_F$O if the retail price is the same as the guaranteed price; hence, the government has to bear the remaining cost, which is equivalent to D$_F$BFS$_F$.

In practice, parastatals tend to dispose of the stock at a lower price in another industry in the same country or to a foreign country to recover at least a part of the loss. The parastatal has the choice of selling the produce at a lower price in the same

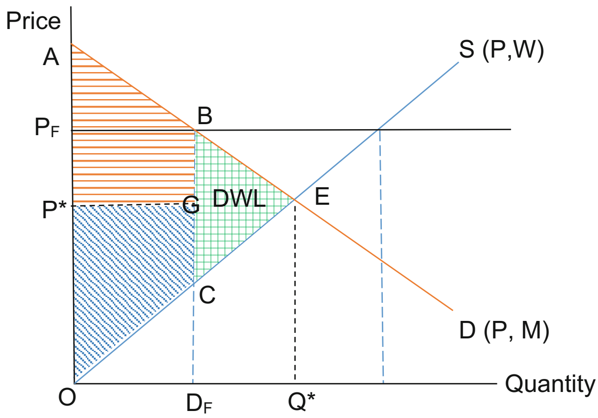

Fig. 11.2 Counterfactual equilibrium: a producer price subsidy with no government procurement

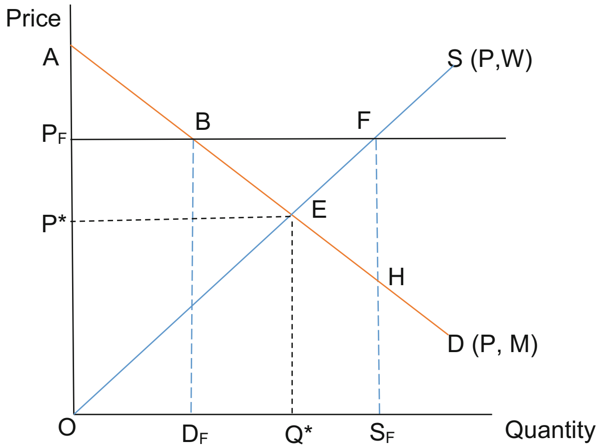

Fig. 11.3 Counterfactual equilibrium: a producer price subsidy with government procurement programme

market too. The local consumers would purchase the entire stock at the intersection of the local demand curve and S_F, which occurs at H. When this happens, consumers gain, the government incurs losses, and society will have to incur a deadweight loss of EFH.

11.2.3 Counterfactual Equilibrium: An Input Price Subsidy

The equilibrium in the market depicted in Fig. 11.1 after imposition of an input price subsidy is depicted in Fig. 11.4. This causes a shift in supply, which leads to an increase in equilibrium quantity demanded and supplied (Q_S) and a lowering of equilibrium price from P^* to P_S. This increases CS by P^*EIP$_s$, but the effects on PS are uncertain. The PS will change from OEP* to OIP$_s$. This change can either be beneficial or harmful to the producers. The size and direction of change in PS depend on the slope of the demand curve and the size and nature of the shift in the supply curve.

It is important to note that in the case of an input subsidy, the cost of the subsidy is not marked in Fig. 11.4, and it has to be shown in the respective input market. Figure 11.5 shows the equilibrium changes in the input market due to the imposition of the subsidy, assuming that there is no local supply and the entire requirement of the input is imported. The world market price is shown by *W**, and the quantity imported is *X** in absence of an input subsidy. When a subsidy is provided, the price of the input is lowered to *W*′, and *X*' will be imported into the country. The cost of the subsidy to the government will be *W**KLW', and there will be a deadweight efficiency loss equivalent to JKL.

The gain in CS in the input market, equivalent to *W**JLW', should be interpreted with caution. The consumers in the input market are the producers in the market

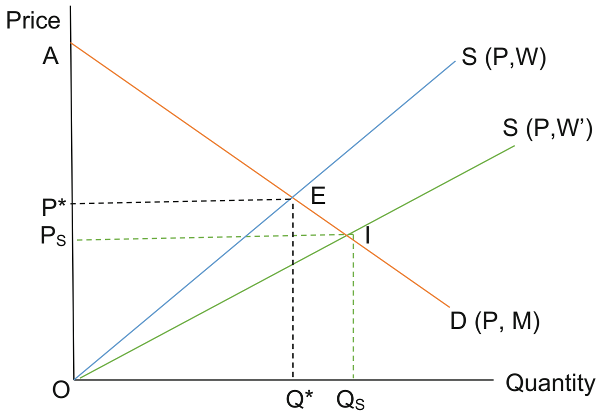

Fig. 11.4 Counterfactual equilibrium: input subsidy

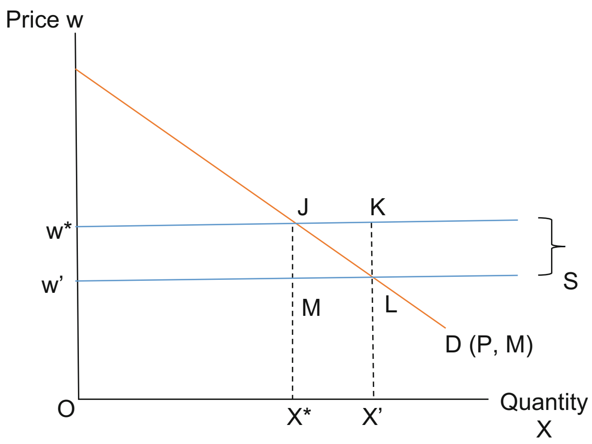

Fig. 11.5 Baseline and counterfactual equilibrium of an input market with and without price subsidy on input

shown in Fig. 11.4. The benefits will be double-counted if the change in CS in the input market and change in PS in the vertically related market are summed.

11.2.4 Counterfactual Equilibrium: A Food Price Subsidy

The equilibrium in the market depicted in Fig. 11.1 after the imposition of a price ceiling, i.e. the maximum price that can prevail in this market, is depicted in Fig. 11.6. The quantity supplied under the price ceiling (P_C) is given by (S_C), and in the absence of a government distribution scheme, this quantity becomes the equilibrium demand. This creates a deadweight efficiency loss (REN) in the market, along with a loss in PS ($P^*\text{ENP}_C$), and a gain in CS (from AEP* to ARNP_C).

The imposition of price ceilings, in economies with large informal sectors, can generate black markets. Generally, the product is sold in limited quantities through the government distribution channel, along with a price ceiling. If the beneficiaries are not properly targeted and/or the product is sold at the concessionary price on a first-come-first-served basis, intermediaries purchase the product from the government agency for sale in the informal market at the highest willingness to pay, as determined by the demand curve. In an extreme case, the entire CS marked by the area ARNP_C will be reaped by the intermediaries.

If the government opens up trade, and the world market price happens to be P_C, then the economy will enjoy trade gains. Consumers would demand D_C, the excess demand would be imported (D_C–S_C), consumers would enjoy a surplus of AUP_C, and gains from trade will be EUN.

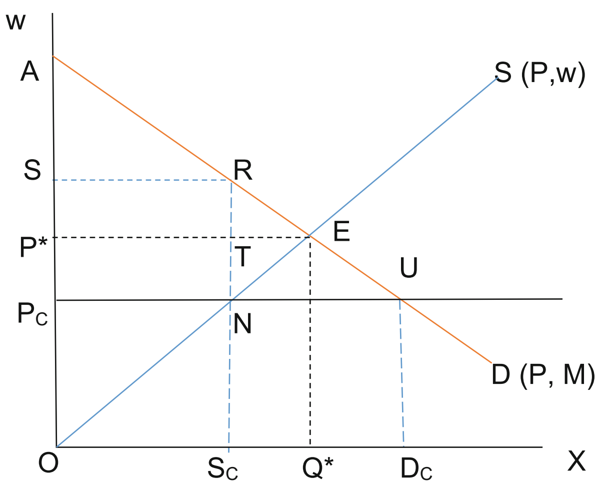

Fig. 11.6 Counterfactual equilibrium: a consumer subsidy with no government intervention

11.3 An Application Using an Econometrically Estimated Structural Model

11.3.1 A Price Ceiling for a Non-tradable Food Commodity

Suppose that you are interested in estimating the effects of a price ceiling imposed on chicken meat. The first step would be to understand the regulations imposed. Given below is an example of a gazette notification imposing the maximum ceiling price for chicken Sri Lanka.

Maximum retail prices of chicken

Details	Price (Rs.)
Frozen refrigerated broiler chicken meat with skin 1 kg	380.00

Let's pose a policy question related to this regulation: *what will be the effects of a price ceiling on chicken on the chicken market of Sri Lanka?*

A slight rewording of the above policy question enables us to make the above researchable and formulate a policy research question. Here is a potential policy research question: *what equilibrium would have prevailed in the chicken market if the retail price had not been regulated by the Consumer Affairs Authority of Sri Lanka?*

11.3.2 Empirical Model

In order to assess a policy research question of this sort, we need to rely on a theoretical framework. The partial equilibrium model explained in Sect. 11.2.4 provides an appropriate framework for this analysis.

The model consists of three equations and three endogenous variables, namely demand, supply, and price. We could extend this model to accommodate the specific characteristics of the chicken market.

If we plan to study the price ceiling on chicken meat, first we need to identify the exact product and limit our analysis to the product that matches the description stated in the regulation: 'Frozen, Refrigerated Broiler Chicken with Skin' bought and sold at the retail level as per the above regulation. Value-added products of chicken (sausages, meatballs, etc.) are excluded.

This also requires a specification of the demand for chicken at the retail level. We could specify a function that treats per capita consumption of chicken as the dependent variable and chicken price, prices of chicken substitutes, per capita income, and a proxy for tastes and preferences as independent variables. To complete the demand side of the model, another equation needs to be added to the model to connect the per capita consumption of chicken with the total demand for chicken. An identity can be used for this purpose.

It would be better to capture chicken supply at the farm level rather than at the retail level. Farm-level supply of chicken can be specified as a function of the farmgate price of chicken. An equation is required to connect the farm-gate price of chicken with the retail price of chicken.

An equilibrium condition needs to accommodate the structure of the market. The whole chicken market can generally be considered as a closed market, yet the demand in a given year is not exactly equal to the supply in that year – stocks, wastage, and some unexplained issues need to be taken into account. A residual in each year can be identified and added to the equilibrium condition to capture such differences.

Box 11.2 specifies an empirical model that can be used to estimate the effect of a ceiling price imposed on chickens. Please note that all price and income terms are expressed in real terms in this model.

Box 11.2 An empirical model to estimate the effects of a price ceiling on chicken in Sri Lanka—equilibrium without price ceiling

Demand side:

1. PCD = $a + b$ RRP + c RPCM, where PCD = per capita *demand*, RRP = *real retail price*, and RPCM = *real* per capita *income.*
2. D = PCD * POP, where D = *total demand* and POP = *population.*

Supply side:

3. RMM = RRP – RFGP, where RMM = *real marketing margin* and RFGP = *real farm-gate price.*
4. S = d + e RFGP + f RW, where S = *supply* and RW = *real wage rate.*

Market-clearing conditions:

5. $S = D$ + INV, where INV = *residual including inventories.*

Exogenous variables:
RPCM, POP, RW, RMM, INV
Endogenous variables:
RRP, D, PCD, RFGP, S
Parameters:
a, b, c, d, e, f

The values of five endogenous variables may be expressed in terms of exogenous variables and parameters by simultaneously solving the above equations. The values of the endogenous variables can be obtained in a sequential manner using the equations given below:

RRP = [$d - e$ RMM + f RW − a POP − c POP * RPCM − INV]/(b POP − e)
RFGP = RRP − RMM

$S = d + e$ RFGP $+ f$ RW
PCD $= a + b$ RRP $+ c$ RPCM
$D =$ PCD * POP
Once the price ceiling is imposed, the closure of the above model changes. Box 11.3 specifies the model after the imposition of the price ceiling.

Box 11.3 An empirical model to estimate the effects of a price ceiling on chicken in Sri Lanka—equilibrium with price ceiling
Demand side:

1. $D =$ PCD * POP

   Supply side:

2. RMM = RRP − RFGP
3. $S = d + e$ RFGP $+ f$ RW

   Market-clearing conditions:

4. $S = D +$ INV

   Exogenous variables:
   POP, RW, RMM, INV, RRP
   Endogenous variables:
   D, PCD, RFGP, S
   Parameters:
   a, b, c, d, e, f

Note that RRP in the above model is exogenous and hence the values of four endogenous variables of this model can be directly obtained by sequentially solving the equations in the following order:

RFGP = RRP − RMM.
$S = d + e$ RFGP + f RW.
$D = S -$ INV.
PCD $= D$/POP.

The models depicted in Boxes 11.2 and 11.3 can be extended to include the equations for CS, PS, and deadweight efficiency loss.

11.3.3 Data, Data Sources, and Econometrics

In the model depicted in Box 11.2, Eqs. (11.1) and (11.4) are stochastic equations to be estimated econometrically. To estimate these two equations, a data set to capture variability in all the exogenous and endogenous variables is required. Variability in prices can only be captured, in a small country like Sri Lanka, in a time series. Therefore, in order to estimate demand and supply equations, a time series data set is required. The prices and income levels are to be deflated using appropriate price indices to obtain a time-varying data set.

The data set can be compiled using the statistics reported in various government publications. Per capita consumption data are available in the food balance sheets of the Department of Census and Statistics; price data are available from the Hector Kobbekaduwa Agrarian Research and Training Institute; per capita income and price indices are available in Central Bank annual reports.

The longer the time series is, the higher the variability and the lower the standard errors are. Suppose that the following data set has been gathered (Table 11.2).

The first step is to obtain a plot of data. Figure 11.7 provides some sample plots. These plots help in identifying missing values, typographical errors, and inconsistencies in data.

The second step is checking the stationarity properties of the data to avoid spurious regressions. A detailed discussion on this aspect is beyond the scope of this chapter; hence, the analysis is carried out without this test.

The two equations can be estimated using ordinary least squares (OLS) if the assumptions for OLS have not been violated.

Tables 11.3 and 11.4 show the results of econometric estimation using the above hypothetical data set and considering the relationships to be linear. Alternatively, a log-log, linear-log, or log-linear functional form can be employed. The nominal price and income variables were deflated using the price indices to obtain the real values of the same.

The above coefficient estimates can be used to obtain elasticities of demand and supply with respect to own prices and other factors affecting demand (income) and supply (wage rate). Table 11.5 shows the elasticities of demand and supply computed at the mean of the sample.

In order to complete the model, exogenous variables in identities (2) and (3) are to be used. Table 11.6 provides the values of MM and INV, which would be consistent with the data set given in Table 11.2. The value of MM is obtained by deducting FP from RP, and the value of INV is obtained by deducting *S* from *D*. Price index was used to obtain the real value of market margins.

11.3.4 Validation of the Model

The next step is to test the degree to which the above model captures the actual values. This can be achieved by predicting the values of endogenous variables using values of the exogenous variables and the parameters of the model. If the predictions

Table 11.2 A hypothetical data set

Year	Demand	Supply	Nominal retail price	Nominal farm gate price	Nominal wage	Nominal income	Price index	Population
2005	144.76	154.76	462.36	452.36	514.80	1500.00	100.00	1.50
2006	151.02	171.02	490.10	479.89	505.29	2042.00	102.10	1.52
2007	166.90	166.90	476.53	466.14	509.25	2181.27	103.87	1.54
2008	162.15	166.15	504.09	493.61	554.42	2252.77	104.78	1.55
2009	162.70	172.70	511.83	501.18	516.46	2397.60	106.56	1.57
2010	168.58	172.58	535.67	524.71	529.60	2530.84	109.56	1.59
2011	177.88	173.88	516.49	505.49	506.81	2673.00	110.00	1.61
2012	177.06	193.06	547.12	535.93	470.12	2799.50	111.98	1.63
2013	180.21	178.21	567.84	556.53	561.89	2918.50	113.12	1.65
2014	178.14	183.14	582.97	571.39	588.65	3010.28	115.78	1.66
2015	184.98	185.98	565.80	554.08	515.79	3058.92	117.20	1.68
2016	183.67	193.67	585.94	574.10	500.36	3114.71	118.43	1.69
2017	164.71	172.71	650.68	638.69	722.30	3201.86	119.92	1.70
2018	191.98	182.98	609.54	597.54	573.62	3600.00	120.00	1.72
2019	186.78	201.78	684.82	672.55	714.57	4296.60	122.76	1.73

Source: Hypothetical data—constructed by the author

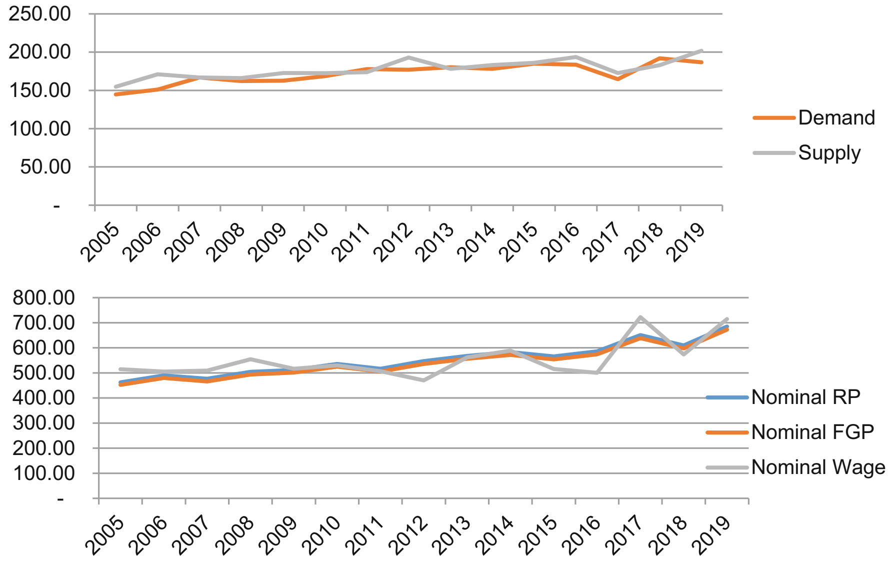

Fig. 11.7 Plots of the hypothetical data set

Table 11.3 Results of the econometric estimation of demand equation

Summary output					
Regression statistics					
Multiple R	0.94				
R square	0.89				
Adjusted R square	0.87				
Standard error	1.75				
Observations	15.00				
ANOVA					
	Df	*SS*	*MS*	*F*	*Significance F*
Regression	2.00	292.31	146.15	47.71	0.00
Residual	12.00	36.76	3.06		
Total	14.00	329.07			
	Coefficients	*Standard error*	*t stat*	*P-value*	
Intercept	162.77	10.27	15.85	0.00	
RRP	−21.91	2.82	−7.77	0.00	
RPCM	3.41	0.35	9.77	0.00	

are close to actual values, we consider that the model is valid for policy analysis. The indicators to test the validity of the model include percentage error, mean square error, root mean square error, bias, etc.

To begin the validation, the two stochastic equations should be validated as single equations first. Figure 11.8 provides the results of the validation of PCD and *S*,

Table 11.4 Results of the econometric estimation of supply equation

Summary output					
Regression statistics					
Multiple R	0.93				
R square	0.86				
Adjusted R square	0.84				
Standard error	4.88				
Observations	15.00				
ANOVA					
	Df	*SS*	*MS*	*F*	*Significance F*
Regression	2.00	1821.33	910.67	38.20	0.00
Residual	12.00	286.09	23.84		
Total	14.00	2107.42			
	Coefficients	*Standard error*	*t stat*	*P-value*	
Intercept	35.26	23.30	1.51	0.16	
RFGP	51.47	6.03	8.53	0.00	
RW	−21.48	3.21	−6.68	0.00	

Table 11.5 Computation of elasticities

Equation	Variable	Mean	Coefficient	Elasticity
Demand	RRP	4.93	−21.91	−1.02
	RPCM	15.06	3.41	0.48
Supply	RFGP	4.83	51.47	1.40
	RW	4.94	−21.48	−0.60

Note: Mean of PCD = 105.96, and Mean of $S = 177.97$
Source: Author's calculations

Table 11.6 Values of the inventories and marketing margins

Year	Inventory (INV)	Nominal marketing margin (MM)	Real marketing margin (RMM)
2005	−1275.23	12,000.00	120.00
2006	349.03	11,231.00	110.00
2007	−638.46	12,983.75	125.00
2008	−1493.27	13,830.96	132.00
2009	2144.22	10,656.00	100.00
2010	1331.15	24,103.20	220.00
2011	3704.45	15,400.00	140.00
2012	−117.50	17,916.80	160.00
2013	1716.36	13,574.40	120.00
2014	−735.58	17,367.00	150.00
2015	1014.59	16,994.00	145.00
2016	2310.86	15,395.90	130.00
2017	−723.63	16,788.80	140.00
2018	3256.26	7200.00	60.00
2019	−2216.92	13,503.60	110.00

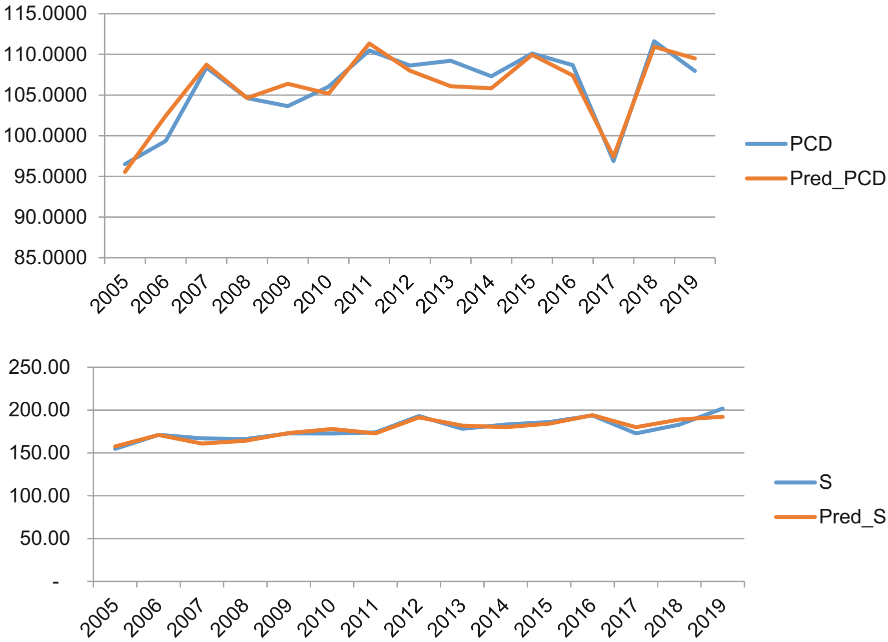

Fig. 11.8 Plots of actual values of PCD and *S*, together with their predicted values

Table 11.7 Percentage error in the predicting of the endogenous variables at the mean

Variable	Actual	Predicted	Percentage error
RRP	4.9340	4.8155	−2.4019
RFGP	4.8340	4.7155	−2.4516
PCD	105.9603	105.9603	0.0000
D	172.1010	172.0705	−0.0178
S	177.9677	177.9371	−0.0172

Source: Author's calculations

treating RRP and RPCM as the exogenous variables for the determination of PCD and RFGP and RW as the exogenous variables for the determination of *S*.

However, we are aware that RRP and RFGP are linked through RMM and that PCD and *S* are linked through INV. RRP was determined through the interaction of demand and supply; RRP, RFGP, PCD, *D*, and *S* are endogenously determined; and the values of the variables were determined by RPCM, RW, RMM, and INV, as depicted in Box 11.3.

The predictions of the endogenous variables are depicted in Table 11.7. The deviations of predictions from the actual levels show the validity of the model. The model is taken for policy analysis despite the deviations.

It should be noted that if we are to predict what will happen in 2020 using this model, we require predicted values for all the exogenous variables for 2020. The procedure adopted for validation in the example cited in Table 11.7 refer to predictions within the study period.

11.3.5 Policy Experiments and Policy Simulations

The above model can now be used to perform a few policy experiments. The nature of the policy to be experimented upon depends on the research questions raised at the beginning of the project. In the current example, the purpose is to examine the economic effects of the price ceiling.

Conducting this policy experiment is generally termed a simulation, and the values of endogenous variables generated through this process are termed as simulated values. Simulated values are different from the predictions made in the previous section, where the purpose was testing the validity of the model to make predictions within the study period. The simulation involves obtaining values for endogenous variables for each of the years by changing one or more of the exogenous variables (price of chicken meat in this example) to reflect the policy change using the model developed for the counterfactual scenario.

11.4 An Application Using a Synthetic Model

Despite the advantages of using an econometrically estimated system of equations for policy simulations, they are not popular among policy analysts. They perceive that the knowledge and skill requirements to perform a policy simulation using econometrically estimated behavioural functions are quite high. Developing a model to perform such an analysis requires a fair knowledge of microeconomic foundations and econometric techniques and numerical skills. Even for an experienced researcher with the necessary expertise, the exercise can be highly time-consuming.

Synthetic models can retain the same structure as in the case of an econometric model, yet they are not demanding in terms of researchers' time. The equations in a synthetic model are deterministic, and they are synthesised using a baseline data set and elasticity estimates available in published articles. The equations are first calibrated to a given equilibrium, commonly known as baseline equilibrium, and then used for the simulation. When elasticity estimates are not available, guess estimates are used. The characteristic feature of the synthetic model is the non-reliance on stochastic equations. All the equations are considered as identities.

Synthetic models can either be static or dynamic. In static models, the baseline data set reflects a snapshot of the market under consideration at a given period. The temporal effects cannot be considered using a static model. In dynamic models, data over a few points in a given time period are used, and connection from a one-time point to another is captured.

Let's look at how a static synthetic model is developed to assess the effects of increasing an import tariff charged on vegetable seeds by the government of Sri Lanka.

11.4.1 Step 1: Gather Information to Depict the Baseline Equilibrium

Suppose that the baseline equilibrium of the market is characterised by a tariff of 25 per cent. Let's consider that 5000 tonnes of seed is produced locally and 10,000 tonnes were demanded by the country in 2019, with a wholesale price of seed in the local market of LKR 50 per kg. The tariff rate and wholesale price imply that the world market equivalent price – the price that would prevail in the wholesale market in the absence of import tariff – is 50/(1 + 0.25), which is equal to LKR 40 per kg. It should be noted that, unlike import price, the world market equivalent price accounts for market margins between the wholesale market and the point of imports. The gap between demand and supply, 5000 tonnes, could be attributed to imports, exports, differences in inventories, and wastages. If the import volume recorded by the official statistics is 4500 tonnes, we could assign the remaining 500 tonnes to the residual in the gap, i.e. exports, differences in inventories, and wastages.

11.4.2 Step 2: Identify the Structure of the Market

This requires some exploratory research to identify the trade dependency of the commodity, whether the specific commodity market in the country can be considered as small (not in a position to influence the world market price) or large (large player in the global market so that world market prices can be influenced) and any hidden taxes or subsidies or any other policy measures exist.

Consider a situation in which Sri Lanka is a small player in the global market and, therefore, world market prices are exogenous. Let's also consider that a tariff is the only policy instrument.

This allows us to depict the market in the following manner:

$$D = D(P, M)$$

$$S = S(P, W)$$

$$P = P^W \ (1 + \text{tariff})$$

11.4.3 Step 3: Calibrate the Market to the Baseline Equilibrium Using Some Elasticity Estimates

Suppose that the price elasticities of demand and supply are -1.0 and + 1.0, as per the previous estimates. If the functional forms of the demand and supply curves and the values that prevailed in the baseline equilibrium are known, then this would enable us to compute the parameters of the two equations.

Suppose that the two equations are in multiplicative form as below:

$$D = \alpha_1 P^{\alpha 2}$$

$$S = \beta_1 P^{\beta 2}$$

The elasticity estimates are the respective exponents. The two intercept terms, which capture all the prices affecting the dependent variable other than the price, can be set to reproduce the baseline equilibrium values:

$$\alpha_1 = D/P^{\alpha 2}$$

$$\beta_1 = S/P^{\beta 2}$$

Given the baseline values of variables and the elasticities, the values of α_1 and β_1 will be $10{,}000/50^{(-1)} = 500{,}000$ and $5000/50^{(+1)} = 100$.

11.4.4 Step 4: Reproduce the Baseline Equilibrium

Use the parameters of the two equations and the exogenous variables to obtain the values that prevailed under the baseline equilibrium:

$$D = 500,000 * 50^{(-1)} = 10,000$$

$$S = 100 * 50^{(+1)} = 5000$$

In the baseline equilibrium, an import volume of 4500 was reported, suggesting a residual of 500.

11.4.5 Step 5: Conduct the Policy Experiment by Changing the Level of a Policy Variable

The policy variable in this example is import tariff, and the policy level that prevailed in the baseline equilibrium was 25 per cent. Consider an increase in the level of policy variable up to 50 per cent.

This policy change will increase the price prevalent in the market from LKR 50 to LKR 60 per kg; lower the demand from 10,000 to 8333.33 tonnes; and increase the supply from 5000 to 6000 tonnes in the following manner:

$$P* = P^W\ (1 + \text{tariff}) = 40 * (1 + 0.5) = 60$$

$$D* = \alpha_1 P^{\alpha 2} = 500,000 * 60^{(-1)} = 8333.33$$

$$S* = \beta_1 P^{\beta 2} = 100 * 60^{(+1)} = 6000$$

The above computation indicates a gap of 2333.33 tonnes between quantity supplied and quantity demanded. Out of this volume, 1833.33 tonnes can be attributed to imports as 500 tonnes are to be left as the residual.

11.4.6 Step 6: Interpret Your Results

The above computation illustrates the equilibrium that would have prevailed in the market in 2019 if the import tariffs on seed had been 50 per cent instead of 25 per cent. In this scenario, the wholesale price of seed would have been LKR 60 per kg (an increase by 20 per cent), the demand for seed would have been 8333.33 (a reduction by 16.66 per cent), the supply of seed would have been 6000 (an increase by 20 per cent), and the import of seed would have been 2333.33 (a reduction of 53.34 per cent). The numbers generated do not provide predictions for the future – rather, they show the equilibrium that would have been in 2019 if there had been an import tariff of 50 per cent.

11.5 Assignment

Design a policy research study to address the following policy questions:

1. A guaranteed price scheme for paddy is implemented in Sri Lanka, together with a procurement programme performed through the PMB. Write a short essay describing how the activities of PMB helped in improving farmer well-being and stability of farm prices of Sri Lanka?
2. The government of Sri Lanka has decided to reduce the maximum retail price (MRP) of milk powder to LKR 325 per 400 g milk powder packet by lowering the price by LKR 61 per 400 g packet. How will this impact producer and consumer well-being?

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Part IV

Tools to Analyse Rural Development Programmes

Cost-Benefit Analysis of Irrigation Projects 12

Sunil Thrikawala, Christof Batzlen, and Pradeepa Korale-Gedara

Abstract

For better decision-making, proposed investments need to be analysed for their technical, social, environmental, commercial, and financial/economic feasibility. A financial/economic feasibility analysis of technically sound projects justifies the usage of scarce resources before they are committed. Cost-benefit analysis (CBA) is one of the tools that can be used for such a purpose. This chapter provides a detailed account of the ex-ante cost-benefit analysis of an investment and practical guidelines for undertaking a CBA. It describes different types of cost-benefit analysis (financial, economic, and extended CBAs) and the context in which each needs to be undertaken. Also, the chapter demonstrates the use of Excel software in undertaking a cost-benefit analysis for a hypothetical investment, followed by a detailed account of the cost-benefit analysis of a real irrigation investment.

Keywords

Cost-benefit analysis · Environmental costs · Investment analysis · Net present value · Internal rate of return

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12.1 Introduction

Cost-benefit analysis provides a systematic framework to identify, quantify, and value project benefits and costs. Cost-benefit analysis converts different project benefits and costs, occurring at different time periods, into a common monetary unit so that alternative investment options can be compared against each other. For a comprehensive analysis and better decision-making, CBA needs to be complemented by various other feasibility analyses: technical, marketing, environmental, social, and institutional.

Cost-benefit analysis is undertaken both as ex ante appraisal of a proposed investment and ex post evaluation of an investment. The former is conducted during the project appraisal period to inform decision-makers of the possible economic/financial gain of a proposed investment by assessing its anticipated effects. In contrast, ex post analysis uses real data to determine whether a specific intervention can be justified, whether its objectives were realised, and why. The goal of the ex post analysis is to assess the lessons learned in an undertaking. It also is useful in investigating unintended effects that were not anticipated during the ex ante project planning process.

Cost-benefit analysis of an investment may be carried out from a social, or individual (i.e. a business entity), point of view. A financial CBA is conducted from a business entity's point of view. It is carried out to compare costs and benefits to the project entity, evaluating the profitability or financial sustainability of the project. An economic CBA is carried out from a social point of view. This is carried out to compare costs and benefits arising for society, especially when the investment is funded by public money. Depending on the analysis, the identification, quantification, and valuation of project costs and benefits vary. This chapter demonstrates how CBA is conducted for irrigation project investments.

12.2 The Context

12.2.1 Global Context

The provision of irrigation water has been part and parcel of the agriculture development agenda in developing countries. Good examples include the Accelerated Mahaweli Development Project (AMDP) in Sri Lanka in the 1970s, the Magat River Multipurpose Project in the Philippines, the India Punjab Irrigation Project, the Kaleshwaram Lift Irrigation Project, and the Three Gorges Dam in China (World Bank 1989a, b). Even today, investments continue into irrigation rehabilitation projects, new construction projects, and small-scale and micro-irrigation projects at the farmer level. With the impacts of climate change, investment needs for irrigation projects are increasing. As these are mostly public investments, governments are eager to know the worthiness of these investments, given the limited budgets and rising demand from other sectors of the economy.

Table 12.1 Average EIRR (%) for investments in some selected projects in Africa and Asia (1965–1999)

	Sub-Saharan Africa	Middle East & North Africa	South Asia	South East Asia	East Asia	Latin America	All
Rehabilitation projects	14	17	20	16	30	15	18
New construction	11	14	14	10	23	16	13

Source: Inocencio et al. (2005)

Irrigation was recorded as long as 7500 years ago in Mesopotamia (AQUASTAT 2014), with agriculture believed to have begun in the same region 2500 years earlier (Angelakıs et al. 2020). Global irrigation expansion was accelerated during the twentieth century as a main component of the green revolution technology to meet the threats of food insecurity. The expansion was facilitated by developments in engineering and the enthusiasm of governments and international development agencies (Playán et al. 2018). Now, around 21 per cent of the cultivated area in the world, around 324 million ha (AQUASTAT 2014), is under irrigation. Asia accounts for 70 per cent of the world's irrigated area. China, which has the largest extent, and India consist of nearly 42 per cent of the world's irrigated area.

In Asia, irrigation investment strategies fall into three eras: the colonial phase (1850–1945), the Cold War phase (1946–1989), and the new phase of globalisation (1990 onwards) (Barker and Molle 2004). Irrigation systems evolved from river diversion/canalling/flood control during the colonial era to storage dams/gravity irrigation during the Cold War phase. Thereafter, pumps and wells became prominent. This expansion of the irrigated area was with the support of international donor agencies, such as the World Bank and the Asian Development Bank, and budgetary allocations in countries. More than 50 per cent of the agricultural budget of most countries in the Asian region and the agricultural budget of the main donor agencies were allocated for irrigation (Barker and Molle 2004).

The expansion of the irrigated area was supported by analyses showing the worthiness of these investments as generally measured by the economic internal rate of return (EIRR). Loosely speaking, if the EIRR of a project is greater than the interest rates prevailing in an economy, the project is considered to be worthwhile. Table 12.1 shows the EIRR of irrigation projects launched in developing countries during 1965–1999. The minimum acceptable EIRR values adopted by different donor agencies lie between 8 and 12 per cent.

12.2.2 Sri Lanka Policy Context

Sri Lanka has invested in irrigation infrastructure for over 2500 years: the monarchy constructed small village tanks, large tanks, and canal systems in the dry zone, which gradually fell into neglect as kingdoms shifted towards the wet zone from the twelfth

Table 12.2 Cost-benefit analysis of selected irrigation investments in Sri Lanka

Project	Economic internal rate of return (EIRR)		
	At appraisal	At completion	During operation
Uda Walawa irrigation and resettlement project	10.0–17.8%	NA	7.0%
Gal Oya scheme	23.2%	47.3%	17.0%
Kirindi Oya irrigation settlement project	17.6%	6.3%	2.6%

Source: Asian Development Bank (2000), Aluwihare (1991), Molle and Renwick (2005)

century onwards. Irrigation works were again initiated during the Dutch and British colonial periods (Weligamage 2012). The restoration of major irrigation schemes began in 1920, focusing on supporting commercial agriculture. By independence, the Minneriya, Elahera, and Parakrama Samudra irrigation systems had been restored. Thereafter, measures were taken to rehabilitate the traditional irrigation systems to enhance domestic agriculture, alongside large-scale irrigation schemes. From 1950 to 1987, 13 and 37 per cent of the budget for public investment was allocated for irrigation (Aheysekera 1993).

Multipurpose projects, catering to both electricity generation and irrigation, were begun. The first was the Gal Oya scheme (1948–1952), which costs LKR 75 million, with a target of irrigating 48,562 ha, though it only realised 26,305 ha. The Uda Walawe scheme was started in 1963 to irrigate 28,733 ha and generate 5 MWP electricity at an estimated cost of LKR 135 million. From 1970 to 1987, irrigation investment increased dramatically with the implementation of the Accelerated Mahaweli Development Project (AMDP), the largest river basin project in Sri Lanka, planned to irrigate 900,000 acres by constructing 15 reservoirs between 1970 and 2000. The cost by 2000 was LKR 76.2 billion. Investment in other rehabilitation programmes from 1978 to 2000 was LKR 16.94 billion (Shand 2002). After 2000, investments were confined to the maintenance of the existing systems due to budgetary demand from other economic development activities.

There are three types of irrigation investments in Sri Lanka: new irrigation, rehabilitation, and operation and maintenance. Even though irrigation projects promise favourable benefits at the outset, the economic return to investments on some new construction projects has been economically non-viable. Table 12.2 indicates EIRR values of three irrigation investments estimated at appraisal, at completion, and during operation.

12.3 Cost-Benefit Analysis

A CBA is an analytical tool used to measure the financial and economic feasibility of a project. The following steps are followed when conducting a CBA:

1. Identification of the costs and benefits of the project
2. Quantification of project costs and benefits
3. Valuing of project costs and benefits
4. Calculation of project worthiness indicators
5. Sensitivity analysis

12.3.1 Identification of the Costs and Benefits of the Project

Identification of project benefits and costs is a responsibility of technical experts and contingent on project design. It becomes possible to identify project costs and benefits once the technical project has been at least roughly designed. The definition of such costs and benefits depends on the objective of the analysis. With a financial analysis, from an individual point of view, then benefits and costs are simply inflows and outflows of money to the project. An economic analysis from the social point of view assesses the costs and benefits to society; in this case, project costs and benefits of projects are defined as anything that respectively reduces and increases national income.

The benefits of an irrigation project arise mainly from an increased value of production or a reduction in the cost. Direct benefits include increased production resulting from an expansion of the cultivated area and/or increased productivity due to increased water availability in existing land, increased cropping intensity, and the cultivation of higher-value crops. In addition, irrigation projects can create new employment opportunities in an area. In several instances, projects create benefits outside the project, called secondary benefits or positive externalities. For example, one of the positive externalities of irrigation projects may be a reduced incidence of flooding in the area. Secondary benefits are not included in the financial analysis as it only focuses on the benefits to the project entity. Secondary benefits, however, are included in economic analysis. Consequently, economic analyses are challenging since a wider area must be considered in identifying benefits and not all benefits bring tangible results to the project entity.

Identification of costs (except for intangible costs) is straightforward for both financial and economic analyses. Typically, investment costs include the cost of land, construction, and machinery. Then project money is spent on working capital. There are different groups of cost items:

– *Capital or investment costs*: these are the costs incurred at the outset of the project, as well as capital costs, including land, buildings, machinery, equipment, and various types of construction and installation.
– *Operational and maintenance costs*: these are costs that are incurred for the continued operation of the completed project. These include costs for raw material requirements, energy and fuel, transport, insurance, maintenance, etc.
– *Contingency allowance*: when estimating costs in projects that involve a significant initial investment in civil works, it is assumed that there will be neither modification to the initial design requiring changes in physical work nor external adverse impacts on construction requiring additional inputs nor relative changes

in input prices. These assumptions are very often violated. Therefore, an additional allocation (cost item) is made to the project to anticipate changes in cost arising from changes in the physical input requirement (physical contingency) and increases in prices (price contingency). Contingencies should be a relatively small share of the total cost. The magnitude of the share depends on the uncertainty associated with estimates of the project input requirements and prices.

– *Sunk costs*: these are costs associated with existing resources upon which a proposed new investment will be based, like an already constructed building on a project site. Once the investor does not incur a cost for these resources associated with implementing the project, the cost of these items is not included in the CBA.

In addition to these direct costs, some projects impose costs on third parties. These externalities include air pollution, water pollution, and soil erosion. More specific to irrigation investments, there often is degradation or destruction of the natural environment and natural habitat of wild animals. These negative externalities need to be identified in the economic analysis to understand the true cost of the project investment to society. Once these costs and benefits to third parties are included in the analysis, it becomes an extended cost-benefit analysis.

12.3.2 Quantification of Project Benefits and Costs

In quantifying project benefits and costs, CBA uses the incremental approach (i.e. the difference between the *with* and *without* project scenarios), in which anticipated benefits and costs are compared against the situation without the project. This is different from 'a *before* and *after* comparison', in which the benefits and costs arising from the project are compared against the situation that prevails before the project is implemented. *With* and *without* analysis prevents underestimation or overestimation of project benefits. For example, as depicted in Fig. 12.1, consider

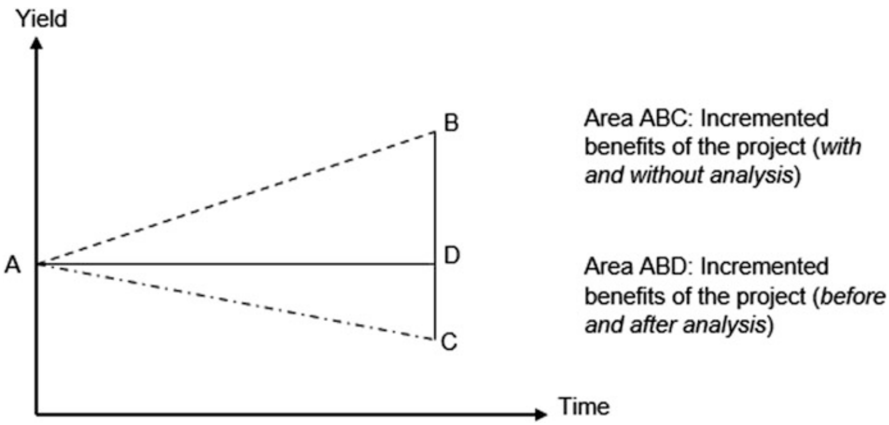


Fig. 12.1 Identification of project benefits

an irrigation rehabilitation project in which yields are expected to decline if the investment is not made but will increase with the investment. In this case, the yield increment associated with the *with* and *without* scenarios would be higher than in the *before* and *after* scenarios. The *with* and *without* scenarios would give a yield increment of ABC, while the *before* and *after* scenarios would give a yield increment of ABD. The difference is that the *before* and *after* scenarios do not take into account the fact that yields will fall without the project due to, for example, the further deterioration of irrigation structures.

12.3.3 Valuing of Project Cost and Benefits

In valuing the outputs and inputs of a project, market prices (also referred to as financial or private prices) are used in financial analysis. Therefore, the relevant sale or purchase price is used in the analysis. On the other hand, economic prices (also referred to as shadow prices) are used in an economic CBA. The market price and the economic price of an item may be different due to various distortions – such as subsidies, taxes, currency overvaluation, imperfect capital market, etc. – in the market. These distortions impact the market prices, which then may not reflect the true marginal cost or marginal benefits to society. In instances where market prices do not reflect the true cost to the society (i.e. economic value), certain adjustments are required to convert market prices into the shadow prices/economic prices to be used in the economic CBA. Thus, when conducting an economic CBA, market prices can be taken as the primary source and starting point for the calculation or conversion to economic prices.

There are three steps in correcting market prices for distortions:

1. *Eliminate transfer payments from the financial prices*. Transfer payments – e.g. subsidies, taxes, and credit transactions that include loans, receipts, and repayment of principal and interest – are not payments for real resources. These are the transfer of claims for real resources from one person to another. Therefore, in deriving economic prices, transfer payments are removed from the financial prices.
2. *Adjust to allow for price distortion of traded items*. For traded items, export or import prices are adjusted to allow for domestic transport and marketing costs between the point of import or export and the project site. The resulting prices are called the export parity price and the import parity price. The assumption is that world market prices are free from distortions. In converting foreign exchange prices into domestic prices, adjustments are needed if the exchange rate is overvalued. Two approaches commonly used to address overvalued exchange rates are as follows:

(a) Use of a shadow foreign exchange rate (SFER) to convert prices in foreign currency to local currency – the shadow exchange rate can be calculated by multiplying the official exchange rate by a conversion factor.
(b) Use of standard conversion factors (SCFs) – a conversion factor is the ratio between the economic and financial prices (they are usually less than 1). SCFs are calculated for categories of goods using national statistics. In this approach, prices in foreign currency are multiplied by the foreign exchange rate and then multiplied by the conversion factor to get the economic prices of these traded items.

3. *Adjust to allow for price distortion of non-traded items*. Certain tradable items may not be imported if the world price at the border is higher than the domestic cost of production. Also, tradable goods may not be exported if the border prices are lower than the cost of production. If the item replaces an import item or reduces the availability of an exported item, then, to derive the economic prices, the same approach adopted for traded items can be taken. However, if the item is not traded due to the nature of the product (i.e. it is non-tradable), then market prices are adjusted to get the true opportunity cost (Amerasinghe 2015). Land is an example of a non-tradable good. In obtaining an economic price for land, opportunity cost or the marginal productivity of the land is taken. In practical terms, we use the returns to land in its next best alternative use. If the land does not have any alternative use besides use for the investment, then the marginal productivity is zero; hence, the economic price also becomes zero.

In conducting a CBA, certain measures are taken to improve the accuracy of the estimates. They are listed below:

(a) *Best price to be used* – if there is a fluctuation of output prices within a year, the lowest price (price during the peak harvest) is taken in valuing outputs, while for input prices, the highest price is taken. This measure is taken to avoid risk. If the project gives a positive net benefit with these conservative estimates of prices, then there is a greater chance the project will generate a positive benefit in implementation.
(b) *Predicted prices* – since CBA analysis involves predicting the future costs and benefits of an investment, there is a need for an approach to predicting future values. The prices of all inputs and outputs are subject to inflation (a general increase in prices). This can be addressed by using constant prices. In this approach, it is expected that the impact of future price changes will equally affect inputs and outputs. However, there also can be relative changes in prices among items within the inputs and/or outputs as well. In such cases, analysts need to adjust current prices. Current prices are inflated to find future prices. The challenge is to accurately predict relative changes in prices. In predicting prices of internationally traded items, it is recommended that an appropriate rate of world market price changes developed by international organisations be used (Amerasinghe 2015).

(c) *Determination of the project length* – for identification, quantification, and valuation, the project length needs to be decided. In general, the analysis needs to be carried out for the period of the technical life of the project. However, if the output generated by the project becomes obsolete before it completes its physical life, then the economic life of the project is considered instead of the technical life. When the technical life of the major investment asset extends beyond about 25 years or so, another consideration comes into play that helps to establish a reasonable project length for the project. Since values are discounted, any return to an investment beyond 25 years or so will make little difference in project selection. Therefore, for such projects, the length of the project is established as 25 years. As a result, few agricultural project analyses need to be carried out beyond 25 years.

Box 12.1 Extended Cost-Benefit Analysis

When projects have considerable impacts on the environment, instead of a conventional economic CBA, an extended CBA is undertaken. In extended CBAs, monetary values for environmental costs and benefits are derived and incorporated into an economic CBA for better-informed decisions. Challenges in deriving a monetary value for environmental costs and benefits include determining the boundary for the study, quantifying the costs and benefits, and valuing the environmental costs and benefits.

The boundary refers to the conceptual and physical limits of analysis. In determining the boundary, both on-site and off-site environmental impacts of the project may be considered. There is neither a standard technique nor an administrative limit in creating the boundary. For instance, if the project affects the water quality of a river flowing through two countries, then those two countries should be defined as one site. The same condition applies to air pollutants generated in one city affecting other cities. A good practice is to consider all the impacts of a project in the analysis without considering legal limits.

In quantifying and valuing the environmental costs associated with projects, different techniques are used. Some of them are listed below:

1. *Change in productivity* – in valuing environmental impacts that affect productivity, an approach similar to that used in economic analysis is utilised. For example, if soil erosion reduces crop yield, then the reduction in yield can be valued using market prices if markets are not distorted. If market prices are distorted, then appropriate shadow prices need to be taken.
2. *Market prices* – if the environmental impact is something that can be prevented, the preventive expenditure measured in market prices can be used as a valuation of environmental impacts. The assumptions in this

(continued)

Box 12.1 (continued)

technique are that there is accurate data on the cost of mitigating expenditures and there are no secondary benefits associated with the expenditure.

3. *Surrogate market prices* – in this technique, actual market prices are used to value un-marketed aspects, such as quality of the environment (e.g. clean air, scenic beauty). The assumption here is that the purchaser's willingness to pay for that specific feature is its value. Property values and travel cost are two techniques that use surrogate market price.
4. *Replacement cost* – this is the cost incurred in replacing productive assets damaged by the project. To apply this technique, the magnitude of the damage must be measured.
5. *Relocation costs* – this technique uses the actual costs of relocating a physical facility to evaluate the potential benefits (and associated costs) of preventing the environmental changes that necessitate the relocation.
6. *Contingent valuation methods* – these are survey-based methods used to value environmental techniques. Some of these techniques include bidding games, take-or-leave-it experiments, and benefit transfer methods.

It is neither necessary nor possible to include and quantify all environmental impacts. If the impacts are internal, mitigated, or relatively small, they can be dropped from the analysis. However, they need to be documented with reasons for non-inclusion. If the impact is uncertain or cannot be measured quantitatively, then it must be described qualitatively in the analysis. If the impact can be quantitatively assessed, then an appropriate technique for valuation should be chosen and monetary values placed on all identified quantifiable impacts.

12.3.4 Calculating the Measures of Project Worth

Once the cost and benefits of the project are valued, it is vital to assess project worthiness using indicators that are not sensitive to the length of the project and the timing of benefits and costs to permit meaningful comparison of alternatives.

12.3.5 Calculating Project Worthiness Indicators

Project worthiness can be assessed using both discounted and undiscounted measures. Commonly used undiscounted measures are the payback period and proceeds per unit of outlay. In these undiscounted measures, project benefits and costs that occur at different time periods are compared with each other. Since the value of money changes with time, this can lead to erroneous conclusions.

Discounting is used to bring benefits and costs occurring at different points of time to a common value. The indicators that use discounted values in measuring project worth are known as discounted measures of project worthiness.

Discounting is the act of determining the present value of future cash flows. The value of money decreases over time due to inflation. That is, one unit of money can purchase a greater quantity of goods and services today than it can in the future. There is an opportunity cost of using money. For instance, the opportunity cost of using your cash for investment today may be the interest foregone by not leaving the money in a bank account. In project analysis, we determine the worthiness of a project by looking at the present value of future costs and benefits.

The equation for present value *(PV)* is

$$PV(X) = \frac{(X_t)}{(1+r)^t}$$

where X_t is the value at time *t (future value)* and *r* is the discount rate. The term $1/(1 + r)^t$ is called the discount factor.

According to the above equation, a future value (or a stream of future values) can be brought into a present value (or its discounted value) by applying a discount rate or by dividing the particular value by the discount factor.

For financial analysis, the market rate or expected return to capital is taken as the discounted rate. In economic analysis, one of the following rates is used as a discount rate:

1. The **opportunity cost of capital** is the marginal productivity of additional investment in the best alternative use. In other words, it is the return on the last or marginal investment made that uses up the last of the available capital. If set perfectly, the rate would reflect the choice made by society as a whole between present and future returns and, hence, the amount of total income the society is willing to save (Gittinger 1982).
2. The **accounting rate of interest (ARI)** is the borrowing rate that the nation must pay to finance the project. ARI is defined as the rate of fall in the value of the public income over time (Squire and van der Tak 1975).
3. The **consumption rate of interest (CRI)** or social time preference rate – it is suggested that the discount attached to future returns by society is different from the discount rate individuals would use. It is usually felt that society has a longer time horizon so that its discount rate would be lower. This implies that a different (generally lower) discount rate would be used for public projects than for private projects (United Nations 1975).

Of note is that the latter two rates are more important in the context of social weighting. However, practical project analysis is mainly based on efficiency prices; therefore, ARI and CRI, which are anyway more of an academic problem than a practical method, become less important.

One interesting point is that it is really difficult to know with certainty what the opportunity cost of capital is. In most developing countries, it is assumed to be somewhere between 8 and 15 per cent in real terms. Bearing this aspect in mind, one can compare the costs and returns of a large infrastructure project, say an irrigation project, with the alternative utilisation of the invested capital. Finally, it is worthwhile pointing out that the opportunity cost of capital does not affect the rate of return of the project. It is merely a figure against which the rate of return is compared.

The worthiness of a project can be measured using three parameters: net present value (NPV); benefit-cost ratio (BCR), also referred to as cost-benefit ratio; and internal rate of return (IRR).

NPV measures the present value of future net cash flows, calculated by subtracting the PV of benefits from the PV of costs. For a project to be worthwhile, it should have a positive NPV:

$$\mathrm{NPV} = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}$$

$$\mathrm{NPV} = \sum_{t=1}^{n} \frac{B_t}{(1+i)^t} - \sum_{t=1}^{n} \frac{C_t}{(1+i)^t}$$

where B_t is the benefit in each year, C_t is the cost in each year, $t = 1,2,3...n$. i is the discount rate.

The second measure we use to determine the worthiness of a project is BCR. BCR is the PV of benefits divided by the PV of costs. For a project to be worthwhile, BCR should be higher than one. Thus, if a project has a positive NPV, the BCR should be greater than one. NPV and BCR decrease with an increasing discount rate:

$$\mathrm{BCR} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}}$$

The third parameter for checking the viability of a project is IRR. By definition, IRR is the discount rate at which the NPV becomes zero. It measures the rate of return that is expected to be created by a project. Thus, for a project to be viable, the IRR should be greater than the actual discount rate. However, different funding agencies use different threshold discount rates to accept or reject projects. The IRR is found by an iterative process, and it is equivalent to the discount rate, which satisfies the following condition:

$$\sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} = 0$$

In general, NPV and IRR are individually used for decision-making, while the BCR is always used in conjunction with either of the other parameters. One issue involves the choice of an appropriate measure (NPV, IRR, or BCR) when selecting among alternative projects: for example, if there is a choice between two projects with different results, specifically one project with a higher NPV but a lower IRR than the other project. As a rule of thumb, if the two projects are mutually exclusive, we should select the project with the higher NPV, ignoring the lower IRR.

Box 12.2 Which Analysis Is more Suitable for the Analysis of Development Projects?

Economic analysis is most appropriate for assessing publicly funded projects. Even so, the analysis would be more complete if a financial analysis also is carried out. As previously mentioned, the objective of financial analysis is to estimate the profitability of the project or, in other words, to assess the ability of the project to generate adequate incremental cash flows to recover its financial (capital and recurrent) costs without external support. The ability of a project to sustain itself is a good factor to consider even for publicly funded projects.

Therefore, assessing the financial viability of a publicly funded project complements and completes the assessment of economic analysis. However, financial analysis should not be used to replace economic analysis as the financial analysis would underestimate the potential benefits of publicly funded projects as the focus is limited only to the benefits to the project entity. For example, a project on enhancing educational outcomes will be financially non-viable although it generates large social benefits.

12.3.6 Sensitivity Analysis

The accuracy of estimates of cost-benefit analysis depends on the assumption or predicted values used in the CBA. Since there is uncertainty regarding these figures, sensitivity analysis is undertaken to assess the effect of variation of the key variables used in the analysis. These key variables may be yields, prices, or quantities of inputs. Sensitivity analysis allows the indices of project worthiness (i.e., NPV, IRR) to be re-estimated for different value/values of key variables. The magnitude of variations in the key variables used in sensitivity analysis is determined taking account of the extent of uncertainty in the estimates of the key variables selected.

Once sensitivity analysis is carried out, switching values are calculated. A switching value is an amount by which an element of a project can change before the project becomes an unacceptable investment. Switching values are usually defined as a percentage change from the base case: for example, compared to the results of the base case, by how much do benefits have to decrease for the project to be economically non-viable?

12.4 An Example

This section presents a step-by-step analysis of the economic CBA of a hypothetical irrigation project. Let's consider a project with a 10-year lifecycle. Initial investments will occur during the first 4 years, and operations and management costs will occur from the fourth year. The sum of these values is the total cost of the project, as described in Table 12.3. The benefits of the project are estimated. Benefits are generated from hydropower (from the fourth year onwards) and agriculture (from the expansion of cultivated land extent in the third year). The number of power units is multiplied by the market price to get the value for hydropower. Similarly, the yield is multiplied by the unit price of the product at the market to obtain the value generated from agriculture. The sum of these benefits is the total benefit of the project, as shown in Table 12.4.

Table 12.5 shows how the cash flow is developed for the project using the benefit and cost streams of the project. Net cash flow is the difference between the total benefits and the total costs.

Now we have the flow of benefits and the flow of costs and the net cash flow for the project. Next, we convert future values to present values. To do this, the figures are discounted using a 10-per-cent market discount rate. Table 12.6 shows the calculation of the present value of costs (PVC) at the market discount rate (10 per cent). Note that the values for the 10-per-cent discount factor keep decreasing as the years progress. It is a value of 1 in year 1, 0.909091 in year 2, and, by year 10, 0.424098. This highlights that values farther into the future have lower present values today.

Now we have the present value of cost (PVC) and the present value of benefits (PVB) at the 10-per-cent market discount rate, as given in Table 12.7. By subtracting the PVC from the PVB, the NPV can be obtained. The BCR is then calculated by dividing the PVB by the PVC.

The calculated NPV at the 10-per-cent market discount rate is LKR 58,813. The BCR of the investment at the 10-per-cent interest rate is 1.06.

The next step is to calculate the IRR of the project. One method is to calculate the NPV at varying discount rates. Then we use this data to plot a graph showing the NPV at the various discount rates. Using the graph, we find the discount rate at which the NPV is zero. This rate is the IRR. Figure 12.2 shows such a graph developed from our earlier data. It indicates that the IRR of the project is between 11 and 12 per cent and closer to 12 per cent.

A more direct and easier method of calculating the IRR is to use the built-in function (formula) in Excel. The IRR function is a financial formula in Excel labelled 'IRR'. This method is presented in Table 12.8. The calculated IRR is 11.64 per cent, and it is higher than the 10-per-cent market discount rate that was assumed and used in the analysis.

The above completes the financial analysis in the cost-benefit analysis of the hypothetical irrigation project. Having completed the financial aspect, we next move to the economic analysis.

Table 12.3 Calculating the cost streams of the project

Cash flow of irrigation												
	Year	1	2	3	4	5	6	7	8	9	10	Total
Cost	Investment	100,000	500,000	300,000	200,000	0	0	0	0	0	0	1,100,000
	O and M	0	0	0	20,000	20,000	20,000	20,000	20,000	20,000	20,000	140,000
	Total cost	100,000	500,000	300,000	220,000	20,000	20,000	20,000	20,000	20,000	20,000	1,240,000

Table 12.4 Calculation of the benefits of the project

	Year	1	2	3	4	5	6	7	8	9	10	Total
Hydropower	No of units	0	0	0	500	500	500	500	500	500	500	
	Price/Unit	100	100	100	100	100	100	100	100	100	100	
	Value	0	0	0	50,000	50,000	50,000	50,000	50,000	50,000	50,000	350,000
Agriculture	Land extent	0	0	250	500	1000	1000	1000	1000	1000	1000	
	Yield (per acre)	0	0	50	50	50	48	46	44	42	40	
	Price/Unit	5	5	5	5	5	5	5	5	5	5	
	Value	0	0	62,500	125,000	250,000	240,000	230,000	220,000	210,000	200,000	1,537,500
Total benefits		0	0	62,500	175,000	300,000	290,000	280,000	270,000	260,000	250,000	1,887,500

Table 12.5 Cash flow of irrigation project

	Year	Units	1	2	3	4	5	6	7	8	9	10	Total
Cost	Investment		100,000	500,000	300,000	200,000							1,100,000
	O&M		0	0	0	20,000	20,000	20,000	20,000	20,000	20,000	20,000	140,000
	Total cost		100,000	500,000	300,000	220,000	20,000	20,000	20,000	20,000	20,000	20,000	1,240,000
Benefit	Hydropower	No. of units	0	0	0	500	500	500	500	500	500	500	50,000
		Price/unit	100	100	100	100	100	100	100	100	100	100	
		Value	0	0	0	50,000	50,000	50,000	50,000	50,000	50,000	50,000	350,000
	Agriculture	Land extent	0	0	250	500	1000	1000	1000	1000	1000	1000	
		Yield	0	0	50	50	50	48	46	44	42	40	
		Price/unit	5	5	5	5	5	5	5	5	5	5	
		Value	0	0	62,500	125,000	250,000	240,000	230,000	220,000	210,000	200,000	1,537,500
	Total benefit		0	0	62,500	175,000	300,000	290,000	280,000	270,000	260,000	250,000	1,887,500
Net cash flow			−100,000	−500,000	−237,500	−45,000	280,000	270,000	260,000	250,000	240,000	230,000	647,500

Table 12.6 Calculating the PVC and PVB

D16 =D4*D14

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1			Year	1	2	3	4	5	6	7	8	9	10	Total
2	Cost	Investment		100000	500000	300000	200000							1100000
3		O&M		0	0	0	20000	20000	20000	20000	20000	20000	20000	140000
4		Total cost		100000	500000	300000	220000	20000	20000	20000	20000	20000	20000	1240000
5	Benefit	Hydropower	No. of units	0	0	0	500	500	500	500	500	500	500	50000
6			Price/unit	100	100	100	100	100	100	100	100	100	100	
7			Value	0	0	0	50000	50000	50000	50000	50000	50000	50000	350000
8		Agriculture	Land extent (acre)	0	0	250	500	1000	1000	1000	1000	1000	1000	
9			Yield	0	0	50	50	50	48	46	44	42	40	
10			Price/unit	5	5	5	5	5	5	5	5	5	5	
11			Value	0	0	62500	125000	250000	240000	230000	220000	210000	200000	1537500
12	Total benefit			0	0	62500	175000	300000	290000	280000	270000	260000	250000	1887500
13	Net cash flow			-100000	-500000	-237500	-45000	280000	270000	260000	250000	240000	230000	647500
14	Discounted cash flow			1	0.909091	0.826446	0.751315	0.683013	0.620921	0.564474	0.513158	0.466507	0.424098	
15	PVB			0	0	51652.89	131480.1	204904	180067.2	158052.7	138552.7	121291.9	106024.4	1092026
16	PVC			100000	454545.5	247933.9	165289.3	13660.27	12418.43	11289.48	10263.16	9330.148	8481.952	1033212
17	Discounted net-cash flow			-100000	-454545	-196281	-33809.2	191243.8	167648.8	146763.2	128289.5	111961.8	97542.45	58813.89

Table 12.7 The financial analysis

Indicator	Values
Present value of benefits (PVB)	1,092,026.00
Present value of costs (PVC)	1,033,212.00
Net present value (NPV)	58,813.89
Benefit-cost ratio (B/C ratio)	1.06

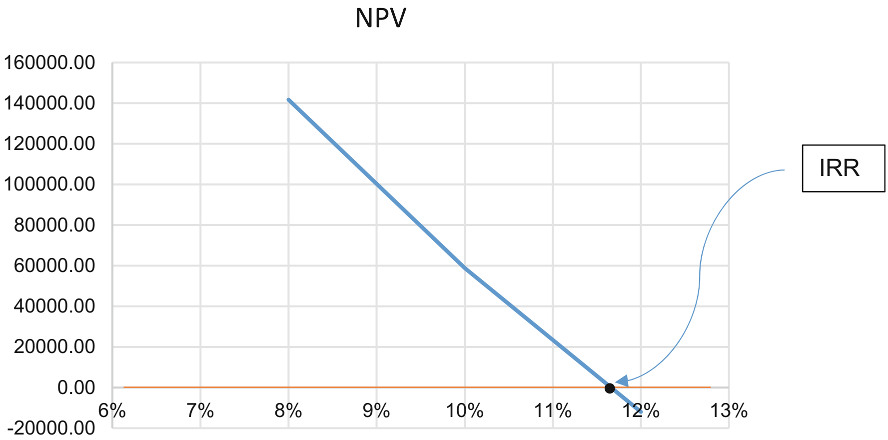


Fig. 12.2 Calculation of IRR using the graphical method

Table 12.8 Calculation of IRR using facilities via Excel

Excel worksheet Irrigation - Microsoft Excel

C19 =IRR(D13:M13, 10%)

A	B	C	D	E	F	G	H	I	J	K	L	M	N
		Year	1	2	3	4	5	6	7	8	9	10	Total
Cost	Investment		100000	500000	300000	200000							1100000
	O&M		0	0	0	20000	20000	20000	20000	20000	20000	20000	140000
	Total cost		100000	500000	300000	220000	20000	20000	20000	20000	20000	20000	1240000
Benefit	Hydropower	No. of units	0	0	0	500	500	500	500	500	500	500	50000
		Price/unit	100	100	100	100	100	100	100	100	100	100	
		Value	0	0	0	50000	50000	50000	50000	50000	50000	50000	350000
	Agriculture	Land extent (acre)	0	0	250	500	1000	1000	1000	1000	1000	1000	
		Yield	0	0	50	50	50	48	46	44	42	40	
		Price/unit	5	5	5	5	5	5	5	5	5	5	
		Value	0	0	62500	125000	250000	240000	230000	220000	210000	200000	1537500
Total benefit			0	0	62500	175000	300000	290000	280000	270000	260000	250000	1887500
Net cash flow			-100000	-500000	-237500	-45000	280000	270000	260000	250000	240000	230000	647500
Discounted cash flow			1	0.909091	0.826446	0.751315	0.683013	0.620921	0.564474	0.513158	0.466507	0.424098	
PVB			0	0	51652.89	131480.1	204904	180067.2	158052.7	138552.7	121291.9	106024.4	1092026
PVC			100000	454545.5	247933.9	165289.3	13660.27	12418.43	11289.48	10263.16	9330.148	8481.952	1033212
Discounted net-cash flow			-100000	-454545	-196281	-33809.2	191243.8	167648.8	146763.2	128289.5	111961.8	97542.45	58813.89
	IRR	11.64%											

To convert the financial analysis to economic analysis, in this hypothetical project, the following adjustments were made to the financial analysis:

- Eliminate transfer payments, such as interest payments, from the financial prices. In this hypothetical project, there were no transfer payments.
- Adjust to allow for price distortion of traded items. In this case, one standard conversion factor (SCF) was applied. The value of the SCF is 0.9.
- Adjust to allow for price distortion of non-traded items. In this case, it is assumed that the price per unit of land was 4 versus the 5 used in the financial analysis.
- Consider the addition of environmental costs and benefits. In our hypothetical project, possible environmental costs could be due to CO_2 emissions from the use of heavy vehicles and soil erosion during the construction period. Environmental benefits could be due to a reduction of CO_2 emissions resulting from the replacement of thermal power generation with hydropower. Environmental costs occur during the construction period (the first 4 years). Environmental benefits are assumed with a 10-per-cent reduction in electricity prices and a reduction in CO_2 emissions worth LKR 10,000 per month.
- Assume a social discount rate of 8 per cent. This is less than the market discount rate.

Table 12.9 depicts the spreadsheet prepared for economic analysis.

Table 12.9 Economic value of costs and benefits

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1			Year	1	2	3	4	5	6	7	8	9	10	Total
2	Cost	Investment		100000	500000	300000	200000							1100000
3		O&M		0	0	0	20000	20000	20000	20000	20000	20000	20000	140000
4		Total Financial cost		100000	500000	300000	220000	20000	20000	20000	20000	20000	20000	1240000
5		Total Economic Cost		90000	450000	270000	198000	18000	18000	18000	18000	18000	18000	1116000
6		Environmental cost		100	150	150	100							500
7		Total cost		90100	450150	270150	198100	18000	18000	18000	18000	18000	18000	1116500
8	Benefit	Hydropower	No. of units	0	0	0	500	500	500	500	500	500	500	50000
9			Shadow price/unit	90	90	90	90	90	90	90	90	90	90	
10			Value	0	0	0	45000	45000	45000	45000	45000	45000	45000	315000
11		Agriculture	Land extent (acre)	0	0	250	500	1000	1000	1000	1000	1000	1000	
12			Yield	0	0	50	50	50	48	46	44	42	40	
13			Shadow price/unit	4	4	4	4	4	4	4	4	4	4	
14			Value	0	0	50000	100000	200000	192000	184000	176000	168000	160000	1230000
15		Environmental benefits		0	0	0	10000	10000	10000	10000	10000	10000	10000	
16		Total benefits		0	0	50000	155000	255000	247000	239000	231000	223000	215000	1615000
17		Net cash flow		-90100	-450150	-220150	-43100	237000	229000	221000	213000	205000	197000	498500
18														

Table 12.10 The economic analysis

Discount rate	PVB	PVC	NPV	BCR	EIRR
8%	1,034,878	961,830	73,048	1.07	10.11%

The cost stream, benefit stream, net cash flow, BCR, NPV, and EIRR were re-calculated using the information in Table 12.9 and Excel functions. The results are presented in Table 12.10.

12.5 Case Study: Financial and Economic Analyses of the Proposed South Rukuru Irrigation Scheme in Malawi[1]

12.5.1 Introduction

This section presents the financial and economic appraisal of two proposed options for an irrigation project, the South Rukuru Irrigation Scheme (2015).

[1]It should be noted that the ecofin analysis for the proposed irrigation scheme included also an economic effects analysis which, however, will not be considered in this section. The economic effects analysis shows the project's impact on other important parameters, such as employment

The two proposed options are as follows.

1. Option A: development of 2900 ha on the left and right riverbanks (total cost EUR 37.8 million)
2. Option B: development of 2000 ha on the right riverbank (total cost EUR 25.3 million)

While the main infrastructure will be completed within 2 years, the distribution, tertiary canals, and infield irrigation system will take up to 5 years for completion in Option A (2900 ha). It is expected that Option B (2000 ha) will take a year less. Since the detailed design is undertaken on the 2900 ha, this case study report is written in such a way that, even if not explicitly mentioned, Option A is referenced.

In the financial and economic analyses, incremental net benefit streams were derived by contrasting the *with* and *without* project situations over a 30-year operation period, which starts with the final acceptance of the scheme. The first dry season harvest will occur in the second year of operation.

On this basis, Economic Internal Rates of Return (EIRR) were calculated to determine the economic viability of the scheme. Detailed sensitivity analysis was then undertaken.

12.5.2 Key Assumptions and Technical Specification of the Project[2]

The key to a successful financial and economic analysis (in short ecofin analysis) is the establishment of realistic and plausible assumptions, particularly for the *with* project scenario. For the economic/financial analysis of irrigation schemes, particular emphasis should be placed on the assumed cropping pattern:

1. Cropping pattern for the *without* project situation
   The present cropping pattern will remain stable in the future. This consists of fallow land amounting to about 3 per cent in the wet season, with an overall cropping intensity of 100 per cent in the two seasons (97 per cent in the wet season and 3 per cent in the dry season). Increases in agricultural output in the *without* project situation will not be accomplished for the following reasons:
   - In the very few areas where water is available and irrigation takes place, yields are already relatively high and cannot be increased. Though 23 irrigation schemes are located in the proposed command area, the average yield level

generation, government revenues, and foreign exchange. The main focus of this section is the financial and economic cost-benefit analysis.

[2]The original ecofin report on the South Rukuru irrigation scheme had a large number of assumptions that cannot be listed in this section. For details, see "Government of Malawi, Rural Infrastructure Development Programme II, Detailed Design Report for the South Rukuru Irrigation Project, Malawi, 2015".

currently amounts to not more than 70 per cent of the (*with* project) projected yields.

- Any technical progress will be offset by the increasing scarcity of water and the fact that farmers will continue to not use fertilisers and chemicals for their crops (apart from tobacco) due to production risks. Given the expected negative long-term effects of climate change, it is assumed that from 2024 onwards (10 years after finalising the detailed design report), the *without* project yields will decrease at an annual rate of 1.5 per cent.
- Farmers will stick to their habits of intercropping and planting at different times of the year to make use of erratic rainfall. Total failures of harvests will continue due to droughts, on the one hand, and floods, on the other.

2. Cropping pattern for the *with* project situation
A major change will be farmers switching from mainly subsistence (apart from tobacco), rain-fed production to irrigated, subsistence and commercial vegetable and cereal production. The cropping systems will primarily be based on the production of annual crops, such as cereals; industrial crops, particularly paprika; and some export crops, such as groundnuts, beans, and vegetable production.

Given their limited experience with irrigation, we allow a period of 4 years in our financial and economic analysis for farmers to reach the yields projected for the *with* project situation. This transition period also considers possible cash bottlenecks for some farmers, resulting in their inability to buy the recommended quantity of farm inputs in the first years of operation should the starter packs for the first crop not be sufficient.

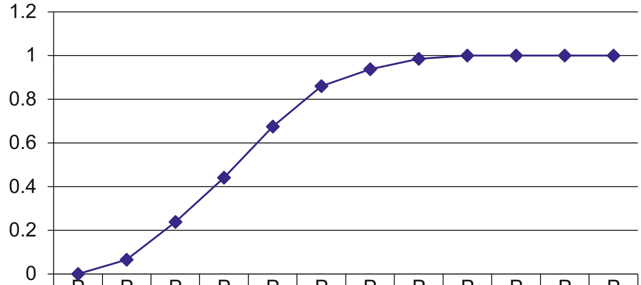
In the financial and economic analysis, this will be taken into account through the following two aspects:

(a) *Land development* – the main bulk conveyance system will be developed within 2 years. The infield irrigation infrastructure will be developed within 5 years (Option A). The first water irrigating the first blocks will flow in the third quarter of the second year of the project (PY 2), irrigating 300 ha in the dry season of that year.
(b) *Yield development for each plot* – a transition period of 4 years will be considered until full yields can be achieved.

Thus, the scheme will be fully developed when all farmers are assumed to achieve the estimated yields, 9 years after the commencement of construction activities (PY 9).

An example of yield development at the scheme level is illustrated in Fig. 12.3 below.

In estimating the net economic value of the project, the analysis took account of the cost of land lost to the project. The net agricultural benefits in the *with* project situation were calculated on the basis of the net cultivated area. Similarly, the opportunity costs of land lost to irrigation infrastructure (such as the main, secondary, and tertiary canals and service roads within the project area) have been taken



	PY 1	PY 2	PY 3	PY 4	PY 5	PY 6	PY 7	PY 8	PY 9	PY 10	PY 11	PY 12
Yield & crop development	0	0.07	0.24	0.44	0.68	0.86	0.94	0.99	1	1	1	1

Fig. 12.3 Yield and crop development of the South Rukuru scheme. Source: Own data

into account with a net benefit foregone of the agricultural production on 5 per cent of the land of the net irrigated area. Also, given the high occurrence of flooding in the command area (due to the South Rukuru and Kasitu rivers, in conjunction with limited flood protection and drainage structures), it is assumed in the sensitivity analysis that 5 per cent of the command area cannot be cultivated in the wet season. Variations of this percentage will be taken into account in the sensitivity analysis. Table 12.11 below illustrates the financial gross margins of major crops for the *without* and *with* project situations.

The construction of the engineering works, the land development/field irrigation, as well as the project organisation/management requires the use of materials, machinery/equipment, and skilled and unskilled labour. As the financial values of these individual cost categories may not reflect their economic values, it is necessary to separate the cost estimates into these categories to allow the application of economic conversion factors to all local costs.

In the derivation of economic conversion factors, import duties, excise duties, sales taxes, and other levies were first omitted from the financial costs as these are transfer payments within the economy and not real resource costs. The financial costs of unskilled labour were also reduced by applying a specific conversion factor of 0.65, while skilled labour has not been adjusted with any conversion factor.

The financial costs of local materials and machinery/equipment have been corrected (wherever applicable) by taking out local taxes and duties, such as duties on raw material usually used for final processing in Malawi (e.g. imported steel for assembling steel pipes). However, it has to be noted that all financial construction costs were calculated without tax (VAT amounts to 16.5 per cent). The financial costs of foreign goods and services remain the same.

Some of the conversion factors derived for the various capital cost components for major cost items are presented in Table 12.12 below. The conversion factors (average about 0.9) indicate that, in general, the financial cost is reduced by 10 per

Table 12.11 Incremental value of agricultural production of project after full development in EUR (Option A)

Crop	Value of production and incremental value of production				
	Without project		With project		
	Gross margin without project in €	Total profit without project	Gross margin with project in €	Total profit with project	Incremental benefit in €
Hectares		3190		2900.00	
Crops					
Maize	35	61,612	240	557,340	495,728
Beans	221	28,214	612	408,421	380,207
Cotton	213	6787	595		−6787
Wheat	179		1673	485,177	485,177
Rice Polished	715		1359	669,860	669,860
Tomato	1584	101,086	2554	555,434	454,348
Soya Beans	493	94,342	1190	379,486	285,144
Sunflower	133		585	118,839	118,839
Groundnuts Shelled	407	64,876	1074	93,454	28,578
Paprika	277		1049	258,701	258,701
BurleyTobacco	654	312,903	775		−312,903
Amaranthus	1437		2540	147,348	147,348
Cabbage Drumhead	1440	91,872	2293	532,086	440,214
Onion	2359	75,256	3560	1,032,535	957,279
Pigeon peas	420		1355		
Potatoes (Irish)	2027	64,670	3033	703,553	638,883
Sweet potatoes	1661	158,951	2684	389,146	230,195
Cassava	1284	204,753	1995		−204,753
Total crops		**1,265,323**		**6,331,381**	**5,066,059**
Summary	**Summary**				
Cereals	Cereals	61,612		1,712,377	1,650,765
Legumes/ oil crops	Legumes/ oil crops	187,433		1,000,201	812,768
Vegetables/ Fruits	Vegetables/ Fruits	268,214		2,526,104	2,257,891
Root crops	Root crops	428,375		1,092,700	664,325
Other cash crops	Other cash crops	319,690			−319,690
Total	**TOTAL**	**1,265,323**		**6,331,381**	**5,066,059**

Source: Data collection and all calculations made by Christof Batzlen for the Rural Infrastructure Development Programme II (RIDP II), Detailed Design Report for the South Rukuru Irrigation Project, Malawi (2015)

Table 12.12 Economic conversion factors for capital and other costs

Cost item	Conversion factor
Weir and intake	0.91
Pipe conveyors and river crossings	0.97
Sedimentation basins	0.90
Main canals	0.90
GRP siphons	0.93
Bridges/box culverts main canal	0.89
Aqueduct	0.91
Main canal off-takes	0.90
Night storage reservoirs	0.85
Secondary & tertiary distribution system	0.86
Land development and drainage	0.94
Infield irrigation (field canals and drains)	0.51
Other costs	
Unskilled labour	0.65
Skilled labour	1.0
Transport	0.9
Imported seeds	1.0
Fertilisers	1.0
Chemicals	1.0

Source: Own calculations based on MRA publications on taxes and duties

cent to obtain the economic cost. Irrigation equipment and fertilisers are exempt from any tax and duty. Finally, where the labour is relatively high, the conversion factor reduces the financial costs even more by applying the shadow price of labour.

For most internationally traded commodities, world market prices are frequently used as the benchmark for the estimation of economic farm-gate prices. The economic prices of maize, rice, beans, and fertilisers were estimated on an import parity basis. Cotton, groundnuts, and tobacco were estimated on the basis of an export parity price. For the sensitivity analysis, rice and maize have been calculated also based on expert parity prices since Malawi might become a partial exporter of the two crops in the future.

12.5.3 Model Developed for the Financial and Economic (Ecofin) Analysis

A very comprehensive model was developed for the ecofin analysis to cater for user-friendly and thorough sensitivity analysis, including the economic effect analysis. The main work file comprising 18 worksheets was linked to another work file with detailed gross margin calculations of 31 crops and another work file where financial costs were automatically converted into economic costs and all tables for the report were automatically developed and updated. The heart of the CBA is the input table illustrated in Table 12.13, in which all parameters for the CBA can be changed and

Table 12.13 Input table for the cost-benefit analysis

	Total COST in €		NPV	F(E)IRR	B/C ratio
INPUT Parameters for financial & economic analysis irrigation scheme	37,499,584		-1,478,005	9.6%	0.92
PARAMETERS	Base figures		Changes compared to Base Figures		
Gross command area in ha	3,045	ha			
Net command area in ha (5% of gross area lost due to structures)	2,900	ha	Area in dry season	2,900	ha
Global Change of Gross Margins WITHOUT PROJECT	1.00		0.0%	% change	100.0%
Global Change of Gross Margins WITH PROJECT	1.00		0.0%	% change	100.0%
Change of total cost (BASE COST, fin analysis sheet)	1.00		0.0%	% change	100.0%
Change of all (incremental) benefits	1.00		0.0%	% change	100.0%
Change of O&M and replacement cost	1.00		0.0%	% change	100.0%
Consideration of benefit foregone reservoir area: 1 = yes, 0 = NO	0				
Area in reservoir area	0	ha			
Change of benefit in reservoir area	1.00		0.0%	% change	100.0%
Change of benefit foregone of agricultural production without project	1.00		0.0%	% change	100.0%
Consideration of decreasing yields without project 1 = yes, 0 = No	1				
Annual decrease of yields without project	1.5%		0.0%	% change	
Change of agricultural benefits with project	1.00		0.0%	% change	100.0%
Benefits considered of agro-industry & Transporters 1= yes 0= No	1				
Rice mill margin in €/ton	11	€/ton	0.0%	% change	100.0%
Other agro-processor margin in €/ton	9	€/ton	0.0%	% change	100.0%
Transport margin in €/ton	3.6	€/ton	0.0%	% change	100.0%
Change of incremental benefit of agro-industry	1.00		0.0%	% change	100.0%
x % of incremental agri. Production transported	100.0%		0.0%	% change	100.0%
Change of Project Coordination & Management Cost (capital cost sheet)	1.00				
Change of Supervision Cost (capital cost sheet)	1.00				
Change of construction (works) cost, fin analysis sheet	1.00		0.0%	% change	100.0%
Change of base environmental mitigation cost (capital cost sheet)	630,000		0.0%	% change	100.0%
Physical Contingencies	10.0%		0.0%	% change	
Price contingencies (annual price increase)	3.00%		0.0%	% change	
x % of incremental production processed	50.00%		0.0%	% change	100.0%
Change of O&M of infield irrigation	1.00		0.0%	% change	100.0%
Change of WUA management cost	1.00		0.0%	% change	100.0%
Flooded area as % where no yields occur in wet season	0.0%		-5.0%	% change	-5.0%
	0.00		0.0%	% change	100.0%
Yield factor	0.00%		0.0%	% change	
Parameters for CBA					
Opportunity Cost of capital (discount rate)	0.10		0.0%	% change	100.0%
Exchange rate adjustment	1.00		0.0%	% change	100.0%
Change of economic prices of cereals & legumes	1.00		0.0%	% change	100.0%
Change of economic prices of horticultural products	1.00		0.0%	% change	100.0%
Conversion financial into economic cost and benefits				Fin CF	Eco CF
Conversion factor for Fertilizer/ Pesticides CF	1.00			1	1
Conversion factor for labour CF	1.00			1	0.65
Conversion factor for material, fuel and misc. Cost CF	1.00			1	0.95
Conversion Factor O&M of main conveyance system	1.00			1	0.90
Conversion Factor O&M of infield irrigation system	1.00			1	0.91
Conversion Factor WUA management cost	1.00			1	0.95
Preliminaries and general Dam	1.00			1	0.92
Site clearance & excavation dam	1.00			1	0.90
River diversion dam	1.00			1	0.90
Embankment dam	1.00			1	0.91
Concrete works and Gabions dam	1.00			1	0.89
Mechanical items dam	1.00			1	0.92
Landscaping	1.00			1	0.89
Miscellaneous dam	1.00			1	0.91
Preliminaries and general Scheme	1.00			1	0.92
Weir & intake	1.00			1	0.91
Sedimentation basin	1.00			1	0.97
Pipe conveyors	1.00			1	0.90
Main Canal Left Bank	1.00			1	0.90
Main Canal Right Bank	1.00			1	0.90
GRP siphons RBMC	1.00			1	0.93
PVC siphon LBMC	1.00			1	0.89
Gully crossings	1.00			1	0.89
Concrete pipe culverts	1.00			1	0.91
Box culverts	1.00			1	0.90
Heavy vehicle bridges	1.00			1	0.90
Farm road bridges	1.00			1	0.85
Foot & cattle crossings	1.00			1	0.86
Main canal off takes, small	1.00			1	0.94
Main canal off takes, large	1.00			1	0.65
Duckbill weirs	1.00			1	0.90
Side spillways	1.00			1	0.90
Gauging weir	1.00			1	0.90
Secondary and tertiary networks LB 900 ha	1.00			1	0.90
Secondary and tertiary networks RB 2,000 ha	1.00			1	0.90
Land development including drainage system	1.00			1	0.90
Engineers' houses, office, laboratory	1.00			1	0.90
Warehouses	1.00			1	0.90
Pit latrines	1.00			1	0.90
CF Project Management & Coordination & Env. Monitoring & Mitigation	1.00			1	0.95
CF Supervision	1.00			1	0.95
Pumping cost (electricity charges)	0	€	0.0%	% change	100.0%
Change of prices for horticultural crops	1.00		0.0%	% change	100.0%
Annual Operation cost in €	224,149	€			1.00
Periodic replacement cost in € (every 5 years)	76,000	€			1.00
Cost of WUA (management, technical staff) in €	169,400	€		change	1.00
Irrigation requirements in m3 / 1 ha	11,000	m3/ ha			
Water price in €	140.05	€/ha	12.73	€/ 1,000 m³	
Consideration of project size 0 = 2,000 ha 1= 2,900 ha	1				
Total Cost per ha in Euro	12,931	€/ha			
From fin analysis SWITCH to eco analysis (1= fin, 0=eco)	1		Import parity price	Export parity price	
Parity price rice (with project)	0.46		0.46		0.13
Parity price maize (with project)	0.30		0.3		0.06
Yield factor of rice with project	1.00		0.0%	% change	100.0%
Consideration of starter packs: Yes = 1, No = 0	1				
Consideration of ancillary infrastructures: Yes = 1 , No = 0	1				
Increase of cost for starter packs & ancillary infrastructure	1.00		0.0%	% change	100.0%
Consideration of fishing benefits : Yes = 1 , No = 0	0				
Consideration of benefits foregone of existing scheme: YES=1 NO = 0	0				
Area of existing schemes in the comman area (reduction of benefit)	365	ha		change	
Yield factor of scheme	70.00%		0.0%	% change	
Crop factor to change area under rice (global both seasons)	1.00		0.0%	% change	100.0%
Crop factor to change area under other crops (global both seasons)	1.00		0.0%	% change	100.0%
Cropping intensity with project	200%		Wet season cropped	2,900	ha
Change of financial price of rice	1.00		0.0%	% change	100.0%
Change of area to be irrigated in dry season	1.00		0.0%	% change	100.0%
Crop factor to change area under rice (dry season only)	1.00		0.0%	% change	100.0%
Crop factor to change area under other crops (dry season only)	2.50		150.0%	% change	250.0%
Yield & GM factor for perennial crops to avoid doublecounting	0.50		-50.0%	% change	50.0%

Cost per benefit. Farm HH in €	10,345	Cost per beneficiary in €	1,521
Yield progression (cumulative)		**Land development progession according to harvest year**	
Harvest Year 1	0.65	PY 1	0.00
HY 2	0.75	PY 2	0.100
HY 3	0.90	PY 3	0.350
HY 4	1.00	PY 4	0.600
HY 5	1.00	PY 5	0.850
HY 6	1.00	PY 6	1.000
HY 7	1.00	PY 7	1.000
HY 8	1.00	PY 8	1.000
HY 9	1.00	PY 9	1.000
HY 10	1.00	PY 10	1.000

2,000 ha				**2,900 ha**	
yield progression		land progression		yield progression	land progression
0.60		0.00	0.00	0.65	0.00
0.75		0.20	0.20	0.75	0.10
0.85		0.50	0.30	0.90	0.35
0.90		0.80	0.30	1.00	0.60
1.00		1.00	0.20	1.00	0.85
1.00		1.00	0.00	1.00	1.00
1.00		1.00	0.00	1.00	1.00
1.00		1.00	0.00	1.00	1.00
1.00		1.00	0.00	1.00	1.00
1.00		1.00	0.00	1.00	1.00

Conversion Factors from financial into economic per crop

	Without Project		With Project	
CROP	CF applied	CF calculated from model	CF applied	CF calculated from model
Maize	1.00	-10.92	1.00	-2.48
Beans	1.00	0.65	1.00	0.69
Cotton	1.00	0.83	1.00	0.87
Wheat	1.00	-0.53	1.00	0.41
Rice Polished	1.00	1.57	1.00	1.50
Rice (Paddy)	1.00	2.32	1.00	1.95
Tomato	1.00	1.00	1.00	0.99
Soya Beans	1.00	0.73	1.00	0.78
Chillies	1.00	1.00	1.00	1.00
Chick peas	1.00	1.00	1.00	1.00
Pearl Millet	1.00	1.00	1.00	1.00
Sunflower	1.00	1.00	1.00	1.00
Groundnuts Shelled	1.00	2.18	1.00	2.05
Paprika	1.00	1.00	1.00	1.00
Burley Tobacco	1.00	1.47	1.00	1.73
NDDF Tobacco (fire)	1.00	0.82	1.00	0.73
Flue Cured	1.00	1.40	1.00	1.58
Kilombero rice (Polished)	1.00	1.39	1.00	1.35
Kilombero rice (paddy)	1.00	1.64	1.00	1.54
Amaranthus	1.00	1.00	1.00	1.00
Cabbage Drumhead	1.00	1.00	1.00	1.00
Onion	1.00	1.00	1.00	1.00
Pigeon peas	1.00	1.00	1.00	1.00
Potatoes (Irish)	1.00	1.00	1.00	1.00
Sweet potatoes	1.00	1.00	1.00	1.00
Cassava	1.00	1.00	1.00	1.00
Water melons	1.00	1.00	1.00	1.00
Bananas	1.00	1.00	1.00	1.00
Sorghum	1.00	1.00	1.00	1.00
Sugar Cane	1.00	0	1.00	0
Other 5	1.00	0	1.00	0
Other 6	1.00		1.00	
Other 7	1.00		1.00	
Other 8	1.00		1.00	
Other 9	1.00		1.00	
Other 10	1.00		1.00	

Provision of starter packs/ grants			Land size in CA	
Average variable cost	650	€/ha	0.80	ha
Proposed coverage	0.80	ha for 1 starter pack		Starter pack on
Starter pack per FHH	520.0	€/starter pack		HH level
Benefitting FHH	3,625	farm HH	per HH	750
Total cost of packs	1,885,000	€	total	2,718,750

Features existing Scheme				
Water price		€/ha	two seasons	
Area benefitting	365.00	ha	1	

Residual soil moisture model	0		
Apply soil moisture model Yes = 1, No = 0			
without yield level compared to with yields		70.0%	

Fish farming				
Number of HH adjacent to lake	6,000	Households		
% HH involved in fishing	0%			
# HHs benefitting from fishing	0		total kg	
Fish caught per HH per year	280	kg		0
Revenues from fishing per kg	1.5	€/kg		
Revenues from fishing per year per HH	420	€/year/HH		
Total revenues per year all HH	0	€/year		
Profit share	30%			
Total net benefit from fishing	0	€/year		
	0%	% change		100%

Month	kg fish/HH
Jan	50
Feb	50
Mar	50
Apr	30
May	30
Jun	20
Jul	20
Aug	10
Sep	10
Oct	10
Nov	0
Dec	0
TOTAL	280

Farm Cash Flow Calculations			**Number of beneficiaries**		
Family labour yes = 1, no = 0	0		Number of benefitting farm households		3,625
Irrigated area	0.8	ha	Number of benefitting persons		24,650
Rainfed area	1.2	ha			
Banana-cane factor	0.7		**Household Loan**		
Farm Loan			Number of adults	2.80	
Loan amount	650	€	Number of children	4.00	
Interest per annum	30%		Adult equivalent	4.80	
Repayment period	2	years	Monthly expenses	108	€
Annual instalment	-478	p.a.	Off-farm income p.a.	159	
Monthly instalment	-40	per month	Loan amount	1,000	€
			Interest per annum	30%	
			Repayment period	2	years
			Annual instalment	-735	
			Monthly instalment	-61	

	Yes=1 No= 0					
WUA Support & Agricultural Extension	1	1.0	0.0%	100%	% change	
Baseline Surveys	1	1.0	0.0%	100%	% change	
Scheme Management & Training	1	1.0	0.0%	100%	% change	
Supervision and additional investigations	1	1.0	0.0%	100%	% change	
Project Implementation Support Unit		1.0	0.0%	100%	% change	
PIU (1= 2,900 ha, 0.689 = 2,000 ha)		1.00				0.689655

Benefits of additional irrigated areas				
1.00	benefits	0.0%	% change	100.0%
1.00	cost	0.0%	% change	100.0%
Area	0	ha		

Source: Data collection and all calculations made by Christof Batzlen for the Rural Infrastructure Development Programme II (RIDP II), Detailed Design Report for the South Rukuru Irrigation Project, Malawi (2015)

Table 12.14 Consolidated result for the FIRR (EIRR), NPV, and switching values (showing only the first 20 years)

		infield development / yield progression					1	2	3	4	5	6	7	8	9	10	11	12	13	14
Financial / Economic Analysis	0.05	0.065	0.2375	0.44	0.675	0.86	0.9375	0.985	1	1	1	1								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
BENEFITS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Benefits foregone from flooded reservoir area incl. Sale of wood																				
Benefits Foregone of agricultural production in €	60,390	120,781	422,733	724,685	1,026,637	1,207,808	1,207,808	1,207,808	1,207,808	1,207,808	1,207,808	1,207,808	1,207,808	1,207,808	1,207,808	1,207,808	1,207,808	1,207,808	1,207,808	1,207,808
Factor for annual decrease of yields (starting in PY 6)							0.0150	0.0302	0.0457	0.0614	0.0773	0.0934	0.1098	0.1265	0.1434	0.1605	0.1779	0.1956	0.2136	0.2318
Factor for annual decrease of yields (starting in PY 6)	1	1	1	1	1	1.0000	0.9850	0.9698	0.9543	0.9386	0.9227	0.9066	0.8902	0.8735	0.8566	0.8395	0.8221	0.8044	0.7864	0.7682
Benefits Foregone in € with decreasing yields	60,390	120,781	422,733	724,685	1,026,637	1,207,808	1,189,691	1,171,302	1,152,637	1,133,692	1,114,464	1,094,946	1,075,136	1,055,029	1,034,620	1,013,905	992,880	971,539	949,878	927,891
Benefits foregone in € with decreasing yields if considerd (if condition)	60,390	120,781	422,733	724,685	1,026,637	1,207,808	1,189,691	1,171,302	1,152,637	1,133,692	1,114,464	1,094,946	1,075,136	1,055,029	1,034,620	1,013,905	992,880	971,539	949,878	927,891
Benefits foregone through existing irrigation in command area													224,091	224,091	224,091	224,091	224,091	224,091	224,091	224,091
Total benefits forgone in €	**60,390**	**120,781**	**422,733**	**724,685**	**1,026,637**	**1,207,808**	**1,189,691**	**1,171,302**	**1,152,637**	**1,133,692**	**1,114,464**	**1,094,946**	**1,299,227**	**1,279,120**	**1,258,711**	**1,237,996**	**1,216,971**	**1,195,629**	**1,173,968**	**1,151,982**
Benefits with project in €		**41,154**	**526,296**	**1,671,485**	**3,632,630**	**5,444,988**	**5,935,670**	**6,236,411**	**6,331,381**	**6,331,381**	**6,331,381**	**6,331,381**	**6,331,381**	**6,331,381**	**6,331,381**	**6,331,381**	**6,331,381**	**6,331,381**	**6,331,381**	**6,331,381**
Indirect Benefits through impact on additional irrigated areas																				
Incremental benefits in € of agricultural production	**-60,390**	**-79,627**	**103,563**	**946,800**	**2,605,993**	**4,237,180**	**4,745,979**	**5,065,109**	**5,178,744**	**5,197,689**	**5,216,918**	**5,236,435**	**5,032,154**	**5,052,261**	**5,072,670**	**5,093,385**	**5,114,411**	**5,135,752**	**5,157,413**	**5,179,399**
Incremental benefit of rice mills (margin (@ € 11 / ton)		940	3,434	6,361	9,759	12,434	13,554	14,241	14,458	14,458	14,458	14,458	14,458	14,458	14,458	14,458	14,458	14,458	14,458	14,458
Incremental benefit of maize milling (margin (@ € 9 / ton)		2,775	10,141	18,788	28,822	36,722	40,031	42,059	42,700	42,700	42,700	42,700	42,700	42,700	42,700	42,700	42,700	42,700	42,700	42,700
Incremental benefit of wheat milling (margin (@ € 9 / ton)		679	2,480	4,594	7,047	8,978	9,788	10,283	10,440	10,440	10,440	10,440	10,440	10,440	10,440	10,440	10,440	10,440	10,440	10,440
Incremental benefit of legumes/oil crops processing (margin @ € 9 /t)		299	1,094	2,027	3,110	3,962	4,319	4,538	4,607	4,607	4,607	4,607	4,607	4,607	4,607	4,607	4,607	4,607	4,607	4,607
Incremental benefit of paprika processing (margin @ € 72/ton)		2,307	8,430	15,618	23,960	30,527	33,278	34,964	35,496	35,496	35,496	35,496	35,496	35,496	35,496	35,496	35,496	35,496	35,496	35,496
Incremental benefit of vegetables /root crops processing (margin @ €9 /ton)		934	3,412	6,321	9,697	12,355	13,468	14,151	14,366	14,366	14,366	14,366	14,366	14,366	14,366	14,366	14,366	14,366	14,366	14,366
Incremental benefit of transporters (margin (@ € 5 / ton)	-1,618	4,896	17,890	33,143	50,844	64,780	70,617	74,195	75,325	75,325	75,325	75,325	75,325	75,325	75,325	75,325	75,325	75,325	75,325	75,325
Incremental benefit of agro-industry and transporters	-1,618	12,830	46,880	86,852	133,239	169,757	185,055	194,431	197,392	197,392	197,392	197,392	197,392	197,392	197,392	197,392	197,392	197,392	197,392	197,392
Benefits from fishing																				
Benefits for other schemes																				
Total incremental benefit	-62,008	-66,796	150,444	1,033,652	2,739,233	4,406,937	4,931,034	5,259,539	5,376,136	5,395,080	5,414,309	5,433,827	5,229,546	5,249,653	5,270,062	5,290,777	5,311,802	5,333,143	5,354,805	5,376,791
Total discounted incr benefits																				
32,437,758																				
Infield development	0.1	0.25	0.25	0.25	0.15															
COSTS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
O&M and replacement costs of conveyance system excluding in-field O&M		39,355	137,742	236,129	334,516	393,549	469,549	393,549	393,549	393,549	393,549	469,549	393,549	393,549	393,549	393,549	469,549	393,549	393,549	393,549
O & M costs of in-field irrigation system)	425	1,488	2,551	3,614	4,251	4,251	4,251	4,251	4,251	4,251	4,251	4,251	4,251	4,251	4,251	4,251	4,251	4,251	4,251	4,251
WUA Management and Operation Costs	16,940	59,290	101,640	143,990	169,400	169,400	169,400	169,400	169,400	169,400	169,400	169,400	169,400	169,400	169,400	169,400	169,400	169,400	169,400	169,400
Sub_total O&M and Management	**17,365**	**100,133**	**241,933**	**383,733**	**508,168**	**567,200**	**643,200**	**567,200**	**567,200**	**567,200**	**567,200**	**643,200**	**567,200**	**567,200**	**567,200**	**567,200**	**643,200**	**567,200**	**567,200**	**567,200**
Construction Cost (works contract)	14,806,035	4,370,048	1,098,301	414,005	9,110															
Starter packs and ancillary cost	188,500	471,250	471,250	471,250	282,750															
Supervision Cost	636,000	588,000	552,000	336,000	174,000	76,000														
Environmental Mitigation Cost	63,000	157,500	157,500	157,500	94,500															
Project Management Cost	858,400	790,900	734,400	779,400	461,900	206,400														
WUA Support & Agric. Extension	382,600	441,600	441,600	437,400	249,400	118,400														
Baseline Surveys	116,000	116,000																		
Scheme Management & Training			66,000	209,200	166,200	166,200														
Base Cost	**17,050,535**	**6,935,298**	**3,521,051**	**2,804,755**	**1,437,860**	**567,000**														
Physical contingencies @10%	1,705,054	693,530	352,105	280,475	143,786	56,700														
Power @ 3 % p.a	0.0300	0.0609	0.0927	0.1255	0.1593	0.1941	0.2299	0.2668	0.3048	0.3439	0.3842	0.4258	0.4685	0.5126	0.5580	0.6047	0.6528	0.7024	0.7535	0.8061
Price contingencies @3 % per annum	511,516	422,360	326,496	352,021	229,014	110,028														
Sub-Total- Construction	**19,267,105**	**8,051,188**	**4,199,652**	**3,437,251**	**1,810,660**	**733,728**														
TOTAL COST	**19,284,470**	**8,151,321**	**4,441,585**	**3,820,984**	**2,318,828**	**1,300,928**	**643,200**	**567,200**	**567,200**	**567,200**	**567,200**	**643,200**	**567,200**	**567,200**	**567,200**	**567,200**	**643,200**	**567,200**	**567,200**	**567,200**
Total discounted Cost																				
35,415,368																				
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Incremental Net Benefits	-19,346,478	-8,218,117	-4,291,141	-2,787,332	420,405	3,106,009	4,287,834	4,692,340	4,808,936	4,827,881	4,847,109	4,790,627	4,662,346	4,682,453	4,702,862	4,723,577	4,668,603	4,765,944	4,787,605	4,809,591
Financial Internal Rate of Return		9.59%			**Net Present Value**		-1,478,005													

Source: Data collection and all calculations made by Christof Batzlen for the Rural Infrastructure Development Programme II (RIDP II), Detailed Design Report for the South Rukuru Irrigation Project, Malawi (2015)

are linked to the corresponding files and worksheets. As such, in changing one cell from '1' to '0', the entire analysis and results change from financial analysis into economic analysis.

In deciding the discount rate for the economic analysis, it has been assumed that the opportunity costs of capital in Malawi are 10 per cent. This discounting rate has been used for similar regions and economies (e.g. Western Kenya, Swaziland) or in Malawi (AfDB-funded National Water Development Programme, Project Appraisal Report 2008). Table 12.14 provides the results of the analysis. It provides the financial internal rate of return (FIRR), the economic internal rate of return (EIRR), net present value (NPV), and switching values (Table 12.14).

Table 12.15 Results of the financial and economic analysis of the South Rukuru scheme

Options	Financial internal rate of return (FIRR)	Financial net present value (F-NPV) in €	Economic internal rate of return (EIRR)	Economic net present value (E-NPV) in €
Option A (2,900 ha)	9.6%	−1,478,005	7.3%	−7,969,966
Option B (2,000 ha)	10.5%	1,291,674	8.0%	−3,823,995

Source: Own calculations. Note: The net present value is defined as the total benefit the project achieves discounted to the present value (present time) by using a discount factor $(1/(1 + 0.1)n)$. We use 10 per cent

12.5.4 Financial and Economic Viability

By deducting the economic capital and operations and maintenance costs from the incremental project benefit stream, an incremental net benefit stream was derived in constant 2013 financial and economic prices. The analysis was undertaken over a 30-year time period after final acceptance to reflect the economic life of the main civil infrastructure (weir, intake, sand trap, canals, pipelines) under good maintenance, including regular replacements.

Since it is expected that major investment infrastructure will have a significantly longer lifespan than the assumed project period of 30 years after final acceptance (e.g. the weir and main canals will have an economic lifespan of 50 years), a residual value of the civil infrastructure has been taken into account amounting to 40 per cent of the construction value in project year 37. However, it has to be noted that the positive effect of the residual value is very insignificant since the discounted value by 30 years of any structure equals close to zero.

The summarised results of the financial and economic analysis are shown in Table 12.15.

The results above show that, based on the assumed opportunity cost of capital of 10 per cent, Option A is slightly below and Option B slightly above the financial viability threshold. Both options are below the economic viability threshold. The results also illustrate that the proposed irrigation scheme is characterised by some differences between FIRR and EIRR (annual price increases are not considered in the economic analysis, among others).

The financial internal rate of return (FIRR) of the project is 9.6 per cent for Option A (10.5 per cent for Option B). It is different from the economic internal rate of return (EIRR) of 7.3 per cent for Option A (8.0 per cent for Option B). These are still relatively good results for smallholder irrigation and particularly good for a poverty-oriented or livelihood improvement project (Squire and van der Tak 1975).

The main reason for the relatively high import parity prices of cereals is the high transportation costs in Malawi and to the main port, Beira, Mozambique. Although the application of these prices is beneficial for the farmers in achieving prices that are (in the case of maize) 50 per cent higher than the financial prevailing price in

Malawi,[3] resulting in higher gross margins, they are detrimental to the consumers, particularly the poor, food-insecure population. At the same time, the high transportation costs are detrimental to farmers in applying export parity prices. If the latter are applied for maize and rice, and assuming that Malawi has become self-sufficient for cereals and any project output is exported, then the prices obtained would be EUR 0.06/kg for maize and EUR 0.13/kg for rice (compared to EUR 0.70/kg of rice in the current situation).

The financial and economic non-viability of the project is due to several factors:

- With the construction of a weir, the conveyance system, and a left bank main canal of about 17-km length in particular, as well as due to the small command area of 900 ha, the costs are relatively high, resulting in an average development cost of EUR 12,931/ha.
- The operation and maintenance costs, excluding Water Users' Associations (WUAs) management costs, are low. The type of irrigation is gravity flow without pumping and is planned to be completely farmer managed. This implies that no major government management structure will be required for managing the scheme after project completion.
- The benefits are relatively high, given that a substantial amount of vegetables and rice for the local market is expected to be produced.
- The benefit foregone (opportunity costs of land) is low as the project aims primarily at irrigating areas that are presently under rain-fed crops where very low yields are obtained at present. Additionally, only a few grazing areas are lost.
- The costs associated with the capacity building of farmers and WUAs, professional scheme management for 4 years, and the provision of starter packs to reduce the risk of farmers not using the recommended inputs and techniques in crop husbandry are high.
- The proposal of having two sub-water users' associations contribute to relatively high annual WUA management costs, which are reflected in a relatively high-water price.

12.5.5 Sensitivity Analysis for Option A

As outlined above, the proposed Option A is financially and economically not viable, while Option B is marginally financially viable but economically not viable. Therefore, the sensitivity analysis is mainly concentrating on parameters that could or might change to make the scheme both financially and economically viable and close to viable. The results of the sensitivity analysis are illustrated in Table 12.16 below.

The sensitivity analysis shows that the likelihood to obtain at least a financial rate of return equal to or above the viability threshold of 10 per cent is not unrealistic. The

[3]The financial price of maize is EUR 0.21/kg, compared to the import parity price of EUR 0.29/kg.

Table 12.16 Results of the financial and economic sensitivity analysis for the South Rukuru Irrigation Project (SRIP)

	Change in	Financial		Economic	
		FIRR	NPV in €	EIRR	NPV in €
Base scenario		9.6%	−1,478,005	7.3%	−7,969,966
Decrease of total costs of 10%	−10%	10.5%	1,624,784	8.0%	−5,289,935
Increase in agricultural benefits	+10%	10.7%	2,681,287	8.3%	−5,235,139
Financial prices of major horticultural crops increase by 50%	+50%	10.2%	690,521		
Period for infield construction by 1 year reduced	−1 year	10.1%	480,743	7.7%	−6,863,875
Period achieving full yields reduced by 1 year	−1 year	9.9%	−975,132	7.0%	−8,229,048
Increase of incremental benefit of agro-industry by 50%	+50%	9.8%	−805,441	7.5%	--7,297,402
Reduction of O&M cost by 25%	−25%	9.8%	−739,241	7.5%	−7,342,307
Flooding in wet season	5%	9.3%	−2,640,068	6.9%	−9,399,830
All 23 existing irrigation schemes operational		9.4%	−2,342,237	7.1%	−8,691,549
Soya beans grown instead of wheat		9.3%	−2,475,141	7.4%	−7,662,095

Source: Authors' calculations

likelihood to obtain an economic internal rate of return above the viability threshold is low. However, the calculations also illustrate that the financial and economic performance is still very acceptable, and on balance the multiplier effects not factored into the project cash flow could well bring the project into viability, all things being equal.

The probability that the profitability indicators will significantly deteriorate is relatively low since the assumptions made are all conservative. Moreover, the risk is low that in the absence of rural credit for smallholders in conjunction with significant cash shortages, South Rukuru farmers might not be in the position to finance seeds and farm inputs in the first years of implementation. The matching grants in the form of starter packs consisting of seeds, fertilisers, and pesticides for farm households for the first planting season will ensure that farmers will have sufficient means to follow the recommended agricultural practices. This will result in higher yields and revenues and, thus, also ensure the *with* project situation. Additionally, to further mitigate this risk, farmers should be encouraged to continue with their upland tobacco production for at least the first years of operation.

The switching values (which reflect the percentage change in benefits or costs required to achieve an EIRR of 10 per cent) indicated that for the project (Option A) to become economic, i.e. generate a real rate of return above the assumed opportunity cost of capital, the benefits of the scheme would have to increase by 4 per cent (FIRR) and 29 per cent (EIRR) or capital costs have to decrease by 5 per cent (FIRR) and 30 per cent (EIRR). The switching values for the two options are given in Table 12.17 below.

Table 12.17 Switching values for the South Rukuru scheme options

	% Change in benefits		% Change in capital and O&M costs	
Options	FIRR	EIRR	FIRR	EIRR
Option A (2900 ha)	+4%	+29%	−5%	−30%
Option B (2000 ha)	−4%	+20%	+6%	−22%

Source: Authors' calculations

12.6 Assignment

Find the full details about the Lower Malwathu Oya Project from the Ministry of Irrigation and Water Management and do the following exercise. You are not expected to do a thorough and complete study of the project. The overall objective is to understand the process of constructing an ECBA. You may use assumptions where appropriate.

1. *Define the project.*
   - The following information should be provided: purpose of the project, activities of the project, project duration, geographical location, and funding.
2. *Identify project impacts.*
   - First, list down all the impacts possible from the project. Categorise them into social, economic, and environmental impacts.
   - Second, identify economically relevant impacts. Through this exercise, you can avoid wasting time on the unnecessary, economically insignificant impacts of the project.
   - Third, using the details in the project proposal, you should be able to identify the physical quantities of each economically important impact.
3. *Identify the monetary valuation of relevant effects.*
   - Use shadow prices for marketed goods.
   - Use values from the other projects to value non-marketed goods. If values are not available, use a BTM or non-market valuation technique to find the value.
4. *Discount the costs and benefits.*
   - Compute the NPV, B/C ratio, and IRR.
5. *Perform sensitivity analysis.*
   - Do the analysis by using different discount rates and environmental values.

Annexure

Water Price

The ultimate beneficiaries, the farmers, should pay a water price either as a lump sum per ha or a volumetric price considering all operations and maintenance costs, replacement costs, and staffing costs required to operate and maintain all major headworks, the conveyance system, and distribution system. A water price, considering long-term discounted (also discounted water quantities) annual maintenance, long-term replacement cost, and WUA management costs, has been calculated and amounts to EUR 12.73/1000 m^3, which corresponds to EUR 140/ha per year, given the proposed cropping pattern. Moreover, each farm household has to make a provision of an equivalent of EUR 7/ha to operate the infield irrigation system. It is expected that farmers do this with their own labour (Tables A12.1, A12.2 and A12.3).

Table A12.1 Derivation of water price for South Rukuru (2013 constant prices in EUR)
Source: Authors' calculations based on engineer estimates

Operation & Maintenance & Replacement costs	Year 1 = PY2	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
O&M Costs included in water price to be paid to WUA	22,415	78,452	134,489	190,526	224,149	300,149	224,149	224,149
Sub-total O&M costs of scheme	22,415	78,452	134,489	190,526	224,149	300,149	224,149	224,149
Management of WUA	16,940	59,290	101,640	143,990	169,400	169,400	169,400	169,400
Total WUA and O&M costs	39,355	137,742	236,129	334,516	393,549	469,549	393,549	393,549
Total WUA & O&M costs discounted to present value	3,312,689							
Irrigation water required in m³	3,190,000	11,165,000	19,140,000	27,115,000	31,900,000	31,900,000	31,900,000	31,900,000
Total Irrigation Water required in m³ discounted to present value	260,191,222							
Water Price in € / m³	**0.0127**	m3						
Water price per 1,000 m³	**12.73**	**€/ 1,000 m³**						
Water price per year / ha	**140**	**€/ha**						

Table A12.2 Derivation of economic prices for internationally traded commodities (constant 2013 prices)

	Cotton Export Parity price	Rice Import Parity price	Rice Export Parity price	Wheat Import Parity price	Maize Import Parity price	Maize Export Parity price	Sugar Export Parity price	Beans Import Parity price	Tobacco Export Parity price	Soya Beans Import Parity price	Groundnuts Export Parity price	Urea Import Parity price	TSP Import Parity price	DAP Import Parity price
							US$ per ton							
Projected World Price in Year 2020 1/	1,600	350	350	195	172	172	261	368	2,897	368	1,381	232	282	336
Adjusted to 2013 Constant Prices (MUV factor 1.2280) 2/	1,965	430	430	240	211	211	321	452	3,559	452	1,697	285	346	413
x Quality Adjustment Factor 3/	0.95	0.95	1	0.90	0.90	1.30	1.20	1.20	0.80	1.00	1.00	1.00	1.00	1.00
Adjusted World Price	1,867	409	409	216	190	275	385	543	2,847	452	1,697	285	346	413
International Shipping cost in US$/ton	(69)	72	72	72	72	(72)	(64)	75	(90)	75	(75)	72	72	72
Insurance cost @1.5% commodity value 4/	(29)	6.5	6	3.6	3.2	(3.2)	(4.8)	8.8	(53.4)	6.8	(25.5)	4.3	5.2	6.2
CIF/FOB Price (Beira)	1,769	487	330	291	265	200	316	624	2,704	534	1,596	361	424	491
tons/container	26	25	25	25	25	25	28	24	20	24	24	25	25	25
CIF/FOB Price, Beira 5/	1,769	487	330	291	265	200	316	624	2,704	534	1,596	361	424	491
Port & Terminal Handling Charges 8 US$/ton 6/	(8)	8	(8)	8	8	(8)	(8)	8	(8)	8	(8)	8	8	8
Shipping line charges & storage, 4 US$/ton	(4)	4	(4)	4	4	(4)	(4)	4	(4)	4	(4)	4	4	4
Clearing & miscellaneous charges, 12 US$/ton	(12)	12	(12)	12	12	(12)	(12)	12	(12)	12	(12)	12	12	12
Transport and Insurance to/from Processor or Market 7/	(87)	90	(90)	90	90	(90)	(90)	94	(113)	94	(94)	90	90	90
Local Ginnery or Market Price in US$	1,658	601	216	405	379	86	211	742	2,568	652	1,478	475	538	605
Processing Costs 8/	(249)	(36)	(36)				(63)							
Processing Ratio	34.0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Value of the processed product in US$	479	565	180	405	379	86	148	742	2,568	652	1,478	475	538	605
km from farm to processing place /main market	20	10	10	10	10	10	40	10	70	10	10	10	10	10
Value of By-product 9/	83													
Transport to/from Farmgate 10/	(13)	(5)	(5)	(5)	(5)	(5)	(20)	(5)	(35)	(5)	(5)	(5)	(5)	(5)
Farmgate Price, US$/ton 11 & 12	550	560	175	400	374	81	128	737	2,533	647	1,473	470	533	600
Farmgate Price, € / kg	0.42	0.43	0.13	0.31	0.29	0.06	98	0.57	1.95	0.50	1.13	0.36	0.41	0.46
Farmgate Price, MWK / kg	190	194	61	139	130	29	44,287	256	877	224	510	163	184	208

Footnotes:
1/ World Bank Commodity Price Forecasts for Year 2020 (2005 constant prices) :
Cotton, middling 1-3/2 inch lint, cif Europe;
Maize (US), no.2, yellow, fob US Gulf ports;
Soybean (US), cif Rotterdam;
Cotton (outlook "A" index), middling, cif Europe;
Urea (varying origins), bagged, fob NW Europe;
DAP (Diammonium Phosphate), bulk, fob US Gulf
N.B. For groundnut, the current world market price has been used adjusted with the MUV
2/ Inflation indices are projections as of July 2011.
MUV is the unit value index in US$ terms of manufacture exported from G5 countries weighted proportionally to the countries exports to developing countries.
3/ Reflects the estimated difference in quality between the traded and locally produced commodity
4/ Shipping insurance estimated at 1.5% of commodity value
5/ All commodities transported through Beira
6/ Port charges, storage, handling
7/ Transport costs based on the respective cost/tonne/km multiplied by distance between Beira and local processor /market
8/ Processing costs based on operating costs/tonne plus margin to miller.
9/ Value of cotton seed estimated per tonne of lint
10/ Based on the respective cost/tonne/km for each commodity multiplied by distance between local market and farmgate;
11/ Farmgate price seed cotton.
DAP: value given is the value of 1 ton of DAP at the corresponding retail shop
12/ Sugar price is computed in € /ton sucrose

Table A12.3 Comparison of farm-gate prices derived from import and export parity prices and prevailing prices in Malawi

Serial No	Crop	Type of parity price	Farmgate price derived in € per ton	Farm gate price paid in Malawi in € per ton	Production cost in Malawi in € per ton (irrigated)	Difference derived price and prevailing farmgate price in €	Difference derived price and prevailing variable cost in €
1	Maize	import	290	209	150	81	140
2	Maize	export	60	209	150	-149	-90
3	Rice shelled	import	430	744	235	-314	195
4	Rice shelled	export	130	744	235	-614	-105
5	Wheat	import	310	558	140	-248	170
6	Groundnuts	export	1,130	628	170	502	960
	Interpretation/Conclusions:						
1	Farm gate price paid to Malawian farmers could be increased by max 81 €/ton allowing Malawi to remain economically competitive as compared to importing maize.						
2	Or: production cost of Malawian farmers could increase by max 140 €/ton allowing Malawi to remain internationally competitive as compared to importing maize.						
3	If Malawi intends to export maize on the world market, then price paid to farmers has to decline by 149 €/ton or farm production cost have to decline by 90 €/ton allowing Malawi to be internationally competitive.						
4	The price of shelled rice to paid farmers exceeds the derived price by 235 €/ton which makes it more economical for Malawi economy to import rice from the world market than producing it. However, since production cost are 195 €/ton lower than the derived price, Malawi could be competitive in producing rice, however farmers would have to accept much lower gross margins as they currently have.						
5	Production cost of rice would have to decrease by at least 105 €/ton to be comptitive to export rice on the world market. However, exports to the neigbouring countries are still possible since their benchmark for the price they pay is the import parity price which may be similar to the one computed for Malawi.						
6	Reviewing the production cost of Malawian farmers, one could assume that producing wheat in Malawi could be more economical than importing. However, the price Malawian farmers get exceeds the derived price by 248 €/ton which means that principally, it is for the Malawian economy more economical to import wheat from the world market than producing it under the current price regime.						
7	Given the high world market prices for goundnuts resulting in high farmgate prices based on export parity prices, there seems to be a very big potential for Malawian farmers to produce more groundnuts, to export them and to receive a higher price. Farmers could get up to 500 €/ton for						

(continued)

Table A12.3 (continued)

Serial No	Crop	Type of parity price	Farmgate price derived in € per ton	Farm gate price paid in Malawi in € per ton	Production cost in Malawi in € per ton (irrigated)	Difference derived price and prevailing farmgate price in €	Difference derived price and prevailing variable cost in €
	groundnuts to remain competitive for export production. In the current case, it seems that the organisations / traders buying groundnuts from the farmers and exporting them make a fortune. The profit margin of the traders is very high since the spread between potential farm gate price and current goes to the trade.						

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Choice Experiment Analysis of Non-market Values of Ecosystem Services

13

Sahan T. M. Dissanayake and Shamen P. Vidanage

Abstract

Small tank cascade systems (STCS) are clusters of hydrologically interconnected irrigation reservoirs with a 2500-year history located in the dryzones of Sri Lanka. They provide irrigation to 40 per cent of the irrigable land and a host of other benefits. The maintenance of STCS was neglected historically partly due to the low recognition of their true value. We highlight how choice experiment surveys and extended benefit-cost analysis can be used to elicit the full value of conducting environmental restoration projects with application to STCS. Respondents have a positive willingness to pay for the restoration (over LKR 78 million for the onsite sample). The cost-benefit analysis proves that cascade restoration is justified.

Keywords

Cascade restoration · Small tank cascade systems · Choice experiments · Cost-benefit analysis · Valuation

13.1 Introduction

There is renewed interest in small tank cascade systems (interconnected small irrigation reservoirs) in the dry zone of Sri Lanka. After years of neglect or conversion to other uses, such as into paddy fields or to facilitate water conveyance,

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there is now recognition of their important socio-ecological role and, more recently, their potential for mitigating the impact of climate change (Ministry of Mahaweli Development and Environment 2016). As a result, there are now several projects for the restoration and rehabilitation of small tanks.

Despite the renewed focus, the question of whether the cost of restoring STCS pays off has not been answered until the doctoral thesis *Economic Value of an Ancient Small Tank Irrigation System in Sri Lanka* (Vidanage 2019) was undertaken. The case study presented in this chapter was prepared based on the latter and other related work (Vidanage et al. 2005; Vidanage 2017; Dissanayake et al. 2018, 2019).

This chapter describes methods from economics, specifically non-market valuation methods focused on choice experiments and cost-benefit analysis, that can help guide decision-making for environmental planning; presents how to apply these methods based on a detailed and comprehensive case study evaluating the restoring and managing of small tank cascade systems in Sri Lanka; and helps the reader to comprehend how this methodology may be applied to decision-making on the restoration of the remaining 1161 STCS in Sri Lanka, as well as to many other agricultural resource management issues in developing countries across the globe.

13.2 Cascade Systems

The STCS are clusters of hydrologically interconnected small irrigation reservoirs in the dry zone of Sri Lanka with a history of over 2500 years (Madduma Bandara 1985). Recent work by Panabokke et al. (2001, 2002) and Madduma Bandara (2007) highlights that these are a unique hydro-ecological system, given their engineering, ecological, and management aspects and the way the individual tanks are designed to function together within a system. The construction of small tanks (also known as minor or village tanks) marked the beginning of organised human settlement in Sri Lanka (Panabokke 2004), and the STCS were economically, socially, and ecologically integral to the dry zone of the country, supporting large population centres in the early kingdoms (Shannon and Manawadu 2007). Sri Lanka currently has over 1100 functioning STCS with more than 15,000 individual tanks. Today, these systems provide irrigation to almost 40 per cent of the irrigable land area for paddy nationally and contribute 191,000 million tons of rice (or 20 per cent) to national production.

The benefits from these tanks extend beyond the paddy harvest as they provide drinking water, as well as water for non-paddy agriculture, washing, bathing, and fisheries, among other benefits. During droughts, villagers may forego irrigation for cultivation in favour of using the tank water to meet social needs, indicating that the non-economic benefits of STCS are arguably more valuable than the economic ones. At the same time, as highlighted by Panabokke et al. (2001), "Though the importance of non-economic functions to which tank water is put into are often inventorised and stressed by many scholars, quantified values of those functions have not yet been scientifically ascertained and demonstrated" (p. 2). In this chapter, we highlight how tools from economics can be used for this task.

Despite their many ecological, cultural, aesthetic, and economic benefits, the STCS began to be neglected and were no longer maintained during the colonial period until the 1980s. This neglect was partly due to inadequate knowledge of the basic functioning of the interconnected nature of the cascade systems; the low recognition of their true value as multipurpose and multifunctional systems; and a focus on their irrigation potential as the major element instead of the multiple benefits generated by the tank systems. Non-market goods and services, or ecosystem services, were not valued through the market system.

Current efforts for restoring small tanks in the STCS target the individual tanks[1] in degraded cascades without taking the cascades as the unit of intervention. As the cascades are a hydro-ecologically functional system, such interventions will yield suboptimal results. The main justification behind tank-level intervention is the cost of investment over the expected benefits of restoration: the authorities mostly value irrigation as the only benefit.

This study estimates the non-market values of the STCS by generating willingness to pay (WTP) for the restoration of the cascades and their sustainable management among direct cascade dependents (on site) and others that are far away from cascades and do not directly depend on them (off site). These estimates will provide guidance to the authorities about how the community would value these systems by taking into account their economic value based on the total economic value principles related to cascades. In addition, this study will generate the marginal WTP for the different attributes of the cascades for appropriate policy guidance. The WTP estimation was calculated using a choice experiment as the main valuation method, with the Pihimbiyagollewa cascade in the Kahatagasdigiliya and Rambewa Divisional Secretariat Divisions of the Anuradhapura District of the North Central Province as a case study.

Water is recycled and reused across a system of small to large tanks. Traditionally, there is one village tank for use for each village. In addition, there are other tanks for different purposes associated with the village tanks, as depicted in Fig. 13.1 and described below.

> *Kulu wewa** (forest tank): created in the upper catchment of the village tank in order to provide water for wild animals to reduce human-wildlife conflict, filter debris and silt, and capture the rainwater that will enter into the village tank through seepage. *Kayan wewa*: built where the upper catchment has been cleared or degraded, used to trap sediment and control salinity. *Olagam wewa*: lies close to the village but not associated with a permanent settlement or

(continued)

[1] There were a few project-based pilot interventions which may be considered exceptions. Notably, Plan Sri Lanka, the Mahaweli Authority of Sri Lanka, and the International Union for Conservation of Nature, together with the Department of Agrarian Development, carried out cascade-wide restoration efforts.

cultivation, used as a source of water for seasonal cultivation *Goda wala* (water hole): constructed for the trapping and deposit of silt to avoid siltation and sedimentation in the main village tank. *Ihala wewa* (storage tank): constructed for the storage of water, associated with paddy cultivation and other community activities. *Maha wewa/pahala wewa* (village tank): the main component of the cascade system; water from all other tanks in the system drain into this tank, which is used for agriculture.

13.3 Policy and Management of Cascade Tank Systems and Need for Valuation

Many of the STCS at present are either abandoned or not functioning to their full potential. Table 13.1 provides the distribution of small tanks in Sri Lanka at the province level with their status (Panabokke 1999, 2009). Roughly 50 per cent or 7553 of the 15,373 tanks are abandoned. As a result, small tanks in the dry and intermediate zones are gradually becoming inefficient in providing an assured supply of irrigation water because of changes occurring in the size and shape of the tank bed due to siltation. Also, these water bodies become shallower due to sedimentation.

Minor irrigation systems[2] are officially defined (by the Agrarian Services Act 58 of 1979) as tanks and anicuts with command areas of 80 ha or less. These were largely under the administration of the Department of Agrarian Development

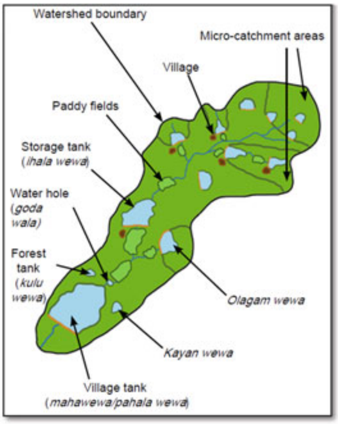


Fig. 13.1 The structure of the village tank cascade system. Source: Updated from International Union for Conservation of Nature (2016)

[2]Minor irrigation schemes are those which irrigate less than 80 ha (or 200 ac) of command area. These include village / small / minor tanks and anicuts (river diversions).

Table 13.1 Number of operational and abandoned small tanks within each province

Province and area (km^2)	Number of small tanks		Total
	Operating	Abandoned	
Northern: 3709	608	816	1424
North central: 10,365	2095	1922	4017
North western: 7760	4200	2273	6473
Southern: 2849[a]	653	757	1410
Lower Uva 2901[a]	16	543	559
Eastern (south of Mahaweli) 3885[a]	–	1017	1017
Eastern (north of Mahaweli)[a]	48	425	473
Total	7620	7753	15,373

[a] Includes only the dry zone part of the province
Source: Panabokke 1999, 2009

(DAD). With the devolution of powers to Provincial Councils under the 13th Amendment to the constitution, the management of minor irrigation became a devolved subject under the Provincial Departments of Irrigation (PDoI). However, in many places, PDoIs are limited and hamstrung due to inadequate resources, personnel, and knowledge of the cascade systems and are capable of only limited action. Hence, in practice, the DAD takes the lead in small tank management. Sakthivadivel et al. (1996) elaborated upon the need for integrating and coordinating the functions of these two separate and independent entities to avoid the duplication and overlapping of their activities.

An enormous amount of foreign aid, loans, and government revenue has been diverted in the last few decades to tank rehabilitation and restoration. In these programmes, the standard actions were to strengthen the tank bund, repair or replace structures, and regain capacity lost due to sedimentation by raising the spill and the tank bund, thereby increasing the water-holding capacity of the tank. However, because the tank is still silted, the water spread also increased, resulting in the formation of larger, shallower water bodies, which lose more water through evaporation and percolation. Further, because the dead storage may be silted, the tank is likely to completely dry out in the dry season, losing the benefits of having dead storage. Other important environmental issues that need to be addressed for the efficiency and effectiveness of the tank ecosystem are as follows:

1. Disappearance of the *gasgommana* (windbreaks) and the resulting increase in water loss
2. Development of salinity in the upstream area around full-supply level, especially if the tank is second or third in the cascade
3. Flooding of upstream rice fields, which has caused conflicts among village communities
4. Disappearance of some of the fish species that cannot survive in shallow waters

As highlighted earlier, it is important to manage the cascade system as a whole system and not on an individual tank basis. Much of the current restoration of cascades has focused on individual tanks, typically the large tank located downstream in a cascade, as a larger number of people receive direct benefits from such tanks. Given that the cascades are an interconnected system, rehabilitating a few tanks in isolation will not bring about the expected results.

It is also important to consider the broad range of ecosystem services and benefits derived from the cascades when managing cascades and planning restoration. Even though these systems were established to deliver multiple benefits to the local economy, planners and decision-makers tend to consider only the irrigation benefits in assessing the feasibility of restoring degraded systems. This often results in the erroneous conclusion that restoring STCS is not financially feasible. This error is due to knowledge and application of market values for irrigation water, which is relatively easily available versus knowledge and application of valuation methods for non-market services. But focusing solely on the provision of water, while ignoring other benefits and services, will lead to ineffective management of the cascades and a loss of the non-water and non-market services and benefits.

This case study highlights how non-market valuation methods, particularly choice experiments and cost-benefit analysis, can be used to guide and inform cascade restoration activities. Specifically, the study demonstrates (Aheeyar 2013) how choice experiment surveys can be used to identify preferences, values, and willingness to pay for agricultural resource management options and (Bateman et al. 2002) how a cost-benefit analysis can be expanded to include non-market benefits to better guide agricultural resource management options.

13.4 Methods: Non-Market Valuation Methods and Choice Experiments

13.4.1 Non-Market Valuation Methods

The value of the environment or the benefits we receive from nature are important contributors to human welfare (MEA 2005; United Nations Environment Programme 2013, 2010; Dissanayake 2018). In neoclassical economics, an item of goods or a service is considered to have an economic value because it contributes to individual utility (Straton 2006). At the same time, the market economy uses price as a signal of value and information to consumers and producers. Given that many of the benefits generated from ecosystem goods and services are not traded in conventional markets (Kragt 2009) and do not have prices, they tend to be undervalued or invisible in economic analyses and policy decision-making contexts.

Over the last few decades, techniques commonly referred to as non-market valuation have evolved to make the benefits of nature more visible (Dissanayake 2018). The purpose of environmental economic valuation is to strengthen the links between the environment and the economy so that they are now seen as closely interrelated. Ecologically sustainable development requires an integration of environment, economic, and social issues. Applying economic valuation to environmental assets through various valuation techniques is one method of promoting this integration.[3]

The basic strategy for environmental valuation is 'commodification' of the services that the natural environment provides (Perman et al. 2003). The services used by households and firms are treated as arguments in the utility and production functions respectively. Most of the environmental valuation literature is about goods and services that flow to households rather than to firms; this study too emphasises the households that receive benefits from village tank ecosystems.

Economists measure environmental values in terms of an individual's willingness to pay to obtain the resources or willingness to accept (WTA) compensation for their loss if an environmental change takes place (or is prevented). Willingness to pay and willingness to accept are closely linked to the concept of consumer surplus. Consumer surplus is the difference between the maximum amount an individual is willing to pay for consuming an item of goods and the amount that is actually paid for the good. Economic theory suggests that changes in well-being can be measured as changes in consumer surplus. These changes can be defined in somewhat different ways, resulting in several measures of changes in consumer surplus available: e.g. changes in the Marshallian consumer surplus, compensating variation, equivalent variation, compensating surplus, and equivalent surplus (Freeman et al. 2014).

These measures of consumer surplus are typically estimated using changes in prices and the corresponding quantity demanded. Special valuation methods have been developed to compute the economic value of non-market goods or services. These valuation methods can be divided into two main theoretically derived groups:

1. Revealed preference methods
2. Stated preference methods

13.4.1.1 Revealed Preference Methods

Revealed preference methods make use of linkages between an environmental good, a policy or ecosystem service, or other benefits and one or more market goods. This means that they are all based on consumers' or firms' actual market behaviour, typically seen as an important advantage compared to stated preference methods. The two key valuation methods within this group are as follows:

1. The travel cost method
2. The hedonic price method (also called the property value method)

[3] Sometimes ecosystem goods and services are subject to free trade and pricing in markets. On such occasions, they resemble market goods or services, and data on consumers' and firms' market behaviour may be directly used to estimate the demand and supply.

The travel cost method values the recreational opportunities provided by nature. The willingness to pay for visiting a recreational area may be estimated if there is enough data on how much money and time people would spend travelling to the area. Early travel cost method applications were used to value recreational access to areas such as nature reserves in the United States. A more modern version of the method is used to analyse how different characteristics of a recreational area affect the demand for recreation. For example, suppose that the number of people visiting a specific beach partly depends on its water quality. If there is information on the number of visitors (and distance and costs) at different levels of water quality, then it is possible to estimate the willingness to pay for improved water quality.

The hedonic price method is based on the idea that the supply of ecosystem services might play a role in property values. A holiday home situated on a beach characterised by poor water quality might have a lower market price than a holiday home situated on a beach with clean water, even if the houses and the surroundings are identical in all other aspects. If data exist on the property values and the characteristics influencing property values (including water quality), an indirect market price on water quality might be estimated and, in some cases, even the willingness to pay for improved water quality.

13.4.1.2 Stated Preference Methods

Stated preference (SP) methods are used when there is weak, poorly explored or no linkage between an environmental good, policy, or ecosystem service one wishes to value economically and a relevant market good. Stated preference methods address this problem by directly estimating the willingness to pay for the ecosystem service through the creation of a hypothetical market situation. This method of gaining information about the economic value of ecosystem services has been increasingly applied in the last two decades. The two main stated preference methods are the following:

1. Contingent valuation method
2. Choice experiments

The contingent valuation method uses (usually) random surveys of individuals to collect data by presenting them with a scenario of a change in the supply of an ecosystem service. The scenario is followed by questions about the respondents' willingness to pay for a realisation of the change. According to Smith (2004), this method has been historically contentious given its hypothetical nature, but it has become a staple in the environmental economist's toolbox in recent decades. At the same time, there are substantial design requirements regarding the text, pictures, and other aspects used in the questionnaire for communicating information about the hypothetical change in the supply of the ecosystem service to ensure the internal and external validity of the results (Smith 2004). As the contingent valuation method and other stated preference methods do not use data on individuals' *actual* market behaviour, the main question of whether the individuals would actually pay the WTP as inferred from their responses if the scenario becomes a reality is debatable.

This and the other questions related to stated preference methods have been subject to extensive testing, and much is known today about how a stated preference method should be applied for maximising reliability and validity.

The hypothetical setting used by stated preference methods makes it possible to also approach people who at present do not use the ecosystem service being evaluated but might still be willing to pay for an increased provision of the service. Revealed preference methods cannot provide information on such a non-use value of ecosystem services. For example, only values held by visitors are taken into account if an improved environmental quality in a recreational area is valued using the travel cost method. However, it is not unlikely that non-visitors also care for the environmental quality of the recreational area. A contingent valuation method study can be used to capture the willingness to pay by these non-visitors.

A choice experiment is a technique under the choice modelling techniques (which also include contingent ranking, contingent rating, and paired comparisons) (Birol et al. 2006; Boxall & Adamowicz 2002; Morey & Rossmann 2003). This set of stated preference techniques is based on the idea that any good can be described in terms of attributes or characteristics and the levels those attributes take (Lancaster 1966). The choice experiments technique (theoretically derived from Lancaster's characteristic theory of value and the random utility theory) is in line with the theory of welfare economics (Lancaster 1966; Bateman et al. 2002; Hensher et al. 2015). The choice experiment is somewhat similar to the contingent valuation method but is based on how respondents make repeated choices among at least two alternatives. The alternatives differ with respect to the levels of attributes characterising the ecosystem service and the payment requirements for the respondent. The willingness to pay for the environmental good or policy can be derived from the respondents' choices. The marginal willingness to pay for the individual attributes can also be derived from these methods, an important factor in determining the best management actions.

In this chapter, since we are interested in understanding the values and benefits of cascade restoration and how those values are associated with the individual attributes of cascade tanks, we use a choice experiment survey. The following are the steps necessary to conduct a choice experiment survey.

13.4.2 Choice Experiment Methods

13.4.2.1 Steps in Conducting a Choice Experiment Survey

The following are the main steps in designing a choice experiment as adopted from Blamey et al. (1997):

1. Problem identification: identify and describe the relevant issues, including status, stakeholders, and threats.
2. Policy scenarios: identify options for management actions that could address the problem.
3. Selection of attributes: identify and select the relevant attributes of the resource using techniques such as literature review, focus group discussions with stakeholders, and expert opinions.

4. Assign levels to attributes: the likely levels of the attributes need to be determined for a status quo scenario and, alternative, policy scenarios. These should be agreed upon through a literature review, expert opinion, and stakeholder consultation.
5. Experimental design: allocate levels of the attributes to each alternative within the choice sets.
6. Survey delivery: choose the presentation, sample size and locations, and survey procedure.
7. Analyse the survey results: use econometric models specifically developed for analysing discrete choice data to obtain estimations of the trade-offs that respondents make between the attributes.
8. Interpret results for policy analysis.

13.4.2.2 Econometric Estimation of Choice Experiment Data

In studying the small tank cascade system in Sri Lanka, an econometric model such as that used by Rai et al. (2014) for estimating the demand for watershed services in the Koshi basin in Nepal may be adopted. In order to ensure internal consistency, a choice experiment contains multiple-choice sets. Each choice set includes the status quo representing no change in the prevailing levels of the different attributes x, as well as two (or more) alternative scenarios with each alternative identifying different levels of the attributes. The utility derived by individual i from an alternative j is not limited to the attributes $\times$ given in the experiment. Several unobservable factors that can influence utility are captured by a random term ε. Consistent with the random utility theory (Hensher et al. 2015), the random and unobservable terms are assumed to enter the utility function additively. Therefore, individual i's utility U from choosing alternative j is expressed as follows:

$$U_{ij} = x_{ij} + {}_{ij} \tag{13.1}$$

Individual i selects alternative j over alternatives j' when expected utility U_{ij} is greater than expected utility from all other options U_{ij}'. The probability Pr that individual i will choose alternative j over other alternatives j' in a complete choice set R is given by

$$Pr\,(j\backslash R) = Pr\left\{\left(Uij > Uij^{'}, \text{s.t.}\forall \text{j}^{'} \in R, \text{and } j \neq j^{'}\right)\right\} \tag{13.2}$$

In order to identify the most preferred alternative, the equation (Greene 1997; Greene 2012, Bateman et al. 2002) can be econometrically estimated based on responses to a household or individual survey. Assuming that the error term is identically and independently distributed (IID) and indirect utility V is linear in the attributes of X, then the equation (Greene 1997; Greene 2012, Bateman et al. 2002) can be estimated with a conditional logit model (McFadden 1974). The conditional logit model is expressed as

$$V_{\text{ij}} = \text{ASC} + {}_{\text{ij}} \tag{13.3}$$

where V_{ij} refers to indirect utility obtained by the i^{th} individual for the j^{th} alternative and β is the coefficient of the attributes $\times$ included in the experiment. The alternative-specific constant (ASC) captures the effect of unobservable factors on the selection of alternatives relative to the status quo. In this analysis, ASC is a dummy variable that is coded as 1 for 2 hypothetical alternatives in the choice set and as 0 for the status quo. A random parameter logit model can also be estimated by relaxing some of the constraints associated with the identically and independently distributed assumption in the conditional logit model. In the random parameter logit model, the observed component βx is decomposed into two parts: the sum of the population mean Υ and the individual deviation of the random parameter η. In this model, socio-economic variables s are introduced to detect sources of heterogeneity. Further, the interaction terms in γ identify the impact of individual-specific characteristics on selected alternatives and ASC. The random parameter logit model is expressed as

$$V_{ij} = \mathrm{ASC} + x_{ij} + x_i + s_i \tag{13.4}$$

The choice experiment method is consistent with utility maximisation and demand theory (Bateman et al. 2002; Revelt & Train 1998). When the parameter estimates are obtained from the appropriate model, welfare measures, in the form of marginal willingness to pay, can be determined by estimating the marginal rate of substitution between a specific attribute included in the choice experiment and marginal utility of income represented by the coefficient of the payment attribute. Then the marginal value of attribute k is the ratio between the parameters β_k and $\beta_{p.}$:

$$MWTP_k = -\beta_k/\beta_p \tag{13.5}$$

13.5 Methods: Cost-Benefit Analysis as a Decision-Making Tool

As Boardman et al. (2006) suggest, cost-benefit analysis is a key input in the ex ante evaluation of public projects and policies. Cost-benefit analysis has its basis in Paretian welfare economics (neoclassical economics). When used for social choices, benefits and costs should be evaluated in a social context and take account of any externalities arising from a particular action.

The basic idea behind cost-benefit analysis is that better decisions could be reached if all costs and benefits (economic and environmental) of a project were identified, measured, valued, and compared. Therefore, with regard to complex environmental assets such as village tanks, a cost-benefit analysis needs to assess both direct and indirect benefits of conservation or proposed actions. In assessing a complex natural asset, a wider range of costs and benefits are needed: they should be identified and measured, and the end monetary value should be assigned. Major limitations of the cost-benefit analysis include potential inaccuracies in the identification and assessment of benefits and costs, increased subjectivity in assessing intangible benefits and costs, and inaccuracies related to converting future values to present values by using the concept of discounting.

For a cost-benefit analysis of the small tank cascade system in Sri Lanka, the cost of restoration was assessed based on ongoing restoration activities undertaken by the International Union for the Conservation of Nature and the Department of Agrarian Development. Market and non-market values derived from the choice experiment will be used for the benefits. Also, the cost-benefit analysis results for different cascades will be different and will help decision-makers in prioritising cascades for restoration.

13.6 The Application: The Cascade Tank Restoration Choice Experiment

13.6.1 Attribute Selection

As highlighted above, a choice experiment survey is specifically developed to generate data based on the choices of possible scenarios or options describing an agri-environmental policy or outcomes. These data are used to obtain estimations of the value and trade-offs that respondents make between the attributes of the project or programme. A choice experiment survey describes respondents' choices among a set of alternatives. In this case study, the alternatives are the different cascade restoration options.

Each choice question in this choice experiment survey describes two cascade-wide restoration and sustainable management alternatives/options and a no-restoration status quo option that represents the present status of the cascade (i.e., Alternative A, the first option in each choice card). The two restoration alternatives (alternative B and alternative C) have different levels of the five attributes and an associated cost, the no-restoration option does not have any cost. The cascade restoration alternatives were made up of a set of attributes differentiated by levels and a cost attribute. Respondents were asked to choose their preferred option from these scenarios, allowing the research to observe the relative importance of the different attributes to the stakeholders.

13.6.1.1 Selecting Attributes for the Choice Experiment Questionnaire

The key task in designing any choice experiment study is the selection of the attributes and their levels used to describe the impact of alternative policy scenarios (Kragt 2009). They have to be relevant to both the decision-makers and the respondents of the questionnaire. It is also important to ensure that the differences between each level are salient to the respondent. For this case study, the attributes and their levels were identified and vetted through an extensive literature review, consultation with experts/scientists working on cascades, use of Google maps, and focus group discussions of cascade-dependent stakeholders.

Tables 13.2 and 13.3 provide the attributes and their levels used in this research study. Fine-tuned in consultation with communities dependent on the Kapiriggama

Table 13.2 Attributes and their levels

Attribute name	Attribute levels in a normal year
Availability of irrigation water in the cascade for cultivating paddy during the dry season (*Yala*[a])	1. Water will be available for cultivating the entire paddy fields in the cascade. 2. Water will be available for cultivating three-fourths of the paddy fields in the cascade. 3. Water will be sufficient to cultivate about half of the paddy fields in the cascade.
Availability of water for other purposes in the cascade during the dry season (*Yala*)	1. Water will be available throughout the year in the cascade for other purposes. 2. Water will be available at least 10 months of the year in the cascade for other purposes. 3. Water will be available at least 8 months of the year in the cascade for other purposes.
Extent of unique cascade ecological components	1. Cascade ecosystem components collectively fully cover the entire cascade area with forest/natural vegetation. 2. Cascade ecosystem components collectively cover two-third of the cascade area with forest/natural vegetation. 3. Cascade ecosystem components collectively cover one-third of the cascade area with forest/natural vegetation.
Cascade biodiversity	1. About 12 types of bird groups were found in the cascade during the *Yala* season. 2. About 8 types of bird groups were found in the cascade during the *Yala* season. 3. About 4 types of bird groups were found in the cascade during the *Yala* season.
Respondent contribution to cascade restoration and management	For cash: in LKR/season/household – 2000, 4000, 6000, 8000, 10,000, and 12,000. For labour: in days/season/household – 2, 4, 6, 8, 10, 12. (A value of 0 was used for cash and labour for the business as usual or status quo case.)

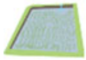
Source: Vidanage (2019)

[a] The water-deficit dry cultivation season depends on the availability of tank water

and Pihimbiyagollewa cascades through a series of focus group discussions, the attributes and their levels may be taken as realistic.

The paddy, water use, and cost attributes are clear. The cascade ecology attributes referred to the extent to which the different components of the cascade were represented in the restored cascade. The biodiversity was presented as bird groups, as that was identified as the best measure that the participants were able to relate to (other options, like using species numbers or species diversity indices, were considered and eliminated during the attribute selection process).

Table 13.3 Attributes and attribute levels by illustrated diagrams

 Availability of irrigation water for cultivating paddy during the dry season	 Water will be sufficient to cultivate for about half of paddy fields	 Water will be available for cultivating three fourth of paddy fields	 Water will be available for cultivating entire paddy fields				
 Availability of water for other purposes in the cascade during dry season	 Water will be available at least 8 months of the year for other purposes	 Water will be available at least 10 months of the year for other purposes	 Water will be available thorough out the year for other purposes				
 Extent of unique cascade ecological components	 Cascade ecosystem components collectively cover one-third areas with forest/natural vegetation of the entire cascade area	 Cascade ecosystem components collectively cover two-third areas with forest/natural vegetation of the entire cascade area	 Cascade ecosystem components collectively fully covered with forest/natural vegetation of the entire cascade area				
 Cascade biodiversity	 About 4 types of bird groups found in the cascade during *Yala* season	 About 8 types of bird groups found in the cascade during *Yala* season	 About 12 types of bird groups found in the cascade during *Yala* season				
 Contribution to cascade management	No monetary  contribution	 LKR 2,000 / season	 LKR 4,000 / season	 LKR 6,000 / season	 LKR 8,000 / season	 LKR 10,000 / season	 LKR 12,000 / season

Source: Vidanage, 2019

13.6.2 Experimental Design and Generating Choice Cards

Once the attributes and levels have been identified, it is necessary to identify which attribute level combinations appear in each choice card. The levels of attributes for the two restoration alternatives (Alternatives B and C) were generated through an experimental design. A design with four attributes with three levels and a six-level payment attribute will result in a total of 486 (34 × 6) possible combinations for each alternative and 235,710 possibilities for a pair of alternatives. (This is called a full factorial design and identifies all the possible combinations of attribute levels).

It is not feasible to conduct a study with such a large number of possible options; therefore, the standard practice is to use experimental design methods to identify a subset of all possible combinations. The SAS package was used to generate an orthogonal main effect design that is 100 per cent D efficient, following Kuhfeld (2010). This resulted in 54 unique choice sets—still too many for one respondent to answer. Therefore, these were blocked into nine sets of surveys, where each survey had six choice questions.[4]

These attribute levels were illustrated graphically on cards to be given to respondents to make their choices. There was a total of 72 choice cards ($6 \times 9 = 54$ unique cards $+2 \times 9 = 18$ repeated cards). A sample choice is shown in Fig. 13.2 below.

Across all the surveys, nine sets of choice cards, each with eight choice cards, were distributed among respondents in such a way that each set is equally distributed among the respondents. Each respondent faced just one set out of the nine sets and answered the eight choice cards in that set.

13.6.3 Survey Implementation

The tool for primary data collection was a structured survey questionnaire drafted through preliminary research and improved through consultations. It was field-tested with communities dependent on the Kapiriggama cascade (adjoining the Pihimbiyagollewa cascade) via the enumerators before finalising. There were two formats for the survey questionnaires: a more detailed one for the on-site sample and a variant for the off-site sample. The questionnaire comprised four sections. The first section provides general information on the survey, including assurances about the confidentiality of the information collected and that the respondents can leave the survey at any point; the respondent's consent; and detailed background of the issues to be addressed in the survey. Section 2 was devoted to introducing the attributes, their levels, and the graphical representation in the choice cards; the third section was on the choice cards and responses. The fourth section was the respondent's socio-economic information.

As choice experiment surveys are somewhat complex, the enumerators (in both Pihimbiyagollewa and Colombo) were provided with detailed training. The training covered an introduction to STCS[5], choice experiments, survey methods, and field testing of the survey. Enumerators also role-played administering a few surveys among themselves before field testing. Enumerators received the survey questionnaire and a set of colour print materials. The latter included materials for introducing the survey and a complete set of labour and cash choice cards ($72 \times 2 = 144$) methodically arranged in folders.

[4] Since choice experiment surveys are a complex survey instrument, there is evidence of a learning process as the respondent progresses through the survey. Some studies have found that dropping the initial first or second choices will lead to a reduction in error variances. To account for the latter in this study, the first and the second choices in each survey were repeated at the end, giving eight choice questions per respondent. In the analysis, the first two choice responses were discarded, as they are captured in the last two responses in a choice set.

[5] Enumerators for Pihimbiyagollewa were taken to the cascade as part of the training.

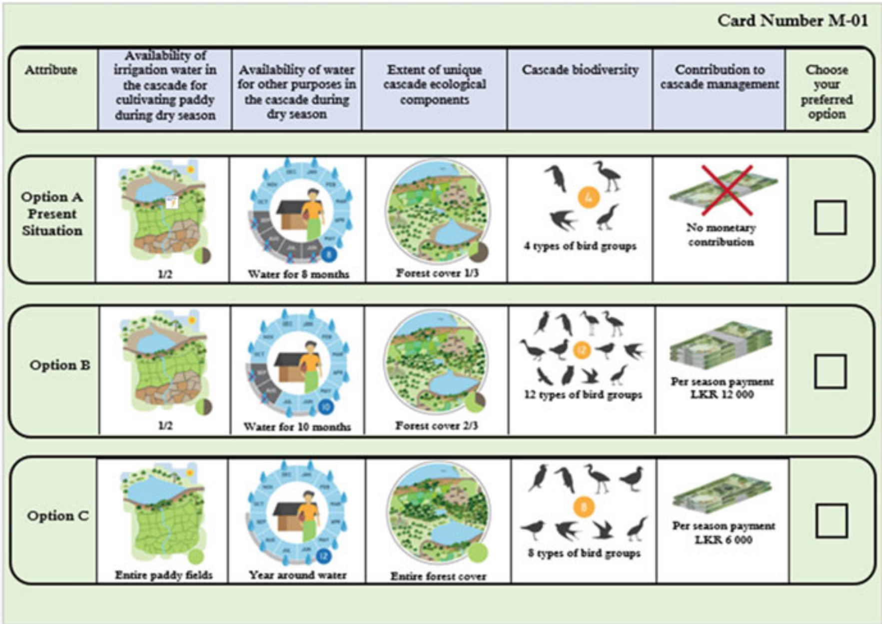


Fig. 13.2 Sample of a choice profile. Source: Vidanage (2019)

The main on-site survey was conducted among the community dependent on the Pihimbiyagollewa cascade. Ten final-year undergraduate students from the Faculty of Humanities, Rajarata University of Sri Lanka, worked as enumerators, supported by an experienced survey coordinator. The on-site sample was selected from residents close to the Pihimbiyagollewa cascade, covering six Grama Niladhari Divisions (GNDs) in two Divisional Secretariat Divisions (DSDs) of the Anuradhapura District. They were Pihimbiyagollewa, Wewelketiya, Thamara Halmillawewa, Balahondawewa, and Ihalakolongaswewa GNDs of Rambewa DSD and Palippothana GND of Kahatagasdigiliya DSD (Figs. 13.3 and 13.4). The on-site survey took place in August–September 2016.

The off-site sample was selected from Colombo District covering four GNDs in three DSDs. They were Kurunduwatta GND of Thimbirigasyaya DSD; Pagoda GND of Sri Jawardenapure DSD; and, Sri Subuthipura and Malabe South GNDs of Kaduwela DSD (Fig. 13.4). The off-site survey too was conducted by university students after the training. Five final-year undergraduate students of the Department of Economics, Faculty of Arts, University of Colombo, were used as enumerators (supported by an experienced survey coordinator).

A stratified random sample of 516 households was surveyed in Pihimbiyagollewa covering approximately 50 per cent of the cascade community. Stratification was done to capture variability in the upstream, mid-catchment, and downstream areas of the cascade. The off-site survey was planned originally as a random sample using the electoral list (i.e. names of voters who were resident in an area). However, this was

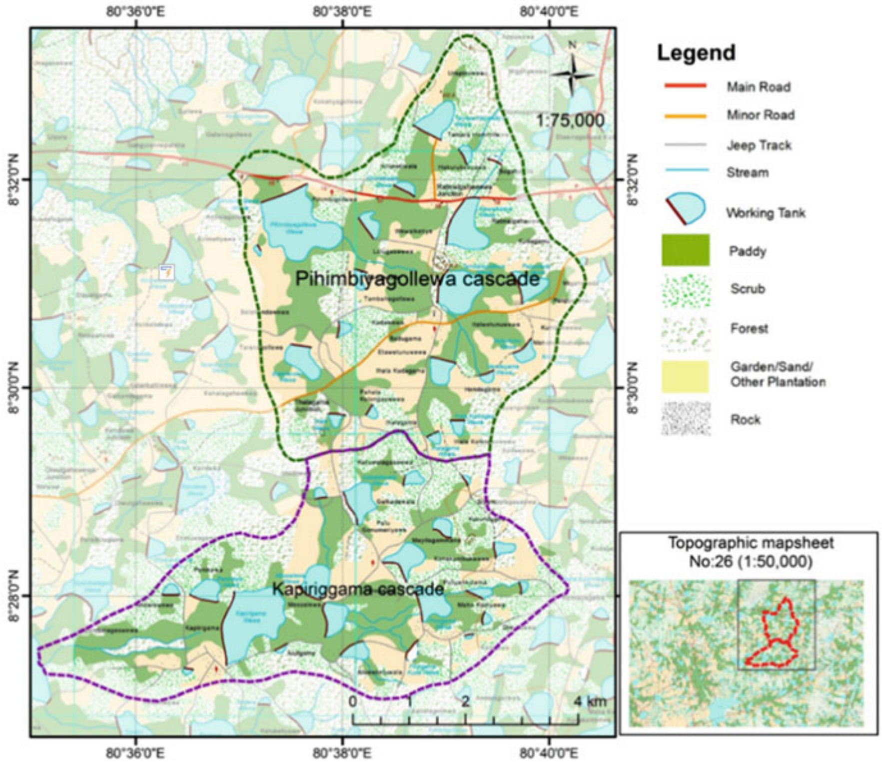


Fig. 13.3 Land use map of the study area. Source: Vidanage (2019)

found to be impractical: there were many instances where house numbers had changed and enumerators couldn't reach respondents because of locked gates. Therefore, the survey in Colombo was conducted by interviewing a predetermined number of respondents of a given lane in the selected GNDs, totalling 206 households.

Data from the choice experiment survey were analysed using logit regression models. The standard multinomial logit model (also referred to as the conditional logit model) was used initially, followed by the mixed multinomial logit (MMNL model, also called random parameter logit or RPL model) by relaxing some of the assumptions. A Stata 14 SE statistical package was used in the data analysis to estimate the willingness to pay of the stakeholders for different segments of the sample. The socio-demographic characteristics of the two samples are provided in Tables 13.4 and 13.5.

Table 13.6 gives the summary findings of the estimated results: the model estimates with attribute coefficient estimates, the level of significance, standard errors related to estimates, sample size, log-likelihood estimates, chi-square value, and the pseudo R2, where appropriate. The marginal willingness to pay estimates for

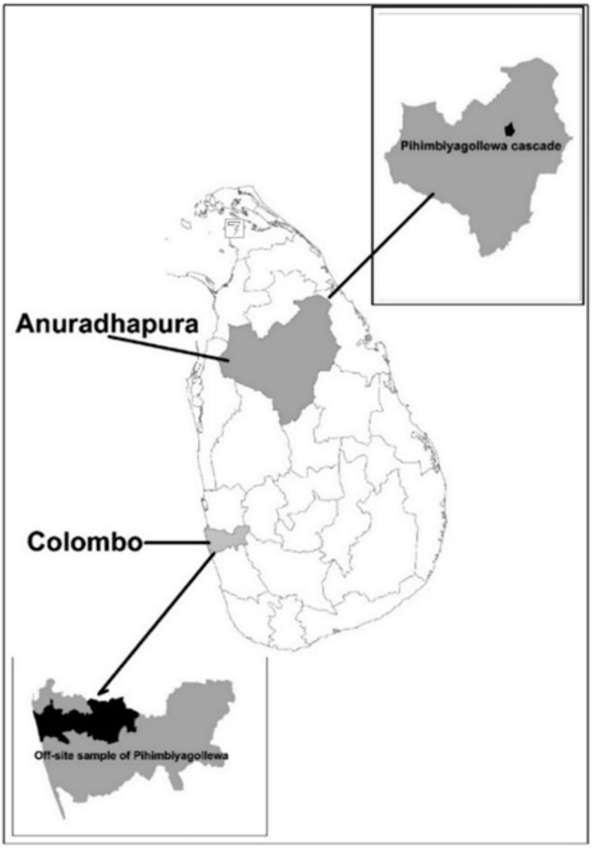


Fig. 13.4 On-site and off-site sampling sites. Source: Vidanage (2019)

attributes under each model are given in Table 13.7 for each sample. Conditional logit and random parameter logit model results for the on-site sample are given in Table 13.6.

In all models related to the on-site cash sample, the coefficients for paddy level and other-use-level attributes were positive and statistically significant at 1 per cent alpha level. The biodiversity attribute, which was presented in terms of bird groups, was statistically significant at 1 per cent alpha level. The cascade ecology attribute, which was presented in terms of the extent of the restoration, was statistically significant only in the conditional logit model but not in the mixed multinomial logit model.

All the cascade restoration and management-related attributes had positive coefficients, indicating that higher levels of any single attribute will increase the probability of the selected management scenario. In other words, respondents prefer those cascade restoration and management scenarios that resulted in higher levels of paddy cultivation, water availability for other uses, biodiversity as represented by bird groups, and cascade ecology. The payment coefficient was negative as expected, indicating that the effect on the utility of opting for a choice set with a

Table 13.4 Socio-demographic characteristics of the on-site cascade sample

Characteristic	Subdivision	Count	Percentage
Age (n = 501)	0–19	6	1.2
	20–34	85	16.9
	35–49	172	34.2
	50–64	178	35.4
	65–79	57	11.3
	80 and over	5	1.0
Gender (n = 501)	Male	206	41.1
	Female	295	58.9
Education (n = 499)	No formal education	17	3.4
	Primary education	112	22.4
	Secondary education	361	72.3
	Tertiary education	8	1.8
Income (n = 495)	Less than LKR 10,000	86	17.4
	LKR 10,000–20,000	123	24.9
	LKR 20,001–50,000	200	40.4
	LKR 50,001–100,000	75	15.2
	LKR 100,001–150,000)	9	1.8
	LKR 150,001–200,000	2	0.4
	More than LKR 200,000		

Source: Vidanage (2019)

higher payment level is negative. The positive sign and the statistical significance of the ASC coefficient imply that the utility is higher for the improved alternatives over the status quo.

The marginal willingness to pay or implicit prices for all selected attributes of cascade restoration and sustainable management in the on-site survey (Table 13.7) were calculated using the Wald procedure (delta method), dividing respective attribute coefficients by payment coefficient in all the models. In models where attributes were not statistically significant, respective marginal willingness to pay figures are shaded in Table 13.3. Results showed that the highest marginal willingness to pay per unit change in the attribute level was highest for paddy in the on-site cash sample, followed by other uses, biodiversity, and ecology. This order was consistent over the six combinations of the two models considered.

Table 13.8 shows the conditional logit and mixed multinomial logit model results for the off-site sample. In both models, the coefficients of all cascade restoration and management attributes were positive and statistically significant at either 1 per cent or 5 per cent alpha level. All cascade restoration and management-related attributes had positive coefficients, indicating that higher levels of any single attribute increased the probability of the selected management scenario. In other words, respondents preferred those cascade restorations and management scenarios that resulted in higher paddy cultivation, other uses, biodiversity, and ecosystem levels. The sign of the payment coefficient was negative as expected, indicating that the effect on the utility of opting for a choice set with a higher payment level is negative.

Table 13.5 Socio-demographic characteristics of the off-site sample

Characteristic	Subdivision	Count	Percentage
Age ($n = 202$)	0–19	1	0.5
	20–34	44	21.8
	35–49	56	27.7
	50–64	63	31.2
	65–79	32	15.8
	80 and over	6	3.0
Gender ($n = 202$)	Male	102	50.5
	Female	100	49.5
Education ($n = 202$)	No formal education	1	0.5
	Primary education	14	6.9
	Secondary education	91	45.1
	Tertiary education	96	47.5
Income ($n = 198$)	Less than LKR 10,000	2	1.0
	LKR 10,000–20,000	11	5.6
	LKR 20,001–50,000	79	39.9
	LKR 50,001–100,000	61	30.8
	LKR 100,001–150,000)	33	16.7
	LKR 150,001–200,000	3	1.5
	More than LKR 200,000	9	4.6

Source: Vidanage (2019)

The positive sign and the statistical significance on the ASC coefficient imply that the utility is higher for the improved alternatives over the status quo (Alternative A).

The marginal willingness to pay or implicit prices for all selected attributes of cascade restoration and sustainable management in the off-site survey (all individual cash surveys, see Table 13.9) were calculated using the Wald procedure (delta method), dividing the respective attribute coefficients by payment coefficient in all the models. Results showed that the highest marginal willingness to pay per unit change in the attribute level was for the other uses in the off-site cash sample, followed by paddy, biodiversity, and ecology. This order was consistent in both models considered for the off-site sample.

13.7 Results: Cost-Benefit Analysis

In conventional cost-benefit analysis, economic evaluation is performed based on goods that are commonly traded in competitive markets. An extended cost-benefit analysis expands the scope to include non-market benefits. Here, we conduct an extended cost-benefit analysis using the non-market benefits generated in the choice experiment to fully capture the benefits of restoration.

Costs were approximated from a recently completed cascade restoration project of a similar cascade, Kapiriggama (which shares a boundary with the

Table 13.6 Estimates of Pihimbiyagollewa on-site survey

	Conditional logit	Mixed multinomial logit
Mean		
ASC	1.342***	5.942***
	(7.66)	(4.05)
Water for paddy	2.754***	4.872***
	(10.90)	(8.60)
Water for other uses	0.279***	0.521***
	(8.13)	(6.86)
Cascade ecological components	0.270*	0.377
	(2.00)	(1.73)
Cascade biodiversity	0.0549***	0.0936***
	(4.69)	(4.61)
Contribution	−0.000104***	−0.000191***
	(−8.69)	(−6.71)
SD		
ASC		−4.556***
		(−5.26)
Water for paddy		−4.024***
		(−5.96)
Water for other uses		0.585***
		(5.68)
Cascade ecological components		−1.042**
		(−2.68)
Cascade biodiversity		−0.0966**
		(−2.68)
Contribution		−0.000240***
		(−6.24)
N	4284	4284
Log likelihood	−898.77	−825.14
Chi-square	1158.09	329.27
Pseudo R2	0.3691	–

Standard errors are in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Source: Vidanage (2019)

Pihimbiyagollewa cascade and is similar with regard to size, geography, economic livelihood, and other factors). Direct financial costs, labour contribution, and agency contribution provided by the Department of Agrarian Development for the restoration of the Kapiriggama cascade were used for the projected total costs of restoring the Pihimbiyagollewa cascade. These restoration costs were spread over a period of three-and-a-half years, as was the case with the Kapiriggama project. Based on consultations with the project manager of the Kapiriggama restoration project, it was determined that the cost of the restored project met only 70 per cent of the cost of doing a complete restoration. Hence, the costs used for Pihimbiyagollewa were

Table 13.7 MWTP of Pihimbiyagollewa on-site cash sample

MWTP in LKR/season/family		
Attribute	CLogit	MMNL
ASC	12,903	31,109
Water for paddy	26,480	25,507
Water for other uses	16,096	16,366
Cascade ecological components	2596	1973
Cascade biodiversity	6334	5880

Note 1: Parameter estimates of the attributes related to shaded MWTP figures were not significant at 10%

Note 2: The marginal willingness to pay figures estimated is per unit of defined attribute levels; for paddy and ecology, the defined units were full extent. For other uses and biodiversity units, the estimates were months and bird groups respectively. Therefore, the marginal values generated were per month and per bird group. They were adjusted to get full 6-month (seasonal) levels by multiplying these two MWTP figures by 6 and 12 respectively

Source: Vidanage (2019)

increased by a factor of 100/70 of the Kapiriggama cascade restoration costs to account for a complete restoration.

The annual operation and maintenance costs of the Pihimbiyagollewa cascade were assumed to be 5 per cent of the total restoration cost. The periodic maintenance costs to be incurred every five years were assumed as 20 per cent of the total restoration cost. The cost estimates used in the cost-benefit analysis are provided in Table 13.10.

It is assumed that the Pihimbiyagollewa cascade restoration will allow an additional 100 ha of land to be cultivated with paddy upon completion, three-and-a-half years from the start of the restoration. The benefits of this additional land will be realised slowly after the completion of the project, with 25 per cent, 50 per cent, and 75 per cent of the 100 ha becoming available in the fourth through sixth years. After the sixth year, 100 per cent of the additional land will be available. The average yield for the cascade is assumed at 4000 kg/ha and the price for paddy at LKR 40/kg.

In the conventional cost-benefit analysis, just the incremental paddy yield was taken as a benefit. As there is no clear spatial demarcation for some of the non-market benefits of the cascade, just the on-site sample estimates were used in the extended cost-benefit analysis. Benefits were taken from the findings of the choice experiment estimates for the on-site sample. As we are interested in the incremental benefits (applying the with and without scenario in project analysis), the value for ASC was not taken as a benefit, which gives the benefits of the cascade a status quo character.[6] An economic discount rate of 8 per cent was used in the analyses.

[6]However, the ASC was used previously in estimating the TEV of the cascade as it relates to the total benefits of the restored cascade.

Table 13.8 Estimates of the Pihimbiyagollewa off-site survey[a]

	Conditional logit	Mixed multinomial logit
Mean		
ASC	0.730***	4.075***
	(4.05)	(6.38)
Paddy_lvl	0.750**	2.215***
	(2.89)	(3.58)
Otheruse_lvl	0.368***	0.805***
	(9.61)	(7.55)
Ecology_lvl	0.623***	1.076**
	(4.34)	(3.24)
Biodiversity_lvl	0.101***	0.200***
	(7.83)	(5.96)
Contribute_lvl	−0.0000978***	−0.000269***
	(−7.74)	(−5.91)
SD		
ASC		2.113***
		(4.62)
Water for paddy		3.742***
		(4.17)
Water for other uses		−0.677***
		(−5.38)
Cascade ecological components		2.325***
		(4.25)
Cascade biodiversity		0.243***
		(5.17)
Contribute_lvl		0.000542***
		(7.48)
N	3546	3546
Log likelihood	−914.29	−710.31
Chi-square	768.52	407.96
Pseudo R^2	0.2959	–

[a] In off-site survey, all surveys were conducted as individual cash surveys
Standard errors are in parentheses $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$
Source: Vidanage (2019)

Table 13.9 Marginal willingness to pay (MWTP) in Pihimbiyagollewa off-site sample

	MWTP in Rs/season/household	
Attributes	Clogit	MMNL
ASC	7464	15,148
Water for paddy	7668	8234
Water for other uses	22,576	17,955
Cascade ecological components	6370	4000
Cascade biodiversity	12,392	8921

Source: Vidanage (2019)

Table 13.10 Cost estimates for Pihimbiyagollewa cascade restoration

Kapiriggama costing summary in LKR	Year 1	Year 2	Year 3	Year 4	Total
Annual total cash	11,721,881	22,344,282	35,553,062	5,384,937	75,004,161
Labour contribution	774,208	1,548,416	2,064,555	774,208	5,161,387
DAD contribution	1,172,188	2,234,428	3,555,306	538,494	7,500,416
Total cost (70% restoration)	13,668,277	26,127,126	41,172,922	6,697,639	87,665,964
Full restoration cost	19,526,109	37,324,466	58,818,461	9,568,055	125,237,091
O&M annual (5% of the full cost)		6,261,855			
Periodic maintenance every 5 year (20% of the full cost)				25,047,418	

Source: Vidanage (2019)

Table 13.11 Estimates of the conventional cost-benefit analysis of cascade restoration

Benefit-cost ratio	0.60
Net present value (NPV) in LKR	(56,618,945)
Internal rate of return (IRR)	−2.01%

Source: Vidanage (2019)

The conventional and extended cost-benefit analyses estimates for the restoration and sustainable management of the Pihimbiyagollewa cascade are given in Tables 13.11 and 13.12.

13.8 Discussion of the Results and Economic Value of STCS Restoration

13.8.1 Discussion of Choice Experiment Results

The marginal willingness to pay, or the implicit prices, for all selected attributes of the restoration and sustainable management of the Pihimbiyagollewa cascade in the on-site and off-site surveys are given in Table 13.13 below.

The highest marginal willingness to pay per change in the attribute level differed in the on-site and off-site samples. LKR 25,507 per season per family was the highest marginal willingness to pay in the on-site sample estimated for cultivating paddy across the full extent of the cascade, followed by LKR 16,366 per season per family for having water for other uses covering all 6 months and LKR 5880 per season per family for biodiversity represented by having all 12 groups of birds. The marginal willingness to pay for ecology was statistically insignificant for the on-site sample, meaning that the on-site respondents did not place significant value upon the ecological aspects of cascades.

In contrast, respondents in the off-site sample placed the attribute other uses of cascades as the highest marginal willingness to pay with an estimated value of LKR 17,995 per family per season, followed by biodiversity with LKR 8921 per season

Table 13.12 Estimates of the EBCA for STCS restoration

Sensitivity analysis for the Pihimbiyagollewa cascade EBCA (values in LKR)

	Base case			Costs increased by 40%			Benefits decreased by 40%			Costs increased by 40% & benefits decrease 40%		
	BC ratio	IRR	NPV	BC ratio	IRR	NPV	BC ratio	IRR	NPV	BC ratio	IRR	NPV
Paddy benefits	2.24	24%	204,920,854	1.60	15%	139,044,834	1.35	11%	57,076,493	0.96	3%	(8,799,527)
Non-irrigation benefits of water	1.44	13%	72,462,577	1.03	5%	6,586,558	0.86	1%	(22,398,473)	0.62	−10%	(88,274,493)
Total restoration benefits	3.43	41%	400,802,244	2.45	30%	334,926,225	2.06	25%	174,605,327	1.47	17%	108,729,307

Source: Vidanage (2019)

Table 13.13 Marginal willingness to pay for on-site cash and off-site cash samples in mixed multinomial logit models

Attribute	On-site Cash	Off-site Cash
	In LKR/season/household	
ASC	31,109	15,148
Water for Paddy	25,507	8234
Water for other uses	16,366	17,955
Cascade ecological components	1973	4000
Cascade biodiversity	5880	8921

Source: Vidanage (2019)

per family, paddy with LKR 8234 per season per family, and ecology with LKR 4000 per season per family. The order and absolute values of marginal willingness to pay for cascade-related attributes differ between the two samples. The marginal willingness to pay in the on-site sample was highest for paddy, followed by other uses, then biodiversity, with ecology being insignificant. The off-site sample placed the highest marginal willingness to pay on other uses, followed by biodiversity, paddy, and ecology.

The total willingness to pay for the restoration of the Pihimbiyagollewa cascade by the on-site community is estimated at LKR 78,865 per season per household. The total willingness to pay among the off-site sample was estimated at LKR 54,260 per season per household.

All statistically significant marginal willingness to pay values for attributes and marginal willingness to pay for ASC were aggregated to arrive at the total willingness to pay the values mentioned above. Aggregate willingness to pay for restoration and sustainable management was calculated based on the sampled populations, as given in Table 13.14.

The individual family willingness to pay estimates were used to derive willingness to pay values for the GNDs covered by the survey by multiplying the individual marginal willingness to pay by the total number of families in the sampled GNDs. These estimates provided total willingness to pay by the population of the sample site per season (see Table 13.15).

As there is no clear demarcation for the boundary of the off-site benefits of STCS due to its being common property, the off-site values were not considered in the economic evaluation (cost-benefit analysis). However, it is clear that off-site communities enjoy some benefits of STCS and are willing to pay for restoration and sustainable management. These values may extend even to a global scale, owing to the unique features of STCS. Due to the unclear boundaries of such values and difficulty in apportioning such values by the off-site community to a particular cascade among the population of STCS, off-site values were not used in the cost-benefit analyses.

Table 13.14 Population data related to on-site and off-site samples

Divisional Secretariat	Grama Niladhari Division (GND)	GND no	Total population	Number of families
Rambewa	*Pihimbiyagollewa*	81	1049	
Rambewa	*Wewelkatiya*	82	1032	
Rambewa	*Thamarahalmillewa*	83	520	
Rambewa	*Balahondawewa*	86	699	
Rambewa	*Ihalakolongaswewa*	87	554	
Kahatagasdigiliya	*Palippothana*	224	592	
On-site sample totals			**4446**	**998**
Sri Jayawerdenapura Kotte	*Pagoda*	519 A	5407	
Thimbirigasyaya	*Kurunduwatta*		9873	
Kaduwela	*Sri Subhoothipura*	492	2558	
Kaduwela	*Malabe north*	476B	7689	
Off-site sample totals			**25,527**	**5110**

Source: Department of Census and Statistics (2015)

Table 13.15 Total WTP

Description	On-site amount in LKR	Off-site amount in LKR
Willingness to pay by individual household/ season	78,865	54,260
Willingness to pay for total sample	78,707,190	7,269,724

Source: Vidanage (2019)

13.8.2 Economic Evaluation of STCS Restoration and Cost-Benefit Estimations

The conventional cost-benefit analysis demonstrated that the incremental benefit of paddy alone is not sufficient to justify investing in cascade restoration. This supports the common belief about cascade restoration feasibility. As indicated earlier, the benefit-cost ratio is 0.60 (less than one), NPV (65,618,455) (less than zero), and internal rate of return is −3.10 per cent (less than the market interest rate).

The extended cost-benefit analysis was performed with the cascade-wide benefits assessed using choice experiments. The results indicate the cascade restoration is economically feasible when non-market benefits are taken into account. The incremental benefits from cultivating paddy in a restored cascade (assessed using the choice experiment) appear to be higher than the benefits calculated using incremental-production-related benefits in the conventional cost-benefit analysis. However, in sensitivity analysis, paddy-only benefits failed to justify restoration investment when a cross-sensitivity option is used (cost of restoration increased by 40 per cent with benefits decreased by 40 per cent). Looking at realities in dry zone agriculture, such cost overruns and forgone benefits are very common. Hence, we can assume that paddy alone is not sufficient to justify cascade restoration, taking into account the vulnerabilities of small tank systems in the dry zone. However, the extended benefits of irrigated agriculture, i.e. non-irrigation benefits arising from other uses of water in cascades and benefits associated with biodiversity, clearly justify cascade-level restoration as a feasible investment option, even after taking account of vulnerabilities in STCS-based farming in the dry zone. The base case benefit-cost ratio was 2.24; the net present value was LKR 204,920,854, with an internal rate of return of 24 per cent. Cross-sensitivity analysis of 40 per cent cost overrun and 40 per cent unrealised benefits over the project period gave a benefit-cost ratio of 1.47; a net present value of LKR 108,729,307; and an internal rate of return of 17%.

13.9 Summary, Overall Recommendations, and Conclusions

This case study assessed the total economic value of a representative small tank cascade system in Anuradhapura District within the Malwathu Oya river basin. The rationale for the research was to find an economic solution to the degradation of small tank cascade systems in Sri Lanka. Despite their multiple benefits to the local community, sustained over millennia, these time-tested traditional irrigation systems are fast degrading. The major reasons for accelerated degradation were lack of local management and insufficient investment for restoration and maintenance. Such investments are justified when the market-based returns (benefits) exceed the associated investment.

This study valued the market (largely irrigation water) and non-market (largely) ecological services of the Pihimbiyagollewa cascade system. The work contributes to literature within the discipline by applying a state-of-the-art non-market valuation technique to a small tank cascade system.

The study concluded that both cascade-dependent people and those away from the cascade with no direct benefits demonstrate a positive willingness to pay for the restoration and sustainable management of the cascade as a whole. The total estimated value is the benefits of restoring the Pihimbiyagollewa STCS. The research methodology helped estimate the welfare changes to society generated by the restoration and sustainable management of STCS using heterogeneous respondents from two distinctly different samples. Further, the cost-benefit analysis proved that the economic evaluation of investments in the restoration and sustainable utilisation of STCS could be justified in light of the total estimated value of a cascade, as opposed to the direct values of individual irrigation tanks.

People in the environs of and dependent on the cascade showed a higher willingness to pay, compared to the off-site sample (LKR 78,865 per season per family vs. LKR 54,260 per season per family). Estimates for the marginal improvements of the different attribute levels of the cascade demonstrated the differences in the preferences of the two sampled communities. The on-site sample that depends on the cascade for their day-to-day sustenance placed the highest value on cascade water for paddy, followed by cascade water for other uses, and cascade biodiversity (respectively LKR 25,507, LKR 16,366, and LKR 5880 per season per family). It is interesting to note that the cascade-dependent community did not consider the level of the cascade ecosystem important in their assessments. This may be due to the practice among farmers of encroaching upon ecological resources for cultivation.

The off-site community that did not receive direct benefits from the cascade placed cascade water for other uses as the top priority, identifying cascade biodiversity, cascade water for paddy, and cascade ecology as decreasing priorities for their willingness to pay for marginal change (values were LKR 17,995, LKR 8921, LKR 8234, and LKR 4000 per family per season, respectively). It is noted that they considered all four attributes in their valuation, including the cascade ecology.

The findings suggest that both cascade-dependent and other communities are willing to pay for cascade-level restoration and sustainable management of small tanks; the extended benefit-cost analysis performed based on the on-site benefits suggests that such cascade restoration is economically feasible.

Assuming that one of the objectives of STCS management is to maximise the social value of these systems to people, improved knowledge of the marginal benefits of extending or reducing some attribute levels could result in a more efficient solution. The full economic implications of managing STCS in alternative ways will then be considered.

13.9.1 Policy Recommendations

The research findings suggest that the cascade-dependent and off-site communities have a high willingness to pay for the restoration and sustainable management of the STCS under study. This proves that a careful design and administration of choice experiment applications can provide robust findings for policy guidance. The following policy recommendations are proposed to reconsider the current practice of managing small tanks in isolation instead of considering them as components of a cascade system in the planning and management process for the sustenance of the services they provide.

1. **Consider the cascade as a functional unit for planning**. The cascade system should be seen as a functional socio-ecological system, as well as the unit of planning/intervention, in recognition of the interconnected nature of the tanks and other ecological components within it.
2. **Establish a cascade-level governance mechanism for small reservoir clusters**. Currently, there is no system of governance at the cluster or cascade level. To reap the maximum benefits of these multifunctional time-tested systems, a cascade-level governance mechanism needs to be formulated and legally established for cascades to be taken as the unit of planning and management. The structure of the governance system needs to be determined in consultation with the Department of

Agrarian Development, farmers' organisations, cascade-level stakeholders, and experts, taking all 1,100 cascades into account.

3. **Raise awareness about the cascades and engage all stakeholders in the sustainable use** of these systems in addressing problems, including adaptation to climate change impacts.
4. **Explore the wider co-benefits of STCS**. Investigate further and manage their other benefits, such as carbon fixation, enhancement of biodiversity, and positive contribution to the micro-environment.
5. **Integrate these recommendations into practice**. The policy guidelines above should be issued by the Department of Agrarian Development in order to ensure that cascades are used as the unit for planning in the development of the national small tank restoration programme.

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14 Analysing Agriculture Extension Programmes Using Randomised Control Experiments

Wasantha Athukorala

Abstract

Agricultural extension or advisory service is a method of providing scientific knowledge to farmers through farmer education. It aims at improving farm-level output while developing the management skills of the farmers. Although the literature has extensively discussed the impact evaluation of agricultural extension, there is still confusion whether correct methodologies or techniques are used to evaluate the outcomes properly. This chapter explains how the impact of a particular agricultural extension service is evaluated using the randomised control trial (RCT). The chapter outlines the basic methodology for designing impact evaluations for agricultural projects directly targeting farmers while demonstrating two empirical examples in Sri Lanka. This will help the readers to understand how the impact of agricultural extension services could be evaluated in a particular agricultural area. It also widens the knowledge of applying RCTs to evaluate any other agricultural policy or programme that is crucial to improving or redesigning an intervention in order to increase agricultural production, productivity, and profitability. Moreover, it is expected that this chapter will further motivate the use of impact evaluations to measure results in agricultural projects in various settings in other developing as well as developed countries.

Keywords

Agricultural policy · Extension service · Impact evaluation · Randomised control trial · Sri Lanka

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14.1 Introduction

Agricultural extension services in many developing countries,[1] including Sri Lanka, are mainly provided as a government service, although a few private and not-for-profit organisations that operate may cater to specific farmer groups. Joshi and Babu (2019) found that Sri Lanka, India, Bangladesh, and Nepal encounter declining growth in the agriculture sector despite continuous investment in extension services. They characterised the systems existing in those countries as 'supply-driven' and incapable of reaching each and every farmer, among other structural and institutional challenges. Thus, Joshi and Babu (2019) identified new approaches to promote innovation among stakeholders as a key requirement in achieving agriculture sector growth.

Despite numerous ministries, departments, and institutions dedicated to furthering agriculture, over the last few decades Sri Lanka has faced unprecedented challenges, such as stagnating productivity, diminishing farmer incomes, and increasing costs of production. Inappropriate policies and ineffective delivery of services to farmers play a major role in exacerbating these issues. For example, at present, there is no formalised procedure to evaluate the effectiveness of extension services in meeting farmers' needs and assess the return on investment of such services through impacts on productivity.

Although the economic literature has extensive discussions on agricultural development via various extension policies and programmes, there is still debate on the appropriate methodologies or techniques for properly evaluating the outcomes. This reveals gaps between the theoretical and empirical literature, particularly on the practical issue of utilising correct economic instruments. This chapter provides an overview of how the effects of agricultural extension services might be evaluated in a particular agricultural area.

14.2 The Context

14.2.1 Intention of Policy and Global Context

Agricultural extension or advisory service is a method of providing scientific knowledge to farmers through farmer education (Cole and Fernando 2012). The intention is to improve farm-level output while developing farmers' management skills. For example, the dissemination of practical information on items, such as improved varieties, water management techniques, crop protection methods, and input usage, will help farmers to make better decisions to increase farm productivity. In most developing countries, farmers make management and technology-use

[1] The public sector delivers the vast majority of agricultural extension services in, for instance, India (Nandi and Nedumaran 2019), Bangladesh (Afrad et al. 2019), and Nigeria (Chibuzo and Chikerenma 2015; Hamisu et al. 2017).

decisions based on available information, including customary practices and own experience. In effect, farmers adopt the method(s) they are aware of: this is one of the major constraints to modernising the sector (Athukorala 2016). Equipping farmers with knowledge through effective communication channels is a means to driving the adoption of appropriate practices and new technologies.

Theoretically, there are several methods of implementing agricultural extension in the world, including the individual approach, the group approach (meetings, field days, demonstrations, and support to groups), the school approach, and mass extension methods (Winters et al. 2010),[2] all with specific advantages and disadvantages. In developing countries, the choice of method basically depends on related government policies, institutional structures, and resources available for extension. Extension services in Sri Lanka are implemented mainly via individual and group approaches. Group methods enable the extension officers to reach a larger number of farmers and discuss the common issues they confront. The individual approach can be relatively effective as extension officers can meet farmers casually at the latter's convenience, discuss issues of interest, and provide both advice and information. From the farmer's side, the individual approach can motivate farmers to participate in extension activities: in this case, a farmer is often likely to listen to the extension officers' advice and benefit from the individual focus. Individual meetings also help in building invaluable confidence between the extension officer and the farmer. According to the literature, individual methods are the most commonly used extension methods in both developed and developing countries (De Soyza 2014). However, evidence shows that a combination of extension methods is more effective than just one method (Rajalahti et al. 2005).

The frontline extension workers in Sri Lanka are the agricultural instructors and technical assistants. These officers have certain primary skills in the field and are expected to communicate with farmers on the basis of equality and mutual respect. They interact with traditional rural households to provide advice on new technologies, farm input use, credit, marketing, and farm management (World Bank 2007). Furthermore, they have a role in production planning. At the beginning of each year/crop season, with the help of other stakeholders, the officers prepare a clear agricultural plan for the area that they use to analyse the performance of the assigned area while identifying constraints at the end of the year/season. However, lack of coordination, other commitments, and absence of a proper supervision mechanism have resulted in minimising the level of the agricultural extension officers' involvement in such tasks.

There is an urgent need for increased productivity and farm incomes in the agriculture sector in Sri Lanka. Achieving this will require policy reforms that transform traditional subsistence, semi-subsistence, and small-farm agriculture into a more market-oriented one. *Effective extension programmes have a pivotal role to play in this regard* by providing farmers the necessary training, knowledge, and

[2]Mass extension methods involve the use of the mass media, e.g. radio, posters, drama, television, newspapers, films, slide shows, etc., to create public awareness.

skills, contributing towards lower input subsidies and increased competitiveness of the sector.

14.2.2 Policy Milestones in Sri Lanka

The agricultural extension service system started with the establishment of an agricultural extension arm in 1920 under the Department of Agriculture (DOA) (Wanigasundera and Atapattu 2019). At the beginning of its functioning, an agricultural officer, supported by 37 agricultural instructors (AI), delivered services covering the entire country with extension programmes implemented under revenue officers at the divisional level. In 1957, 24 district agricultural extension officers[3] were appointed covering 24 administrative districts. Subsequently, agricultural extension officers were recruited to execute extension programmes at the village level. Then in 1963, a separate division for extension services was set up in the DOA under the supervision of a deputy director (extension). The introduction of the training-and-visit system in 1979, under the World Bank funded Adaptive Research and Agricultural Extension Project, was a turning point for agricultural extension reforms.

In keeping with the liberal economic policies introduced in 1977, the government prepared a national agriculture, food, and nutrition strategy in 1984, which mainly focused on agricultural policy reforms, including an expanded role for extension services in the country (Henegedara 2002). Under the 13th Amendment to the Constitution in 1989, agricultural extension was listed as a responsibility of the Provincial Councils and delivering the extension services was assigned to both the DOA and Provincial Councils.

After 1988, the role of the agrarian service centres (ASCs) established in 1971 was limited to training and extension. With the revised National Agricultural and Policy Framework (NAPF) introduced in 1995, a more integrated participatory approach was introduced to solve farmers' problems in association with officers, traders, and financial institutions. The National Agriculture Policy (2007) and Sri Lanka National Agriculture Policy (2017) also attempted to reorganise and strengthen the existing extension system to disseminate innovation and information to the farming community.

At present, the country has agricultural extension systems at national and provincial levels. National extension services are governed by the Ministry of Agriculture.[4] Moreover, several cabinet and non-cabinet ministries are involved in some form of agricultural extension at the national level, while Provincial Councils also run

[3]They were termed Krushi Viapthi Sevaka (KVS).

[4]Hierarchy and accountability in extension flows downwards from the Secretary, Director General, Deputy Director, District Agricultural Extension Officers, to Agricultural Instructors, and Technical Assistants. Extension services implemented at the provincial level have their own hierarchy and accountability systems.

extension services within their regions. However, there is no proper coordination among the various ministries, departments, and institutions. This fragmented approach has made it very difficult to achieve the objectives of the extension system effectively,[5] and the service is not available to all farmers due to issues in connectivity.[6]

14.3 Impact Evaluation in Agriculture

An impact evaluation provides information about the (negative or positive) consequences that can be attributed to a particular intervention (Nichol et al. 2010). Impact evaluations can inform decisions on whether to continue a particular policy intervention, provide information to improve or redesign an intervention, or identify necessary support in the enabling environment of an existing policy/ programme. Post-evaluation of programmes is increasingly viewed as critical for learning and improving the accountability of public policies (Peduzzi et al. 2002; Ferraro and Pattanayak 2006; Pattanayak 2009; Nichol et al. 2010). Unfortunately, there is often little attention paid to the need for such evaluations, as well as a lack of expertise concerning the sound and rigorous empirical methods required for the task (Dhehibi et al. 2018).

Various methods in economics – experimental, quasi-experimental, and non-experimental – are used to identify the impacts of a particular agricultural policy. In experimental design methods, a counterfactual generated by random selection is taken from an alternate control group. A quasi-experiment is an empirical interventional study used to estimate the causal impact of an intervention on a target population without random assignment. In quasi-experimental design methods, a comparison group is not randomised (Pattanayak 2009). The most commonly used experimental design method in the literature is randomised control trials (RCTs),[7] where investigators study two or more interventions in a series of individuals who receive them in random order. Common quasi-experimental design methods include difference-in-differences, matched comparisons, regression discontinuity, and interrupted time series. The main component of a true experiment is randomly assigned groups, and a quasi-experiment does not have randomly assigned groups.

The net impact or effectiveness of an agricultural intervention (policy or programme) can be assessed through impact evaluation methods using different

[5]The Council for Agricultural Research Policy (CARP) was established in 1987 to handle agricultural research and extension simultaneously with coordinating different departments/institutions in the country. However, CARP has principally engaged with research and without progress towards extension.

[6]Currently, more than 2500 grassroots agricultural extension workers are employed to maintain close contact with farming households; nevertheless, there is no proper mechanism to evaluate their services (Athukorala et al. 2017).

[7]RCT design can be randomised offering of intervention, randomised promotion of intervention, or multiple treatment design.

direct indicators, such as yields, income, productivity, profitability, and input use. In addition, intangible impacts can be identified through indirect indicators, like changes in farmer knowledge, diversification of farm activities, improvements in rural infrastructure, reduction of risks, and access to credit and insurance. However, most studies concentrate on the more easily identifiable indicators of impact. Although the interest in conducting impact evaluations of agricultural projects has increased, economists have increasingly emphasised the use of randomised trials to determine the effectiveness of projects and programmes (Dhehibi et al. 2018; Behaghel et al. 2019). Therefore, rather than identifying all the available methods of impact evaluations in agriculture, this chapter focuses on RCTs.

In evaluating the impacts of a programme or policy intervention, it is necessary to quantify the impact on the outcome of interest. One of the fundamental issues here is the inability to compare the outcomes with and without the programme for the same individual (Banerjee et al. 2015). This is because it is not possible for a particular individual to be both in and out of the programme at the same time. Consequently, an impact evaluation must determine what would have happened in the absence of the programme – which is known as the counterfactual (Pattanayak 2009; White 2013).[8] Since the counterfactual is naturally unobservable, programme evaluation literature focuses on methods to construct the missing counterfactuals using statistical methods (Behaghel et al. 2019).

Following the pioneering work of Peirce and Jastrow (1885) and Doll and Hill (1952) in psychology and medicine, RCTs have become increasingly popular among many researchers (Peto et al. 1977; Senn 1989). Applications of RCT mostly concentrated on health issues until the early twenty-first century when this methodology began to be widely applied to other fields, such as education, sanitation, environment, microfinance, and agriculture (Kleiman et al. 2000; Toroyan et al. 2000; Pullin and Knight 2001; Sutherland et al. 2004; Miguel and Kremer 2004; Hutton et al. 2007; Cohen and Dupas 2010; Hamad et al. 2011; Banerjee et al. 2015; Dhehibi et al. 2018; Behaghel et al. 2019).

14.3.1 Basic Steps in Conducting an RCT

Since the late 1980s, there has been an increasing shift towards evidence-based practice in agriculture to understand ground realities (Behaghel et al. 2019). A significant element of the evidence-based concept involves research that has sought to identify and provide robust evidence of 'what works' in relation to agricultural programmes and interventions. RCT is a trial in which subjects are randomly assigned (see Box 14.1:) to one of two groups: one (the experimental group) receiving the intervention that is being tested and the other (the comparison group or control) receiving an alternative (conventional) treatment (Gertler et al. 2011).

[8] The counterfactual is necessary for comparing actual outputs and outcomes to what they would have been in the absence of the intervention, i.e. with versus without.

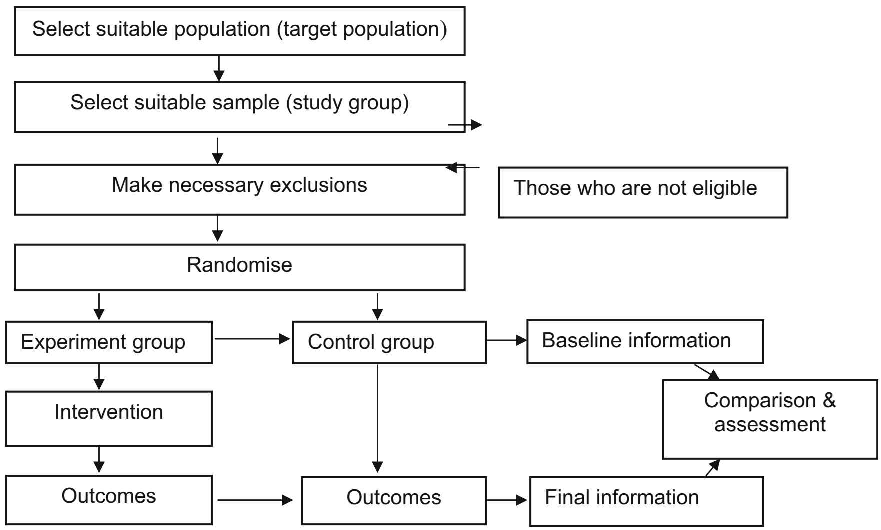

Fig. 14.1 Schematic diagram for the design of randomised controlled trials

The two groups are then followed to see if there are any differences in outcome. The results of the trial are used to assess the effectiveness of the intervention, in terms of the extent to which treatment has produced extra outcome or whether a cause-effect relation exists between the intervention and the outcome (Toroyan et al. 2000). The basic RCT design for the parallel group is illustrated in Fig. 14.1.

Box 14.1 Randomisation Schedule

Randomisation requires generating randomisation schedules. This usually involves obtaining and assigning random numbers to each subject. Random numbers can be generated by computers or can come from random number tables. There are different methods of implementing randomisation procedures in practice (Dettori 2014; Kim and Shin 2014). Four commonly used methods are explained below.

1. *Simple Randomisation*

Simple randomisation is based on a single sequence of random assignments (Suresh 2011). Treatment assignment is made by chance without regard to prior allocation. For example, for each eligible object, the investigator can flip a coin (heads – control, tails – treatment) or use a deck of cards or throw a die (below and equal to 3 – control, above 3 – treatment) to determine whether the object goes into the intervention or control group. This can also be

(continued)

Box 14.1 (continued)
achieved by means of a table of random digits or randomisation software, like SAS, SPSS, and Ngene. The Excel spreadsheet software can be used too. For example, suppose ten individuals (A to J) need to be allocated to group 1 or group 2 using the random number generator in Excel:

ID	Random numbers	Excel command
A	1	=randbetween(1,2) More than two groups can be accommodated. For example, 3 groups: =randbetween(1,3) 4 groups: =randbetween(1,4)
B	2	
C	1	
D	1	
E	2	
F	1	
G	2	
H	2	
I	1	
J	1	

However, this procedure can result in a different number of subjects in each group, which is more likely to happen with a small sample.

2. *Matched Pair Randomisation*

In this case, individuals or objects are grouped into pairs based on similar observable characteristics. Then one unit in each pair is randomly assigned to the treatment group and the other to the control group. This initial matching helps to ensure balance and reduces the required sample size.

3. *Block Randomisation*

Objects are randomised in blocks so that equal numbers are assigned to each group. This method is designed to randomise subjects into groups that result in equal sample sizes to ensure a balance in sample size across groups. The block size is determined by the researcher and should always be a multiple of the number of groups. After block size has been determined, all possible balanced combinations (permutation) of assignment within the block need to be calculated (Suresh 2011). Blocks are then randomly chosen to determine assignment into different groups. The main issue with fixed blocks under block randomisation is that the researcher may be able to predict the group assignment of the next object.

(continued)

Box 14.1 (continued)
4. *Stratified Randomisation*

This refers to the situation in which strata are constructed based on the key variables, and a randomisation scheme is performed separately within each stratum. Very important confounding variables (those, other than the one studied, that course or prevent the outcomes of the interest) can often be used to identify the strata (Dettori 2014; Behaghel et al. 2019). This is more convenient when the number of samples is smaller and the variables can be stratified and the two groups were assigned equally. The main purpose of stratified randomisation is to ensure a balance between the treatment groups with respect to the various combinations of the confounding variables. Any confounding variables should be equally distributed in the two groups to make balanced groups. When two or more groups are compared in a study, there are often systematic differences between the groups. As a result, the outcome of the groups may be different because of these differences rather than due to the actual intervention (due to compounding effects).

In practice, the researcher can use simple randomisation with/without stratification or block randomisation with/without stratification.

This chapter is intended not to be an exhaustive guide on conducting research but, rather, to be an introduction to the major concepts and approaches involved in designing and conducting an RCT. Readers are expected to consider additional information to understand how to conduct research in general and are encouraged to consult with researchers experienced in this area. The basic steps of conducting RCT are explained below.

Step 1: Identify a specific researchable policy or programme that requires evaluation to assess the impacts.

Generally, it is not feasible to conduct impact evaluations for all interventions in a programme. An RCT may be used to evaluate the impact of a policy/programme if the inputs and possible output variables can be defined (Behaghel et al. 2019). Furthermore, the researcher should be able to clearly identify the causal (or result) chain from inputs to outcomes, as well as alternative causal paths, and the major external factors influencing the outcomes of the intervention. At the outset, the background and the rationale for conducting the study should be defined with a thorough literature review and clearly defined objective(s). The main purpose of the impact evaluation should be to build strong evidence for providing guidance for policymakers. Therefore, details of the individual variables pertinent to the study, before and after interventions, at specified intervals, need to be clearly identified according to the study goals.

Step 2: Identify the target population and sample with the exclusion and inclusion criteria.

The target or reference population, which will supply the subjects[9] and to which the results of the trial will be applicable, needs to be decided for generalising the results (Pattanayak 2009; Nichol et al. 2010). Next, the sample or experimental group needs to be identified: representatives of the reference population and the actual group of participants who will be involved in the trial.

At this stage, it is necessary to decide where the study will be conducted, who will be randomised, who will be given the intervention, and the key performance measures (Hamad et al. 2011; Banerjee et al. 2015). This is one of the crucial steps as most of the errors in selection will arise at this point and may affect the external validity of the study. In general, RCTs can only be used when the sample size is large enough to detect the effects of the programme with sufficient precision (Dhehibi et al. 2018). Sample size needs to be decided based on statistical power,[10] which is the probability of correctly concluding that an effective programme is working.

Making necessary exclusions and identifying the sample or the study group accurately are essential in any RCT study. Reliable and valid measures for inclusion and exclusion need to be used so that the study sample represents the population of interest (Van Spall et al. 2007). Inclusion and exclusion criteria for selecting a study group should be carefully determined, balancing generalisability and minimisation of bias.[11]

Step 3: Identify the time frame for conducting the RCT.

The time frame for the study should be identified at the design stage of the RCT, taking into account the starting points, intervention points, and end points of the project/programme. (These stages need to be determined before or at the start of programme implementation.) For example, if the RCT is involved in primary data collection, information such as when the project started, when the intervention occurred, and when the final survey is done is required at the beginning. In order to observe the impact of an intervention, a sufficient time period needs to be factored into the time frame.

[9] Instead of randomising individuals, randomisation can be done at cluster levels, such as villages, or schools, or health clinics. Such experiments are known as cluster randomised control trials.

[10] Statistical power refers to the probability of detecting an impact of a programme.

[11] At this stage, the researcher needs to obtain the informed consent of those recruited for the trial, after explaining the purpose, methodology, risks, and benefits. Only those participants willing to remain engaged throughout the study period should be selected.

Step 4: Perform randomisation.

Randomisation is the allocation of objects to study groups by chance. The main purpose of randomisation is to balance known and unknown confounding factors between intervention and control groups, to minimise their impact on the relationship between the intervention and the outcomes observed. Randomisation can be done in various ways. Box 14.1: describes three popular methods.

Typically, randomisation ensures that each eligible participant has an equal chance to be allocated to the intervention or other group. The simplest way of achieving this is by a parallel-group design,[12] where each group of participants is exposed to only one of the study groups by a random chance. Additionally, randomisation should be done to select an equal number of participants in each group for generating adequate statistical power and to avoid selection bias.

Step 5: Conduct a baseline survey.

Once the random assignment of participants is completed, researchers usually carry out a baseline survey to gather data, which will serve as the basis for comparison with the end results. This type of data can also be used to assess the equivalence of baseline characteristics between the treatment and control groups.

At this stage, including information to allow the tracing of the respondents for later rounds of the survey is crucial. The comparison of the treatment and control groups using baseline information is called balance checking and helps to ascertain whether the mean of the treatment group and the mean of the control group are similar for different observable variables (Banerjee et al. 2015). It helps to confirm that randomisation is successful.[13] Usually, the baseline survey is conducted at the individual or household level. Data are collected on household, socio-economic, and other characteristics that are potentially associated with the programme to be evaluated and the impact to be achieved.

Step 6: Implement the intervention and follow up.

The intervention needs to be carried out based on the pre-designed method. The intervention mechanisms, instruments, and time frame would have been designed and planned in advance of the implementation. The evaluators should have a clear understanding of the intervention.

A later examination of the treatment and control groups can be done at defined intervals of time. Failures to follow up on the participants or selected members should be minimal. At this stage, it is important to ensure that people in the control

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[12] In a crossover design, all the trial participants receive both interventions in a sequential manner and only the order of intervention is randomly assigned.

[13] In cases where important differences are found (or anticipated), the use of stratified random assignment may be warranted.

group do not suffer from ‘contamination’ or ‘attrition’ (Pattanayak 2009). Contamination can happen either through a similar intervention being carried out in the control areas or through self-contamination, where participants cross over from one arm of the study to another. It is also critical to recognise attrition within the groups, when participants of the study drop out from the sample between one data collection round and another, as this can produce misleading results.

Step 7: Collect final data.

After the implementation of the programme, a final survey needs to be conducted. There is no specific time period for conducting the final survey. This will depend on the theory of change specific to a particular policy intervention in terms of the time it will take for the expected impact to be expressed (Dhehibi et al. 2018). If the programme continues for a longer period of time, final data can be collected after the passing of a reasonable period, following which it can be expected that any change in outcomes due to the intervention will begin to be expressed. It is important for primary and secondary data to be collected by independent observers who are unaware of the allocation and treatment arms of participants. As far as possible, it is advisable that objective measures are used for ascertaining the outcome so that personal bias on the part of the collector does not come into play (Miguel and Kremer 2004).

Step 8: Analyse the data.

Many RCT studies report baseline characteristics of the intervention and control groups (sample size, and the mean and standard deviation of measurements). If the allocation of individuals for each group is random, any difference in the baseline characteristics of the two groups must be by chance. Therefore, a comparison can be easily undertaken with statistical testing. If the difference in the primary outcome is significant at an acceptable margin, chances are the observed difference is real. The magnitude of the observed difference is also important. In data analysis and reporting, first, a summary of the outcome for each group is reported, followed by a contrast between the two groups, known as the estimation of treatment effect, as well as the precision of this estimation, and the statistical significance of the treatment effect. For this purpose, the average treatment effect (ATE), which measures the effects of the programme with no intervention, needs to be estimated. The ATE measures the difference in mean (average) outcome between individuals of the treatment and the control group. Usually, the average treatment effect can be estimated using Eq. 14.1. Assume that there are two potential outcomes:

Y_{ti} is the value of the outcome variables for i^{th} individuals in group t (treatment group).
Y_{ci} is the value of the outcome variables for i^{th} individuals in group c (control group).

The average treatment effects would be

$$ATE = \frac{1}{N} \sum_{i=1}^{N} [Y_t(i) - Y_c(i)] \tag{14.1}$$

This is valid if the initial status of the outcome variables is the same for both groups. The impact of treatment on individual i, denoted by Π_i, can be defined as the difference between the outcome in the presence of treatment $\left(Y_i^*\right)$ and the outcome in the absence of treatment (Y_i). Accordingly, the equation that explains the impact of treatment on individual i may be expressed below:

$$\prod_i = Y_i^* - Y_i \tag{14.2}$$

Ordinarily, there is no reason to expect this effect to be constant across all individuals. So the researcher needs to estimate the average impact of the policy or project by averaging the impact across all the individuals in the sample. Accordingly, ATE may be calculated using the average or expected value for the entire sample, thus:

$$ATE = E\left(\prod\right) = E(Y_t - Y_c) \tag{14.3}$$

In addition to the above, a regression method may be used to identify the impact of the treatment. Here, the dependent variable is the value of the outcome variable at the final survey, and the independent variable can be defined as a dummy variable (where treated = 1, otherwise = 0). The basic model for a simple linear regression would be

$$Y_i = \beta_0 + \beta_1 D_i + u_i \tag{14.4}$$

where Y_i is the impact indicator of interest for individual $i = 1...N$. D is equal to 1 if the individual is in the treatment group and 0 if the individual is in the control group, and u is the error term. With this estimation, β_1 coefficient provides the average treatment effect. This is the average difference between treatment and control groups for the indicator of interest, giving the impact of the project. Depending on the way that the impact variable is measured, the type of mode can be decided. For example, if the outcome variable is continuous, then the ordinary least-squares (OLS) model is appropriate. If it is a discrete variable, then models such as probit or logit can be used.

It is often argued that an adjustment for baseline differences is only necessary when the difference between the groups at baseline is statistically significant. If the baseline difference of the outcome variable is significant, it may be incorporated into the regression model:

$$Y_{fi} - Y_{bi} = \beta_0 + \beta_1 D_i + u_i \tag{14.5}$$

This can be written as follows:

$$Y_{fi} = \beta_0 + \beta_1 D_i + \beta_2 Y_{bi} + u_i \tag{14.6}$$

where, $Y_f =$ the outcome measured at the final survey.

$D = D$ is equal to 1 if the individual is in the treatment group and 0 if the individual is in the control group, and u is the error term.

$\beta_1 =$ overall treatment effect.

$Y_b =$ outcome variable measured at baseline.

To assess the effect of the treatment at the follow-up measurements during different time periods, the interaction between the treatment variable and time can be added to the model. For example, assume our treatment variable is X and all others are the same, as defined earlier. The model after incorporating the follow-up measurements will be

$$Y_f = \beta_0 + \beta_1 X + \beta_2 Y_b + \beta_3 time + \beta_4 (time \times X) + u \tag{14.7}$$

In this model, the regression coefficient for the treatment variable reflects the treatment effect at the first follow-up measurement. The treatment effect at the second follow-up measurement can be estimated as the sum of the regression coefficient for the treatment variable and the regression coefficient for the interaction between the treatment variable and time ($\beta_1 + \beta_4$). It is also clear that depending on the requirement, more independent variables can be added to this basic model.

Step 9: Interpret results and complete the report.

Given that impact evaluations are usually of specific interventions in a specific context (Cohen and Dupas 2010), it might not be possible to generalise the results to the same intervention in different contexts. RCT studies require quality assurance in order to guarantee the quality of the study. Therefore, it is important to provide sufficient details when writing up the methodology and findings, explaining clearly the intervention being evaluated in detail. A detailed description of the intervention allows for the theory of change to be linked with the analysis of the findings. When reporting the findings of an RCT, a detailed description of the theory of change needs to be provided. It is essential to report the sample size calculation, details of the methodology with primary and secondary outcome measures, procedures of randomisation, treatment method, method of quality assurance, results and observations, analysis, and statistical tests applied.

When reporting results, a summary of the outcome for each group (participation rate, as well as the mean and standard deviation of measurements) needs to be reported. A comparison between two groups based on baseline information is also helpful. After evaluation of the impact, identifying the contrast between the two groups, known as the estimation of treatment effect, as well as the precision of this estimation, the statistical significance of the treatment needs to be provided (Winters et al. 2010). For continuous outcomes, the measure of treatment effect is the difference in means between the treatment and control groups. With those details, reporting standard deviation will help to identify the dispersion of values around the mean. Proper documentation of all sources of data is essential in any RCT study. Outcome measures need to be well defined, reproducible, and easy to measure. While documenting all the adverse effects, it is always important to compare the positive and negative results for both groups at the end. Furthermore, the potential limitations of the entire process or the sources of error need to be discussed so that the policymakers can judge for themselves the validity and generalisability of the research.

14.3.2 Challenges and Issues of RCT

Winters et al. (2010) discuss in detail the main challenges of applying RCT to evaluate the impact of agricultural projects: deciding on the appropriate sample size, proper randomisation, failure to follow the treatment protocol, possible attrition and measurement errors, behavioural impact appearing as experimental effects, and identifying spillover effects and contamination. Nichol et al. (2010) note some of the major pitfalls in the existing studies of RCTs, such as unclear hypotheses, multiple objectives, inappropriate selection criteria, infeasible treatment/intervention, inadequate randomisation and stratification, insufficient sample size/power, failure to use the intention to treat analysis, and failure to anticipate common practical problems encountered during the conduct of an RCT. However, it is widely accepted that a well-designed RCT provides the strongest evidence of any interventional study design if the researcher can maintain its effectiveness and efficiency. Furthermore, randomisation provides a powerful tool to control confounding, even for the factors that are unknown or difficult to measure (Rajalahti et al. 2005; Cohen and Dupas 2010). Thus, if well-designed and -conducted, an RCT could minimise the possibility of other sources of bias while providing a strong basis for statistical inference.

In order to maximise the potential gains of RCTs, the randomised assignment of treatment needs to ensure both the internal and external validity of the impact evaluation (Miguel and Kremer 2004). Internal validity assures the similar characteristics of both groups. It implies that the estimated impact of the programme or policy is the net of all other potential confounding factors; in other words, the comparison group represents the true counterfactual so that we can estimate the true impact of the programme (Peduzzi et al. 2002; Ferraro and Pattanayak 2006). In general, the internal validity of an impact evaluation is ensured through the process of randomised assignment of treatment. External validity means that the estimated impact of the sample can be generalised from the population (Pattanayak 2009; Nichol et al. 2010). In order to satisfy external validity, the evaluation sample must be selected from the population by using a random sampling technique.

Despite its advantages, RCTs face a range of ethical and practical concerns similar to other impact evaluation methods (Pattanayak 2009). Ethical concerns arise due to the RCTs' experimental nature. Randomisation involves withholding the intervention from the control group, so the decision to randomise is not a morally neutral one (Peduzzi et al. 2002). Some researchers hold the view that RCTs are resource- and time-consuming and the result of limited generalisability (Miguel and Kremer 2004). RCTs are relatively costly and may not be feasible for all interventional settings. They demand a complex design and analysis if the unit of allocation is not the individual. Another common issue with RCT is spillover effects, where technology is easily transferred (Pattanayak 2009). If these spillover effects are substantial (often exceeding the direct effects of the project), then the estimated treatment effect can be misleading. Dealing with these potential issues requires carefully designed impact evaluation techniques while assuring quality.

14.3.3 Non-experimental Approaches

An impact evaluation explains how an intervention affects the outcomes of interest to analysts and policymakers. If an impact evaluation fails to systematically undertake causal attribution, there is a great risk that the evaluation will produce incorrect findings, leading to incorrect decisions. If an experiment is not possible or unsuccessful, a non-experimental method may be used to assess the impact of a project. Under non-experimental approaches, subjects are not randomly assigned to treatment and control groups (Pattanayak 2009). However, the approach allows a control group to be created, representing a reasonable counterfactual to the treatment group. Some typical non-experimental approaches are presented below.

14.3.3.1 Difference-in-Differences (DID)

The DID approach is one of the most popular non-experimental techniques in impact evaluation. When randomisation may not be successful, the difference-in-differences (DID) method[14] may be used (Winters et al. 2010). It estimates the counterfactual for the change in outcome for the treatment group by calculating the change in outcome for the comparison group over time. This allows any differences between the treatment and comparison groups that are constant over time to be taken into account. The comparison is made between the trends in the control group from before and after the project versus the trends in the treatment group (Pattanayak 2009). This is similar to taking the double difference. We calculate the difference over time (the first difference) and the difference between the control and treatment groups (the second difference). If the trends are statistically significant for the treatment group, this suggests that the project had an impact on society.

Also, it is possible to assess heterogeneous and differential effects for subgroups using difference-in-differences. For example, the effect of a programme may differ according to different groups (men versus women, rich versus poor, old people versus young people, educated versus uneducated, etc.). Comparing outcomes across these different groups (between control and treatment groups) can help in estimating the impact on these subgroups (Independent Evaluation Group 2011). This can be done by comparing difference-in-differences in effects for the various

[14] Also known as the ‘double difference’ method.

subgroups of the eligible sample or population. The DID approach can also be estimated using a regression method, so:

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 T + \beta_3 X_i * T + u_i \tag{14.8}$$

where Y_i is the impact indicator of interest for individual $i = 1 \ldots N$ *and* X_i is equal to 1 if the individual is in the treatment group and 0 if the individual is in the control group. T is equal to 0 if at baseline and 1 after treatment, while u is the error term. In this estimation, coefficient β_1 controls the initial differences between control and treatment, while β_2 controls the general trends over time, and β_3 provides the estimate of impact, which is the average treatment effect. The main advantage of this specification is that it can be easily extended to a case with several groups and several time periods by adding group-specific and time-period-specific dummy variables (Winters et al. 2010).

14.3.3.2 Regression Discontinuity Design (RDD) or IV Method

This method can be used to evaluate projects in which the targeting depends on a specific variable defining a clear threshold for participation. RDD can be used to evaluate programmes that have a continuous eligibility index with a clearly defined cut-off score to determine who is eligible and who is not.

14.3.3.3 Propensity Score Matching

This method seeks to find non-treated objects that are similar to treated objects except for project benefits. Matching methods typically rely on observed characteristics to construct a comparison group, so the methods require the strong assumption of no unobserved differences in the treatment and comparison samples that are also associated with the outcomes of interest.

14.4 Application of RCT to Evaluate an Effective Agricultural Extension Service

The application of RCTs has become very common in the fields of public health, education, sanitation, microfinance, and poverty reduction through evidence-based practice. However, their use is still at a preliminary level. This section aims to explain how to apply RCTs to evaluate the impact of agricultural extension services using an empirical data set.

14.4.1 Evaluating the Impact of an Effective Agricultural Extension Service

This is an account of a study that employed an RCT to separate the impact of education and the monitoring of farms on rice output between two groups of farmers in Uhana Divisional Secretariat (DS) Division in the Ampara District. The impact evaluation was implemented during the Maha season in 2016/17. The application of the RCT follows the basic protocol described in Sect. 14.3.1 is used to explain the emperical work here.

Step 1: Identify a specific researchable policy or programme that requires evaluation to assess the impacts.

The overall aim of the study is to identify how effective the education of farmers and continuous monitoring of farms, via agricultural officers, is in improving rice output in the Ampara District. The study evaluates the impact of an effective agricultural extension service on the performance of rice farms in the study area. The outcome variables are yields and land productivity.

Step 2: Identify the target population and sample with the exclusion and inclusion criteria.

The Ampara District is divided into 20 DSDs, which are further subdivided into 507 Grama Niladhari Divisions. A significant contribution to the economy in the district derives from the primary agricultural sector: paddy, other field crops, coconut, sugar, livestock, and fisheries. Paddy is one of the most important crops cultivated in all DSDs. The target population is defined as paddy farmers in the district.

Sample Selection

The Uhana DSD was selected using a simple random sampling technique. Uhana has 59 GND Divisions with approximately 10,000 paddy farmers (receiving fertiliser subsidies) cultivating approximately 24,000 acres of paddy during the Maha (major rainfall) season every year. After obtaining a list of paddy cultivators, a sample of 250 farmers was selected using a random sampling technique. At the end of the Maha season in 2015/16, discussions were held with the 250 farmers to determine their plans for cultivating paddy during the next Maha season and their willingness to participate in the survey. A total of 230 farmers were selected based on availability and willingness to participate in the survey.

Step 3: Identify the time frame for conducting the RCT.

On completion of the planning work for this study in January 2016, the research team visited the study area for several informal and formal meetings as well as focus group discussions with farmers and agricultural officers (agricultural instructors, technical officers, and other related officers). Table 14.1 details the time frame for major activities in the study.

Step 4: Randomisation

This is the allocation of objects to study groups by chance. Of the 230 farmers, 115 farmers were separated randomly. Given the small sample, the technique for random selection involved writing each farmer's name on equal-sized slips of

Table 14.1 Time frame for the study

Activity	Period covered	Coverage
Study period (RCT)	March 2016 to March 2017	All farmers
Baseline survey	2016 March (2015/2016 Maha season)	All farmers
Implementation	September 2016 to March 2017	Treatment group
Final survey	April 2017	All farmers

papers, rolling them up, and placing them in a bowl. Then the rolled-up slips of paper were mixed several times before they were taken out and separated from the remaining 115. Finally, one group was named the treatment group and the other the control group.

Step 5: Conduct a baseline survey.

The baseline survey was carried out at the end of the Maha season in 2015/2016 (March 2016), covering all farmers in the two groups, to obtain basic information on their rice-farming practices during the season prior to project implementation and understand their present socio-economic characteristics.

Step 6: Implement intervention and follow up.

A pre-designed education and monitoring programme was implemented from the beginning to the end of the season focusing on the treatment group. For this purpose, 12 agricultural instructors (AIs) were hired. Several meetings were held with them, with the assistance of the director of agricultural extension (for the Ampara District). The AIs were trained to educate farmers via a consistent format (face-to-face informal discussion). Each AI was assigned 9–10 farms and expected to train farmers in the use of recommended quantities of inputs of time, water use practices, and additional farm-care practices. The AIs regularly monitored the farms to ensure that farmers followed instructions. Also, AIs provided individual consultations with farmers, wherein the researcher was also on hand. A field supervisor was stationed in the survey area for 4 months to supervise and monitor the AIs' progress.

Step 7: Collect final data.

The final survey was carried out in March 2017 covering both groups. Only data from 110 farmers in each group was used for the analysis, taking into account the AIs' recommendations.[15] The final questionnaire used for this study was developed using the results from eight focus group discussions and a pretest. Before the

[15] A few farmers did not continue participation in the consultation process, while during monitoring it was discovered that others had not followed the AIs' instructions. The questionnaires relevant to these farmers were dropped from the analysis. At this stage, the impact of smaller sample size on the results was not analysed.

Table 14.2 Comparison of two groups using baseline information (descriptive statistics)

Variable	Control (averages)	Treatment (averages)	Difference	*P* value
Yield (kg_2016)	1143.48	1147.50	−4.02	0.954
Productivity_2016	1125.52	1215.67	−90.15	0.110
Land size (AC)	1.06	1.04	0.02	0.791
Labour (days)	15.06	10.93	4.14	0.000
Power (hours)	18.58	14.44	4.15	0.000
Pesticide (Li)	2.95	2.15	0.80	0.000
Fertiliser (kg)	123.68	157.32	−33.64	0.000
Age of the farmer	37.18	41.78	−2.69	0.916
Education level	7.18	8.71	−0.87	0.805
Family size	3.67	3.90	−0.23	0.196
Land ownership (%)	60	62	(2)	–
Extension contacts (%)	11	14	(3)	–

Note: If the *P*-value is greater than 0.10, a no-difference hypothesis is accepted under a 10-per-cent level of significance

interview, it was confirmed that the respondents were generally those responsible for decision-making concerning farm production. A well-trained group of enumerators was employed for the survey.

Step 8: Analyse the data.

The data of the control and treatment groups were taken from a survey carried out in Ampara District in 2016 and 2017 included in the appendices. The researcher's expectation was that, with random assignment, the control group should be on average similar to the treatment group in all characteristics, except for the treatment group having received the educational and training programme. This can be verified using baseline data, through comparisons of key variables using statistical tests of significant differences, presented below in Table 14.2.

The results show no statistically significant differences between the treatment and control groups in rice production practices prior to the project. This suggests that the experiment can do a good job of creating a reasonable counterfactual. All the hypotheses, except those related to the labour, power, pesticides, and fertiliser variables, are accepted under the 10-per-cent level of significance. For example, the null hypothesis (H_0) related to the first variable is *the average yield between the control and treatments group is the same*. The alternative hypothesis (H_1) related to the same variable is *the average yield between the control and treatment groups is different*. In this case, the null hypothesis will not be rejected; that is, the mean level of yield for the control and treatment groups is the same. All the hypotheses related to the other variables may be similarly set up.

The null hypotheses related to the labour, power, pesticides, and fertiliser variables are rejected. This implies that existing differences are due to the usage of inputs in the production process that come under the farmers' management function.

Table 14.3 Estimating output difference between two groups or ATE

	Yields (kg) – control group	Yields (kg) – treatment group	Difference	*P*-value
2015/16 Maha (average)	1143.48	1147.50	4.02	0.954
2016/17 Maha (average)	1260.93	1496.29	235.35	0.003
Changes of the yield in 2016/17 Maha seasons (%) – after agricultural extension services			18.70	

Table 14.4 Estimating land productivity difference between two groups

	Productivity (kg) – control group	Productivity (kg) – treatment group	Difference	*P*-value
2015/16 Maha (average)	1125.52	1215.67	90.15	0.110
2016/17 Maha (average)	1257.60	1548.03	290.42	0.000
Changes in productivity in 2016/17 Maha seasons (%) – after agricultural extension services			23.1	

Therefore, the output difference between two groups or ATE was estimated using final survey data, shown in Table 14.3.

As shown above, the ATE of 235 kg is the average treatment effect. The difference between the yields is statistically significant. The total difference of output between the two groups may also be estimated by multiplying 235 by the number of farmers (110), which is 25,850 kg. Estimates of the (land) productivity difference between the two groups are given in Table 14.4.

In conclusion, the treatment has resulted in improved land productivity among the treatment group. The difference between the two groups in terms of productivity is statistically significant. The average productivity difference is approximately 23 per cent, the net outcome of the treatment.

Next, the OLS method is used to measure the treatment effect.

1. $Y_i = \beta_0 + \beta_1 D_i + u_i$

Assume that the dependent variable is yields during the 2016/17 Maha seasons taken from the final survey for both groups and D is the dummy variable, which takes 1 if in the treatment group and 0 if not. The result of the estimated OLS model is given below:

$Y = 1260.93 + 235.35D$

P (0.000) (0.005)

According to the results, the intercept and the treatment variable (D) are significant at a 5-per-cent level of significance. The coefficient of the treatment variable, which shows that the ATE is 235, is similar to the earlier results.

2. $Y_i = \beta_0 + \beta_1 D_i + u_i$

Assume that the dependent variable is the difference of the yields between the two seasons taken from the baseline and final surveys for both groups and D is the dummy variable, which takes 1 if in the treatment group and 0 if not:

$Y = 117.45 + 231.33D$

P (0.003) (0.000)

According to the results, the intercept and the treatment variable (D) are significant at a 5-per-cent level of significance. The coefficient of the treatment variable, which shows that the ATE is 231, shows the treatment effect after adjusting to the baseline differences.

3. $Y_i = \beta_0 + \beta_1 D_i + u_i$

Assume the dependent variable is the productivity in the 2016/17 Maha seasons taken from the final survey for both groups and D is the dummy variable, which takes 1 if in the treatment group and 0 if not:

$Y = 1257.60 + 290.42D$

P (0.000) (0.005)

According to the results, the intercept and the treatment variable (D) are significant at a 5-per-cent level of significance. The coefficient of the treatment variable, which shows that the ATE (productivity change) is 290, is similar to the earlier results.

4. $Y_i = \beta_0 + \beta_1 D_i + u_i$

Assume that the dependent variable is the difference in productivity between the two seasons taken from the baseline and final surveys for both groups and D is the dummy variable, which takes 1 if in the treatment group and 0 if not:

$Y = 132.09 + 200.27D$

P (0.000) (0.000)

According to the results, the intercept and the treatment variable (D) are significant at a 5-per-cent level of significance. The coefficient of the treatment variable, which shows that the ATE (productivity change) is 200, shows the treatment effect after adjusting to the baseline differences.

Consequently, all the models provide evidence related to the treatment effect. Depending on the requirements, any other socio-economic variables may be included in the basic models estimated.

Step 9: Interpret results and complete the report.

The agricultural extension programme designed to improve the output of rice farmers had a positive effect on productivity and the total production of paddy. The impact was statistically significant and indicates that, on average, yield and productivity could be increased by, respectively, 18 per cent and 23 per cent if the government implements a well-defined agricultural extension service targeting rice farmers in Sri Lanka.

14.5 Application of Difference-in-Differences (DID) to Evaluate Agricultural Extension Services

This section considers an example where significant heterogeneity is observed between the two samples. Such heterogeneity is possible if no randomisation process took place in the initial sample selection or a non-experimental approach is adopted to identify the treatment and control groups. Table 14.5 below shows comparisons of key variables for the baseline data, using statistical tests.

The evidence clearly shows that all the hypotheses, except those related to the variables power and family size, are rejected under a 10-per-cent level of significance. For example, a null hypothesis (H_0) related to the first variable is that *the average yield between the control and treatment groups is the same*, and an alternative hypothesis (H_1) related to the same variable is that *the average yield between the control and treatment groups is different*. In this case, the null hypothesis, which is the mean level of yield for the control group and treatment group, is the same. All the hypotheses related to the other variables may be similarly set up and conclusions drawn. Accordingly, except for power and family size, the averages of all the variables show statistically significant differences between the two samples. Here, DID will be more applicable to identify the treatment effect. The estimated impact between the two groups using DID is given in Table 14.6.

In a DID model, the relevant comparison is changes in the indicator over time. In a DID model, the trends in the control group from before and after the project must be compared against the trends in the treatment group. The double difference refers to the difference over time and the difference between the control and treatment

Table 14.5 Descriptive statistics

Variable	Control (averages)	Treatment (averages)	Difference	*P*-value
Yield (kg_2016)	1056.77	1355.69	298.92	0.0003
Productivity_2016	1014.36	1131.29	116.93	0.0970
Land size (AC)	1.07	1.45	0.38	0.0002
Labour (days)	10.20	16.85	6.65	0.0000
Power (hours)	16.67	16.81	0.13	0.8895
Pesticide (Li)	3.65	2.38	−1.26	0.0000
Fertiliser (kg)	124.05	207.22	83.17	0.0000
Age of the farmer	37.40	42.73	5.33	0.0003
Education level	7.03	10.95	3.92	0.0000
Family size	3.69	3.79	0.1	0.5556
Land ownership (%)	55	89	34	

Note: If the *P*-value is greater than 0.10, a no-difference hypothesis is accepted under a 10 per cent level of significance

Table 14.6 Estimating DID using baseline and final survey data

	Indicator (average yields)			Indicator (average productivity) Land productivity		
	Yields (kg)	Difference	DID	Productivity	Difference	DID
Control group: before the project is implemented (baseline survey)	1056.77	68.91	236.8	1014.36	75.71	163.43
Control group: after the project is implemented (final survey)	1125.68			1090.08		
Treatment group: before the project is implemented (baseline survey)	1355.69	305.71		1131.29	239.15	
Treatment group: after the project is implemented (final survey)	1661.4			1370.44		

groups. For example, consider the data sets explained above. DID estimates for average yields and productivity (land) are shown in Table 14.6. The results show a clear difference between the treatment and control groups during the project implementation period. This implies that farmers who received an effective agricultural extension service as the project intervention demonstrated significant improvements during the cultivation season. The difference of the outcome variables is called the average treatment effects, which are similar to 163.4 for average productivity and 236.8 for average yield.

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Further Readings

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Using Agricultural Production Functions to Analyse Land Tenure Reforms

15

Dilini Hemachandra

Abstract

Agricultural land policy changes have important implications for an economy. Their effect on agricultural productivity is of great interest. This chapter aims to provide the necessary knowledge and skills to carry out an ex post analysis employing econometric techniques to understand the impact of agricultural land policies (pertaining to tenure rights and land sizes) on agricultural productivity. Specifically, upon completing the chapter, the reader should be able to evaluate the impact of changing land plot sizes on agricultural productivity and, by using a simple dummy variable method, the effect of ownership on agricultural productivity employing the Excel spreadsheet or STATA software. The chapter concludes with an exercise to practice the methods explained in the chapter with a data set provided.

Keywords

Land policies · Tenure rights · Land size · Productivity · Ex post analysis

15.1 Introduction

Land is an important resource for both national and rural development. It is an important source of wealth in rural areas as, observations show, people with land endowments enjoy better living standards compared to those who are landless. It is the most vital input for agricultural production, and land quality influences yields and farm incomes. Given its importance in agriculture, land is central to food security, foreign exchange earnings, and rural employment in a country. Also,

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agricultural land is a highly politically sensitive subject owing to its centrality in rural livelihoods and the presence of large rural voter bases.

Agricultural land is of great interest to policymakers. Governments are required to take decisions with respect to land allocation, land use, land rights, and land transfer in order to achieve certain national goals as needs dictate. Hence, historically, land policies are one of the oldest public policies in any country.

Changes in government policies alter people's behaviour. Some behavioural changes are intended and others, unintended. Some are favourable; some, unfavourable. Since land is connected to all sectors, the outcome of a change in land policy might not be directly seen. A proposed change in land policy (in any public policy for that matter) may be evaluated before implementation (ex ante) and/or after implementation (ex post). Policies are analysed before implementation to quantify the likely impacts, as well as to understand the direction in which important variables could change upon the implementation of the policy. Policies may be withdrawn before implementation if analysis shows unfavourable outcomes. Moreover, a policy may be evaluated upon implementation to assess the magnitude and direction of the impact on important variables and, if necessary, amended accordingly. Therefore, policy analysis is as important as the policy itself. Agricultural land policies require rigorous analyses for the political, social, and economic advancement of a country.

15.2 The Context

15.2.1 Intentions of the Policy and Global Context

In ancient times, when land was abundant, there was no need for land policies. Later, as land increasingly became a scarce resource, decisions had to be taken on who has what rights to land and how best to use it productively (because the latter required high investments); i.e., property rights became a concern. Historically, the ruler or the governing body was vested with the ownership of land, which was distributed among the public for different purposes. In the feudal system, rent was collected by the ruler for occupying and using land. Commoners neither owned the land nor possessed the authority to engage in land transactions. In most places, the user rights to the land were transferred to the next generation mostly for the same use. This led to commoners rising in rebellion against the unequitable distribution of land, which was the basis of their livelihood. As a result, early land policies took account of issues of equity in the distribution of land. Property rights to land thus distributed were also defined to avoid confusion and conflict.

It is believed that having ownership rights to land increases efficiency. Property rights to land need to have a time horizon long enough to provide incentives for investment and be defined in a way that makes them easy to observe, enforce, and exchange. They need to be administered and enforced by institutions that have both legal backing and social legitimacy and are accessible by and accountable to the holders of property rights. Even if property rights to land are assigned to a group, the rights and duties of individuals within this group, and the way in which they will be enforced and can be modified, have to be clear. Finally, as the precision with which property rights will be defined will generally increase in line with rising resource values, the institutions administering property rights need to be flexible enough to evolve in response to changing requirements.

Historically, property rights to land were social conventions that regulated the distribution of the benefits that accrue from specific uses of a certain piece of land. Public interventions in terms of policies in this regard were required due to several reasons. First, unless property rights are defined and enforced by society, households and entrepreneurs will be forced to spend resources to defend their claims to property, for example through guards, fences, etc. This not only is socially wasteful but also disadvantages the poor, who will be the least able to afford such expenditures, and, in the extreme, leads to a chaotic situation. Second, the high fixed cost of the institutional infrastructure needed to establish and maintain land rights favours public provision, or at least regulation. Finally, the benefits of being able to exchange land rights at low cost, which are, for example, the basis for the use of land as collateral in credit markets, will be realised only in cases where such rights are standardised and can be easily and independently verified, e.g. through a publicly accredited registry of deeds or title that is guaranteed by the state (Christensen et al. 1973).

In any country, there are land policies that deal with the distribution of land to the public, acquisition of land from the public, and definitions of property rights, land uses, and development. Most countries experienced land reforms as a crucial milestone in their development path. For instance, post-war Japan undertook a land reform that is very much applauded across the world as a successful move. There, the government introduced a permissible limit to the extent of land that individuals could own to achieve a more equitable distribution of land among people. Landlords who owned more than the permitted amount were required to sell the excess land at a fixed price to the government, which then sold it at the same price, giving first preference to any tenant who had been farming the land. Japan's land reform succeeded for two reasons. The first is that the then ruling authority had the power to impose and enforce a law that hurt the interests of a very powerful class of people, wealthy landlords, in order to bring about social and economic change. The second reason is more complex. When the land reform law was passed in October 1946, it provided reasonable compensation to the landlords who had to sell their land to the government.

Another well-known example is China. Land reform has characterised rural China since the founding of the People's Republic in 1949. Shaping its farmland policy on the Soviet model, China established collective ownership and unified collective operation. During the reform process, individual farmers were compelled to join collectives. Collectivisation finally developed an institution called the People's Commune. This policy is criticised for its centrally controlled property rights and misapplied egalitarian principle of distribution; in effect, communes destroyed farmers' operational freedom and their enthusiasm for production (Chen and Davis 1998).

15.2.2 Milestones of the Policy Implemented in Sri Lanka

In Sri Lanka, land policy documents date back to the colonial era. The first land policy implemented was the Crown Land Ordinance in 1840, through which the colonial government appropriated private lands for the expansion of the plantation sector. All land for which the traditional users failed to provide deeds was taken under the Crown.

Since then, several land policies have been implemented to achieve various political and socio-economic objectives. Table 15.1 summarises the major policies. A policy is never perfect in its original form. Oftentimes, the original policy will be amended several times to iron out weaknesses. If there are drastic changes to an existing policy, its policy is repealed and a new policy issued in its place.

15.3 An Application

15.3.1 Selection of a Tool to Analyse the Effects of Agricultural Land Policies

There are several analytical tools available for empirical policy analysis. They may be categorised broadly as experimental methods and non-experimental methods. Randomised control trials (RCTs), field experiments, lab experiments, and discrete choice experiments are experimental methods available for policy analysis. Qualitative methods, simulations (partial/general equilibrium models and mathematical programming tools), and econometric methods are non-experimental methods available. The selection of an appropriate tool is dependent on several factors: the nature of the policy, the context (i.e. whether it requires an ex ante analysis or ex post analysis), the trade-off between internal and external validity, the type of data available, and the cost of the method (Colen et al. 2016).

Simulation models are commonly used in ex ante evaluations. Econometric analysis refers mostly to ex post evaluations and includes regression analysis and quasi-experimental approaches. Quasi-experiments are sophisticated econometric methods in which assignment to conditions (treatment versus no treatment or comparison) is via self-selection (participants choose treatment for themselves), by the researcher, or both of these routes by artificially constructing or mimicking the counterfactual (Shadish et al. 2002). Quasi-experiments include the following empirical strategies: instrumental variable estimations, regression discontinuity designs, difference-in-difference matching, and propensity score matching.

Some experimental and non-experimental methods are used complementarily. For instance, experimental methods and simulation methods are used together for ex ante analysis, whereas econometric analyses using observational data and RCTs are used together in ex post policy analysis.

This chapter will focus on the use of regression analysis to assess the effects of land policies.

Table 15.1 Major land policies implemented in Sri Lanka

Ordinances, acts and laws related to land ordinance/act/law	Year	Summary
Crown Lands (Encroachments) Ordinance No. 12	1840	• Acquired around 90 per cent of existing lands in the country and converted them to Crown properties • These lands were later sold to Europeans to start plantation agriculture, a land use unfamiliar to the native people
Waste Lands Ordinance No. 1	1897	• Prevented encroachment of Crown wastelands by the peasants
Land Development Ordinance No. 19	1935	• Set the course for the future development of lands in Sri Lanka • Led to rapid land settlements; starting from the mid-1930s, continued up to the implementation of the Accelerated Mahaweli Development project in the mid-1980s
Paddy Lands Act, No. 1	1953 and 1958	• Two major tenure reforms of Sri Lanka enacted to ensure tenure security and to regulate the rent paid by tenants to the landlords with the objective of improving land productivity through increasing the tenure security • Led to a detrimental, rather than beneficial, landlord-tenure relationship and finally resulted in the eviction of a large number of tenants by the landlords
Land Reform Law, No.1 Land Reform (Amendment) Law, No. 39	1972 1975	• Imposed an ownership ceiling of 25 acres of paddy lands or 50 acres of highlands or both together with a maximum of 50 acres • Land ceiling was not effectively enforced • Provision of small parcels of land to a large number of landless farmers led to increasing agricultural production over the years
Agrarian Services Act, No. 58	1979	• To secure tenure rights of tenant cultivators of paddy and improve the productivity of those lands • Considered as a more realistic approach to resolve the problems in the paddy sector
Agrarian Development Act, No. 46	2000	• Identified the necessity of having a national policy to safeguard tenure rights • Imposed restrictions on the conversion of agricultural land to non-agricultural purposes
Land Grants (Special Provisions) Act, No. 43	1979	• Land under the purview of the Land Commissioner's Department was alienated for various purposes to the private sector
Registration of Title Act, No. 21	1998	• To provide freehold titles to land parcels in order to promote the efficient functioning of land markets and resource utilization

15.3.1.1 Theoretical and Empirical Model

Production involves converting inputs to (an) output(s). Producers of agricultural commodities seek to maximise farm profits or, at least, maximise revenue subject to resource constraints, such as land, labour, and farm machinery. In any production process, the output depends on the factors used and the production technology in which they are combined. These input-output relationships, which can be expressed in a production function, provide the foundation for economic theory from a production perspective. A production function relates the physical output of a production process to the physical inputs or factors of production; it is a mathematical relationship that relates the maximum amount of output that can be obtained from a given number of inputs. There are many objectives of using production functions in empirical research: to derive the physical relationships of inputs and outputs, to derive marginal productivities of inputs, to assess the resource-use efficiency of decision-making units (e.g. technical and economic efficiency), to estimate technical/technological changes of a production process over time, and to test economic theories (e.g. diminishing marginal returns). Due to their appealing properties, production functions are used in a wide array of areas (Beattie and Taylor 1993).

The concept of duality in production theory (McFadden 1978) brought a breakthrough in the empirical application of production theories. Duality (or dual concept) means that all of the information needed to obtain the corresponding cost function is contained in the production function and, conversely, the cost function contains all of the information needed to derive the underlying production function. Consequently, according to the dual concept, any constrained maximisation problem can be converted into a corresponding constrained minimisation problem and vice versa. The use of inputs becomes the function to be minimised; the revenue function becomes the constraint. Since cost/price data are more easily available than quantity data, the estimation of the parameters of the production function indirectly from the profit/cost function data became increasingly popular (Beattie and Taylor 1993).

The application of the theory of the firm in agricultural commodities involves production functions, profit or cost functions, derived input demand functions, and output supply functions.

The farmer faces an allocation problem. She/he seeks to allocate resources such that profits are maximised and eventually her/his utility is maximised. Profit is the difference between the revenues obtained from what is sold (total value product) and the costs incurred (total factor cost) in producing the goods. From an input perspective, total profit is explained as the difference between the total value product (TVP) and the total factor cost (TFC). A farmer, under perfectly competitive conditions, receives constant output price (p^*), TVP $= p^*y$. Hence, profit becomes

$$\pi = p^* y - \mathrm{TFC} \tag{15.1}$$

Output y is determined by the production technology, i.e. how inputs are combined and the quantities of inputs used:

$$y = f(x_1, \ldots, x_n | x_{n+1}, \ldots, x_m) \tag{15.2}$$

where y is the output, $x_1, \ldots, x_n$ are the variable inputs, and $x_{n+1}, \ldots, x_m$ are the fixed inputs. In producing a crop, fertiliser, agrochemicals, and labour are some examples of variable inputs; land is an example of a fixed input. Quantities of variable inputs can be changed in a cultivation season, but fixed inputs cannot be changed.

Empirical estimation of the production relationships involves the selection of a functional form that best describes the relationship between the variables. The most common functional specification is the Cobb-Douglas (C-D) type.

$$y = x_1^{\beta 1} x_2^{\beta 2} \tag{15.3}$$

The common use of the C-D type specification is attributed to several characteristics of the C-D type. Most of all, there is the computational ease. Input elasticities can easily be obtained by the log-log specification of the C-D production function, where the input coefficients (β_s) are the input elasticities. The log-log specification of the C-D production function is as follows:

$$\log y = \beta_1 \log x_1 + \beta_2 \log x_2 \tag{15.4}$$

However, the C-D type functional specification has a few weaknesses, which limit its ability to closely relate to the true functional form of the technical relationship of interest. Its inherent assumption of constant elasticity of substitution is one limitation of its empirical application. Elasticity of substitution is defined as the percentage change in the input ratio divided by the percentage change in the marginal rate of substitution. Due to these limitations, more flexible functional forms, such as constant elasticity of substitution (CES) production functions and transcendental logarithmic (translog)-type specification, have been used.

Specifically, the translog production function[1] introduced by Christensen et al. (1973) became popular due to its many advantages over the C-D or CES specifications. First, it does not assume rigid premises, such as smooth substitution between factors or perfect competition in factor markets (Klacek et al. 2007). Second, it permits non-linear relationships between the output and the factors. In addition, due to its properties, the translog production function can be used for the second-order approximation of a linear-homogenous production, the estimation of Allen elasticities, the estimation of production frontier, or the estimation of the total factor productivity dynamics (Pavelescu 2011). The general form of the translog production function for i inputs is given below:

[1]The first form of a translog production function involved the approximation of a CES production function with a second-order Taylor series when the elasticity of substitution is very close to one.

$$lny = ln\alpha + \sum_{i=1}^{n} \beta_i \, ln\, x_i + \left(\frac{1}{2}\right) \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} \, ln\, x_i \, ln\, x_j \tag{15.5}$$

The estimation of the production function for an annual crop is different from doing so for a perennial crop due to several reasons. One is incorporating capital expenditure on perennial crops. A grown perennial crop is capital accumulated over a period of time. Production functions are defined for a short period of time, usually a year. It is necessary to obtain the annual service flow from machinery cost when estimating production functions for perennial crops. Some studies deal with this by using lag variables.

15.3.1.2 Types of Data

Analysis, more often than not, will be constrained by the type of data available. The data requirement will also depend on the unit of analysis. If the problem entails the effect of land policy on the country, a time series of the country's socio-economic data should be used. If the problem entails the effect of land policy on farmer behaviour/decision-making/agricultural output, panel data or a repeated cross-section of farmer data should be used. In all these cases, the data series should span the period *before* the year of policy implementation until *after* the year of policy implementation to syphon out the effect. This may require the use of secondary data. Moreover, if the problem entails only a specific group of farmers/farmer households, a cross-section of data comprising both the groups of affected and unaffected farmers may be used. In this case, primary data can be used.

Another important dimension is whether one is interested in studying the long-term impact or short-term effects. Obviously, for long-term impacts, there must be a reasonable time series of data that spans a few years before and after the policy implementation. If the interest is in short-term effects, data spanning a couple of seasons after the policy may be good enough.

Land policies, while having a long-term impact, could also have immediate effects as they change the decision-making behaviour of people. Cross-section data will be helpful in identifying immediate responses. However, there must be a cross-section of data before and after the policy is implemented in order to infer the effect of the policy.

15.3.2 Production Function Approach

A production function approach can be applied to study the effects of various land policies that have an effect on agricultural productivity/production. Below, an example of how to econometrically analyse the effect of land fragmentation and land ownership is discussed. Reduced forms of the production functions may be used if policy variables can be approximated with an input used in production. Since there exists a corresponding dual cost function for production functions, cost functions can also be estimated with input costs as explanatory variables. As cost data are more commonly available than production data, cost function estimation is a popular alternative.

15.3.2.1 Land Fragmentation

When a household operates a number of owned or rented non-contiguous land plots at the same time, it is referred to as land fragmentation. Three variables determine the level of land fragmentation: farm size, number of plots, and size of plots. Fragmented land is a common feature of developing-country agriculture that often is a result of a process of subdivision of land through inheritance.

Fragmented land is considered a drawback to the agricultural development of a country, given the negative impact on productivity and costs. Productivity is negatively impacted as fragmented small plots are an obstacle to mechanisation, reduce the scope for irrigation and soil conservation investments, and increase land 'wasted' for access roads and boundaries. Increased costs occur in a situation of scarce labour or when farm households must manage and travel among several distant land plots as this increases transportation costs and demands more of the farmer's time, thus lowering labour productivity and increasing the difficulty in supervising farm labour. In effect, land fragmentation introduces a lot of inefficiencies to agriculture. Land consolidation is often proposed as a policy alternative to address the issue of land fragmentation. Land consolidation refers to the process of reallocating land parcels, with the aim of allowing landowners to obtain larger parcels at one or more places, in exchange for their former smaller and fragmented land plots.

Land fragmentation is a common issue discussed in Sri Lankan agriculture. The majority of farms operate in multiple small plots (Wickremaarachchi and Weerahewa 2016). Around 47 per cent of agricultural holdings operate on less than a quarter-acre of land (Department of Census and Statistics 2015). The issue has often been highlighted as a hindrance to increasing agricultural productivity, with land consolidation proposed as a way of encouraging private investors to invest in agriculture.

Econometric analysis can be used to provide empirical evidence to support policy decision-making on the impact of fragmented land and the need for land consolidation. This requires empirical estimation of a production function to assess the effect of land fragmentation on the agricultural productivity of a farm. Note that the unit of analysis here is a farm, not a land parcel. A land parcel may be used as a unit of analysis if the problem entails assessing the effect of land size on land productivity.

$$Y = f(X_1, X_2, X_3, X_4, X_5) \tag{15.6}$$

where

$Y =$ agricultural productivity

This may be expressed in quantity form or value form. If it is in quantity form, it is the total farm output. If it is in value, it would be the total value of farm output. If the farm produces more than one output, then it becomes difficult to express productivity as a quantity produced per farm. In this situation, the total value of farm output is a more appropriate measure (variable) for farm productivity. The quantities or values used should be for the past year or season.

X_1: farm labour

This may be the number of people working on the farm, both hired and family labour, used in a particular year or season. If some workers are part-time workers, then fractions may be considered in calculating labour. To be more precise, the number of labour days or labour hours per year may be used.

The following function specification may be selected:

X_2: fertiliser

The amount of fertiliser applied per year or the cost of fertiliser per year may be used.

X_3: water

If cultivation is rain fed, it is difficult to give a quantity or value. If cultivation is irrigated, then the amount of water may be used as cubic feet per year/season. If water is purchased, the water bill of the farm (excluding water consumed by the household) may be used.

X_4: capital

Since machinery is a fixed cost of the farm, the cost of buying machinery should not be used as a variable. Instead, the service flow per year from the machines should be used. There are various ways to calculate the annual service flow. For example, a simple way to calculate the service flow of a tractor would be

$$\text{Annual cost} = (\text{total cost of the tractor} - \text{scrap value})/\text{life time} \tag{15.7}$$

The service flow per year of all farm machinery should be added. If farm machinery is rented, the rental fee should be used as the annual cost of capital.

X_5: land fragmentation

The average plot size and the average number of plots per farm may be used as measures of land fragmentation. Alternately, a fragmentation index can be used. An index could be created as a function of farm size, the number of plots per farm, and plot sizes (e.g. Simpson Index of Blarel et al. 1992).

$$\text{Simpson Index} = \frac{\sum_{i=1}^{n} a_i^2}{A^2} \tag{15.8}$$

where a_i is the individual plot size and A is the size of the farm.

The econometric specification could be a linear function, exponential function, lin-log function, or log-log function.

An example of a log-log specification is as follows:

$$\begin{aligned}\log\ (\text{productivity}_I) = \beta_{0i} &+ \beta_{1i}\ \log(\text{labour}_i) + \beta_{2i}\ \log(\text{fertiliser}_i) \\ &+ \beta_{3i}\ \log(\text{water}_i) + \beta_{4i}\ \log(\text{capital}_i) \\ &+ \beta_{5i}\ \log(\text{farm size}_i) + \beta_{7i}\ \log(\text{number of plots}_i) \\ &+ \varepsilon_i \end{aligned} \tag{15.9}$$

where i is the individual farm and ε is the error term.

15.3.2.2 Land Ownership

Land ownership is argued to have a relationship with the effort a farmer/tenant takes in farming. Effort or management is input to agricultural production. To see if a particular land tenure policy has an effect on agricultural productivity, a production function could be estimated. The same type of data as discussed for land fragmentation above could be used. Land ownership type may be modelled as a proxy for the effort a farmer is exerting in farming.

There could be two types of farmers: those who cultivate their own land and the tenant farmers, who cultivate someone else's land. This could be modelled as a dummy variable where it would take value '1' for owned land and '0' for rented land (or otherwise).

The econometric model in a log-log specification will be as follows:

$$\begin{aligned}\log\ (\text{production}) = \beta_0 &+ \beta_{1i}\ \log(\text{labour}_i) + \beta_{2i}\ \log(\text{fertiliser}_\text{i}) \\ &+ \beta_{3i}\ \log\ (\text{water}_i) + \beta_{4i}\ \log(\text{capital}_\text{i}) + \beta_{5i}\ \text{own} \\ &+ \varepsilon_i \end{aligned} \tag{15.10}$$

where i is the individual farm and ε is the error term.

15.3.2.3 Simulation

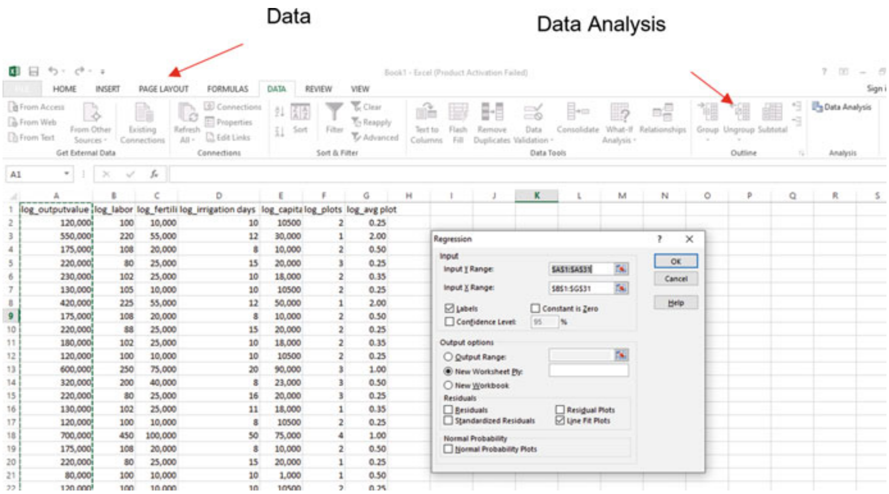
The estimated model may be simulated to see how close the estimated data are to the data observed in real life by multiplying the input variables with the estimated coefficients and obtaining the predicted output (dependent variable). This should be compared with the actual observed output for the same input use. If the values are close, the econometric model is able to simulate the actual data.

15.4 Assignments

1. Estimate the effect of land ownership on agricultural productivity.
   Use the farm cost data to estimate the effect of land ownership on farm production. Comment on the effect of land ownership on farm production. The data is available at https://drive.google.com/file/d/1HTc0zaYq2XPp05csgWYWX2WuWtoXYjde/view?usp=sharig:
   (a) Create a dummy variable for 'ownership', where 'owned' land gets a value of '1' and 'rented' land gets a value of '0'.
   (b) Create log variables for other variables.

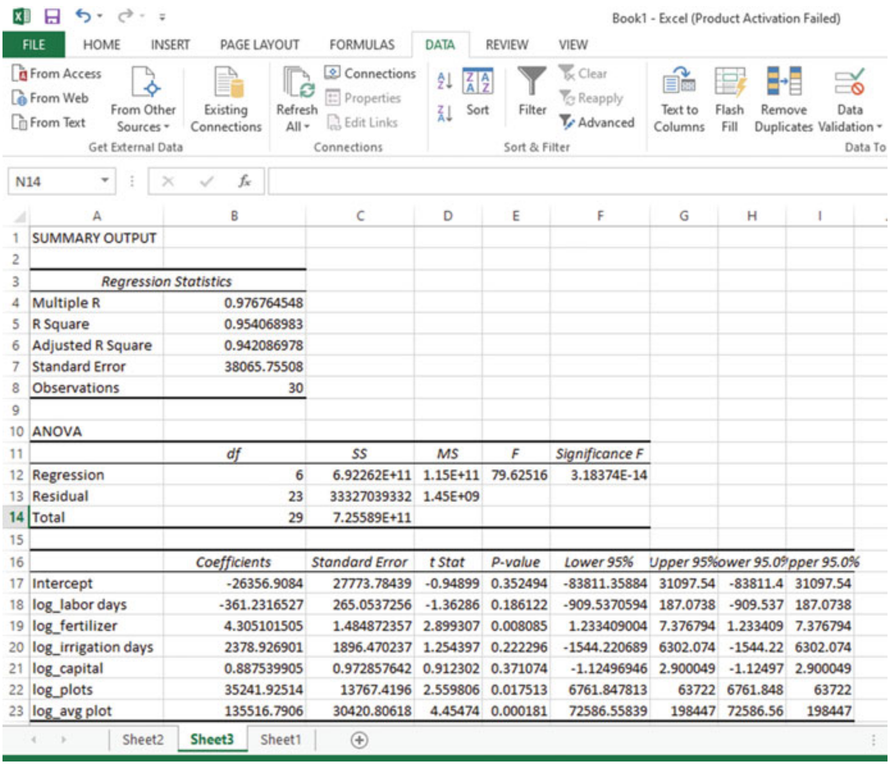
(c) Run regression of log of farm production on log of inputs and ownership dummy. Regression analysis may be carried out in Excel. In an Excel spreadsheet in which you have entered data, go to Data, Data Analysis.[2]
1. Select regression.
2. Select Y range.
3. Select X range.
4. Click OK.

Here is a screenshot of the data and the regression dialog box:



The regression output will appear in a separate sheet as follows:

[2]Analysis ToolPak is available in all versions of Excel from 2003 to 2019 but is not enabled by default. It needs to be turned on manually. Follow the instructions given in this link to manually add ToolPak: https://www.excel-easy.com/data-analysis/analysis-toolpak.html



SUMMARY OUTPUT	
Regression Statistics	
Multiple R	0.976764548
R Square	0.954068983
Adjusted R Square	0.942086978
Standard Error	38065.75508
Observations	30

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	6.92262E+11	1.15E+11	79.62516	3.18374E-14
Residual	23	33327039332	1.45E+09		
Total	29	7.25589E+11			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-26356.9084	27773.78439	-0.94899	0.352494	-83811.35884	31097.54	-83811.4	31097.54
log_labor days	-361.2316527	265.0537256	-1.36286	0.186122	-909.5370594	187.0738	-909.537	187.0738
log_fertilizer	4.305101505	1.484872357	2.899307	0.008085	1.233409004	7.376794	1.233409	7.376794
log_irrigation days	2378.926901	1896.470237	1.254397	0.222296	-1544.220689	6302.074	-1544.22	6302.074
log_capital	0.887539905	0.972857642	0.912302	0.371074	-1.12496946	2.900049	-1.12497	2.900049
log_plots	35241.92514	13767.4196	2.559806	0.017513	6761.847813	63722	6761.848	63722
log_avg plot	135516.7906	30420.80618	4.45474	0.000181	72586.55839	198447	72586.56	198447

(d) Interpret the coefficient estimates. Is farm production of owned farms higher than rented farms?

(e) If you are using STATA software, type the following:

reg log (name of then Y variable) log (name of the X_1 variable) log (name of the X_2 variable)

Press *Enter* to get the regression output.

2. Collect data from 50 crop farms for the following variables in a selected area village or a Grama Niladhari Division:
   (a) Value of total farm output sold in Maha 2018
   (b) Number of labour days used, including family labour in Maha 2018
   (c) Cost of fertiliser for Maha 2018
   (d) If irrigated, number of days irrigated
   (e) Rent/cost per year of machinery
   (f) Number of cultivated plots per farm
   (g) Average size per plot

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Analysing Land-Use Planning Regulations Using Linear Programming Models

16

Thiagarajah Ramilan and Jeevika Weerahewa

Abstract

Owing to the important role that lands play in achieving economic, social, and environmental goals of a country, policy makers often impose regulations on the use of land. These regulations can have serious implications on societal order and well-being and hence detailed analysis of their impacts are required make informed policy decisions. This chapter develops and applies a simple linear programming model to assess a land zoning restriction on revenue, resource-use efficiency, and environmental sustainability.

Keywords

Cascade · Bioeconomic models · Land use · Optimisation · Trade-off

16.1 Introduction

Land is a natural resource that has multiple uses, such as residential, commercial, industrial, agriculture, environmental, and recreational. Land is a scarce resource. Using land for one particular activity has an impact on its other uses. For example, conversion of forest land into agricultural land will reduce the land available for other uses as well as the beneficial environmental services of forest land. Similarly, filling in and constructions in wetlands may lead to water-logging problems in the

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surrounding areas. While land-use changes may occur in response to local or national economic drivers, social dynamics, and environmental factors, their consequences, in terms of ecological, economic, and social impacts, may reach regional and even global scales (Gomes et al. 2020). Importantly, land use affects the well-being of a nation and it is a critical factor in meeting the overarching goals of economic growth, social inclusion, and environmental sustainability.

Land-use regulations govern how land can be used and how uses can be changed. Zoning, planning rules, private contracts, location-specific rules, and approval processes are some of the actions imposed through land-use regulations. They play a vital role in allocating land in a sustainable manner to accomplish the different needs of people in a certain geographical area and optimise the use of allocated lands for a specific use.

In many countries, land-use planning is within the purview of local governments. The higher levels of government develop policy guidelines, and local governments prepare strategic plans with spatial implications. Local governments use detailed land-use plans with zoning restrictions to regulate land use.

Land-use regulations, by definition, alter property rights to land. As a result, conflicts, both between private and public property rights and among private rights, are common. For example, land-use restrictions on the type of crops to be cultivated constrain the private property rights of affected farmers. For example, in Sri Lanka, the Agrarian Development Act restricts the cultivation of paddy land in the off-season to permissible annual crops (Weerahewa et al. 2020). Therefore, landowners are deprived of the opportunity to cultivate more profitable crops, creating a conflict between the private and state sectors. The human-elephant conflict in the dry zone of Sri Lanka is another example. It highlights the issue of allocating limited lands between agriculture and forest services. Restrictions on land use and expansion of agricultural holdings to preserve elephant habitats constrain the private property rights and livelihood of smallholder farmers. At the same time, though, this action helps to preserve public rights for the protection of the environment, natural ecosystems, and habitats. Similarly, using the limited mangrove land to meet a variety of human needs creates conflicts that require the imposition of regulations to safeguard and manage the resource in a sustainable way.

Since land-use decisions are difficult, complex, and costly to reverse, it is prudent to quantify the effects of various types of land-use planning regulations before finalising land-use plans. Exploring potential impacts of land-use changes on ecosystems will lead to better informed decision-making and support land-use planning to strengthen socio-economic development and nature conservation (Gomes et al. 2020). Linear Programming (LP) models can be used to produce needed scientific evidences in this regard. These models have the flexibility to combine biological, social, environmental, and economic aspects of production to derive sustainable land-use solutions. Moreover, they can be used to test the sensitivity of land-use patterns to changes in selected variables (Veldkamp and Lambin 2001). Further, they help to quantify the impact of envisaged policy decisions.

16.2 An Application

Land use is determined by a multitude of economic, sociocultural, and environmental factors and the regulatory environment within which decision-makers operate. The latter includes various regulations governing agricultural production and land use as indicated in the previous section. This section presents some issues to be considered in selecting a tool to analyse the effects of regulation concerning land-use planning.

The effects of a regulation related to land-use planning will be felt across multiple spatial scales, ranging from the local to the regional level, and will foster behavioural changes in various decision-makers. For example, at the farm level, farmers may seek to obtain the maximum possible profits from agricultural production, subject to various resource constraints and the new land-use regulation. This may affect the crop and livestock enterprise combinations that the farmer uses, as well as the employment of labour and other resources. Similarly, at the regional level, a regional planner may consider aspects such as nature conservation, environmental protection, and landscape quality, in addition to profits to farmers. Therefore, regional planners may introduce additional regulations. At a national level, a country planner may seek to maximise the social well-being of the entire nation subject to various global-political constraints. The addition of a land-use planning constraint requires a change in the policy decisions made by a national planner as well.

In the real world, decisions are made simultaneously by different individuals. Ideally, a single model would capture the behavioural changes of these various decision-makers triggered by a regulation related to land-use planning. In this section, a modelling framework is presented to ascertain the behavioural changes of a farming household, without incorporating the effects of behavioural changes among regional planners and national planners. However, this modelling framework could be scaled up for the decision support at regional and national levels.

In selecting an appropriate tool to address the effects of land-use planning regulations on a farming household, due consideration should be given to the objective function of the farmer and the various constraints faced. The farmer's objectives will be profit maximisation, cost minimisation, or risk minimisation subject to a given level of profit over a certain period of time. The constraints facing the farmer include the availability of production technologies, resource constraints, and regulatory barriers. A problem of this nature requires an optimisation model that either minimises or maximises an objective function subject to a set of constraints. LP is an appropriate tool to analyse this types of problems.

16.2.1 Structure of a Linear Programming Model

LP is a mathematical procedure that allows the determination of the optimal allocation of scarce resources. A linear programming model consists of the objective function as the central element and a set of constraints specifying different activities and their resource requirements. These elements are formulated as a system of equations that are linked to each other in a matrix. An algorithm then calculates the optimal solution to the equation system.

LP is the foundation of many economic optimisation models. In its simplest form, LP is a method of determining a profit-maximising combination of farm enterprises that is feasible with respect to a set of constraints. The following section presents a simple linear programming framework for a single period. This modelling framework can be expanded to accommodate spatial variability, price uncertainty, and multiple periods.

For a given land-use unit, the LP model requires the specification of the following:

(a) Alternative land-use activities, their unit of measurement, their resource requirements, and any specific set of constraints, such as labour, fertilisers, etc.
(b) The fixed resource constraints, such as maximum land size and allowable nutrient load; and
(c) The economic value generated from each activity

The mathematical formulation of the problem is presented below:

X_j: the level of the jth land-use activity, such as hectares of rice grown. Let n denote the number of possible activities. $j = 1$ to n.
C_j: net revenue per unit of the jth production activity.
a_{ij}: quantity of the ith resource (for example, hectares of land or days of labour) required to have one unit of jth activity. Let m denote the number of resources. $i = 1$ to m. These coefficients represent the technology of activity-specific production functions.
b_i: quantity of the ith resource restricting production. There are m restricting resources.

With the above notation, a simple LP model that maximises the objectives subject to the limitations imposed by the resources available and regulations may be written as follows.

That is, find $X_j$values that maximise Z:

$$Max\, Z = C_1X_1 + C_2X_2 + \ldots . + C_nX_n$$

Subject to

Table 16.1 A linear programming table

Row name	Columns			RHS	
	X_1	X_2	…………	X_n	
Objective function	C_1	C_2	…………	C_n	
Resource constraints					
1	a_{11}	a_{12}	…………	a_{1n}	$<=b_1$
2	a_{21}	a_{22}	…………	a_{2n}	$<=b_2$
.	.	.	.	.	.
.	.	.	.	.	.
M	a_{m1}	a_{m2}	…………	a_{mn}	$<=b_m$

$$b_1 \geq a_{1,1}X_1 + a_{1,2}X_2 \ldots. + a_{1,n}X_{n.}$$

through to

$$b_{1m} \geq a_{m,1}X_1 + a_{m,2}X_2 \ldots. + a_{m,n}X_n$$

where $b_i=$ quantity of the ith resource restricting production.
There are m restricting resources.

$$X_j \geq 0 \text{ all } j$$

The problem is to find the land-use plan defined by a set of activity levels X_j, where $j = 1$ to n, which has the largest possible total gross margin Z but which does not violate any of the fixed resource constraints without involving any negative activity levels. This problem is known as the primal linear programming problem.

The problem defined above is portrayed in Table 16.1, a matrix showing all the coefficients of the algebraic statement of the model. The first row shows the equation to be maximised and is called the objective function. In the current problem, the objective function is to maximise net returns from various activities. However, this could be a composition of various objectives or multi-objectives, for example a blend of maximising crop returns and biodiversity quantified in some form. Quantifying biodiversity, however, is beyond the scope of this chapter. The constraints are shown in rows, and the activities are shown in columns. b_i, the fixed resource supply coefficients, are called the right-hand side (RHS) of the problem. They have all been stipulated as less than or equal (<=) constraints in this example, although it is possible to include equality constraints (=) or greater than or equal (=>) constraints.

In order to further simplify the concept, we assume there are only two activities, $X_1$and X_2, and two resource constraints, b_1 and b_2. Figure 16.1 depicts the model.

The feasible area (two variable cases and two constraints) (Fig. 16.1): shaded area – a combination of variables that is feasible with respect to resources. The reality is multidimensional when more activities and constraints are involved but follow the same principles.

The optimal solution is a feasible solution that provides the maximum profit. Figure 16.2 illustrates profits associated with two iso-profit lines. The iso-profit line

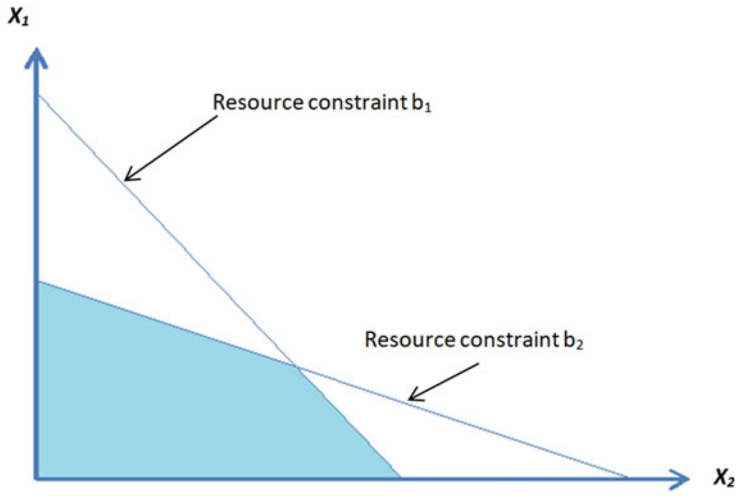


Fig. 16.1 Graphic representation of linear programming

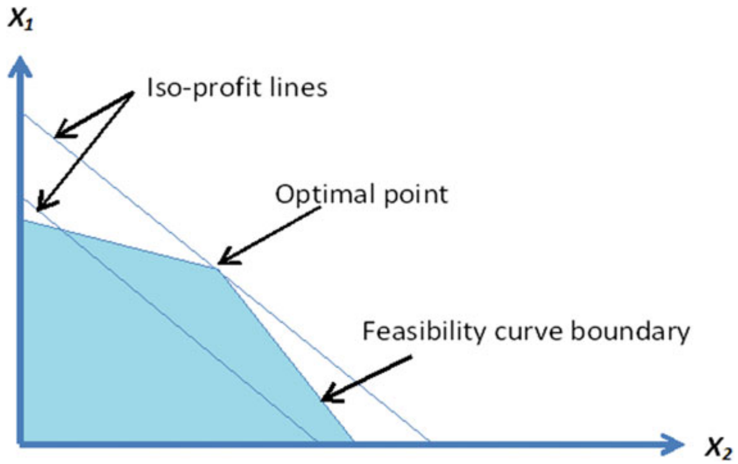


Fig. 16.2 Finding the optimal solution using a graph

that touches the last point in the feasible region becomes the optimal point. As long as the slope of the iso-profit line is not equal to the slope of one of the resource constraints, the optimal solution will be unique.

The above problem is described as a primal problem. This primal problem can assist a land manager in deciding which activities to select and how much of each activity can maximise the objective. Further increases in the objective are only possible if the land manager can acquire additional units of the fixed resources. This raises an important question: by how much does the value of the objective function change when the availability of a fixed resource is changed by one unit? In economic theory, this is known as the value of a marginal product. In LP literature, these values are called shadow prices.

16.2.2 Using Excel 'Solver' to Obtain Optimal Solutions to an LP Problem with Hypothetical Data

This section provides a step-by-step guide to developing a basic LP model and resolving it using the 'solver' add-in function in Microsoft Excel.

Suppose that a farmer can cultivate three crops, rice (R), chilli (C), and onion (O), with the net profit of cultivation being LKR 40,000, LKR 60,000, and LKR 50,000 per acre, respectively. Rice requires 15 man-days per acre per season, while chilli requires 60 man-days per acre, and onion requires 50 man-days per acre. The water requirement per acre of rice, chilli, and onion is 1000 mm, 700 mm, and 300 mm, respectively. The farmer has access to 10 acres of highland and 8 acres of lowland. He has access to 12,000 mm acre of irrigation water per season, and the maximum number of man-days per season is 1000.

Suppose that the land-use planning restriction prohibits the cultivation of crops other than rice in the lowlands.

The farmer's problem may be specified thus:

Maximise: $40{,}000\ R + 60{,}000\ C + 50{,}000\ O$
subject to
$15\ R + 60\ C + 50\ O \leq 1000$ man-days
$1000\ R + 700\ C + 300\ O \leq 12{,}000$ mm
$C + O \leq 10$ highland
$R \leq 8$ lowland
$C \geq 0$
$R \geq 0$
≥ 0

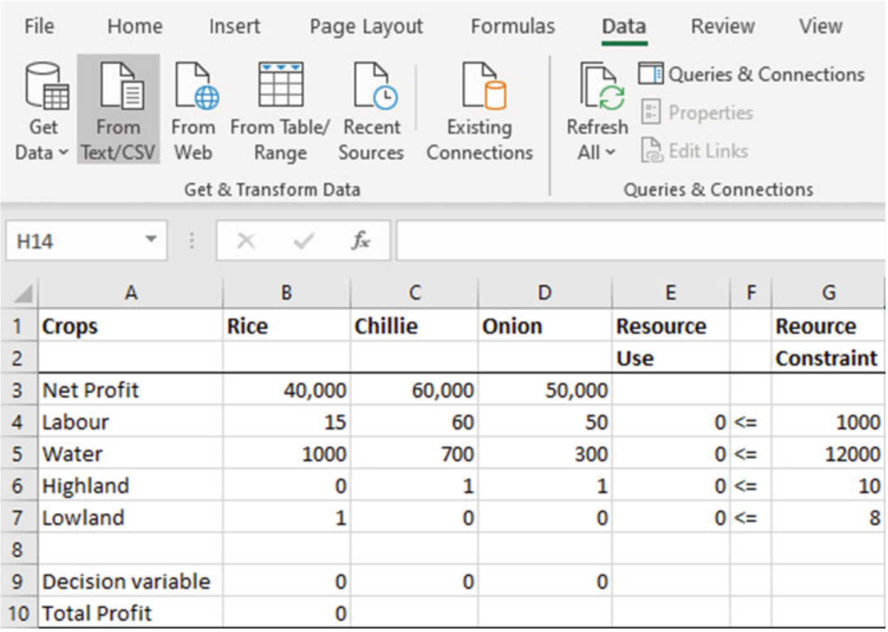
The solver facility in Excel can easily be used to find the optimal solution to the above model. Some detailed instructions to install the solver and obtain the optimal solution to a sample LP problem can be found in https://www.excel-easy.com/data-analysis/solver.html.

The problem can be specified in Excel, as shown in Fig. 16.3 below.

The formula to calculate total profits should be included in cell B10. It is the sum product of the optimal land usage by the three crops, specified in B9:D9, and the profitability of each, specified in B3:D3. Hence, the total profits are given by B3*B9 + C3*C9 + D3*D9.

The usage of labour, water, highlands, and lowland are shown in cells E4, E5, E6, and E7. It is the sum product of the optimal land usage by the three crops, as specified in B9:D9 and the respective resource usages.

Cells F4, F5, F6, and F7 show the availability of labour, water, highlands, and lowlands, respectively.



	A	B	C	D	E	F	G
1	Crops	Rice	Chillie	Onion	Resource		Reource
2					Use		Constraint
3	Net Profit	40,000	60,000	50,000			
4	Labour	15	60	50	0	<=	1000
5	Water	1000	700	300	0	<=	12000
6	Highland	0	1	1	0	<=	10
7	Lowland	1	0	0	0	<=	8
8							
9	Decision variable	0	0	0			
10	Total Profit	0					

Fig. 16.3 Excel representation of optimal solution to the model

The following details need to be entered in the solver function (Fig. 16.4).

The optimal solution is given in rows B9:D9 once the above details are entered. For the above problem, the optimal solution is presented in Fig. 16.5. The Answer Report in Excel provides detailed results.

The above solution shows that when the lowland is cultivated with rice, with the highland cultivated with chilli and onion, the farmer earns LKR 845,000 from the cultivation. The results also show that only 645 man-days will be employed even though the farmer had access to 1000 man-days, suggesting that labour is not a binding constraint. Water and land resources are fully utilised, suggesting that improved access to those resources might increase the profitability of farming. The Excel report provides sensitivity analysis on the results when the bar titled 'sensitivity' is chosen in the solver results. This feature allows us to ascertain whether the resources are binding (Fig. 16.6).

An extract of the sensitivity analysis report in Table 16.2 below shows that only water, highlands, and lowlands are binding resources. The shadow prices are useful indicators to ascertain the extra profits that can be obtained by relaxing the binding constraints. Table 16.2 shows that an increase in water availability by 1 mm can increase profitability by LKR 25 and an increase in 1 acre of highland can increase profitability by LKR 42,500 while keeping other resources at constant levels.

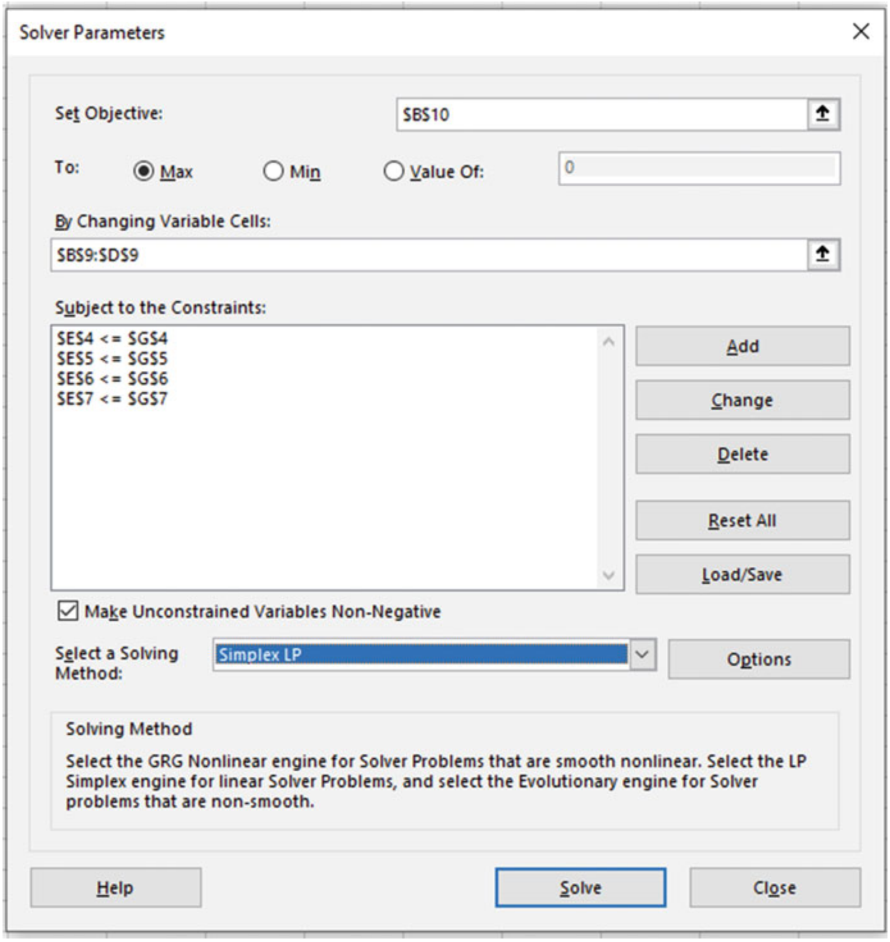
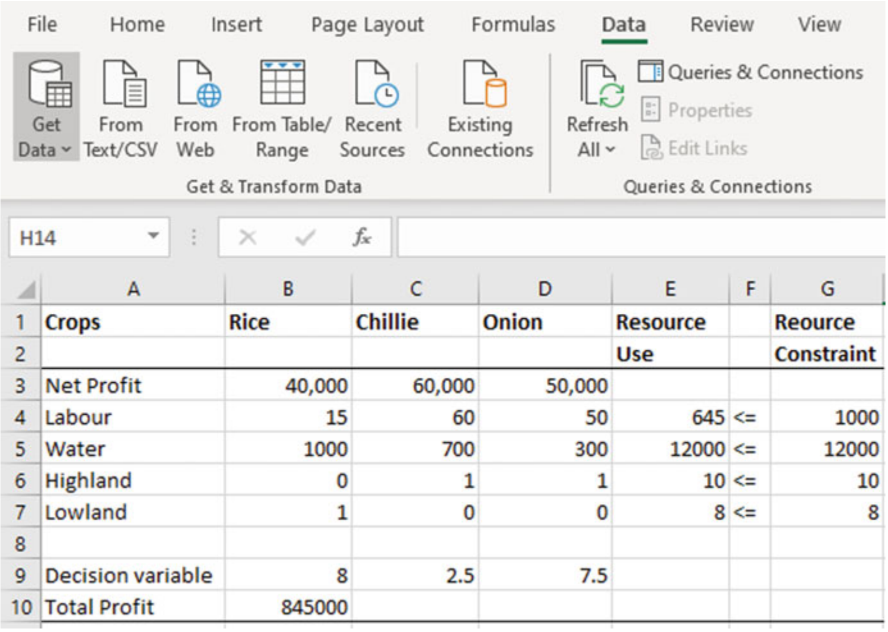


Fig. 16.4 Solver parameters

16.2.3 Policy Experiments and Simulations with Hypothetical Data

The basic model shown above can be used to simulate crop plans under alternative land-use planning regulations. This section develops a series of models

Scenario 1: Modelling of a Land Conversion Regulation—Lowland to Highland
Let's speculate that farmers are allowed to use a portion of their lowlands for the cultivation of highland crops and our farmer from the example above decides to cultivate chilli in lowlands. In order to assess the optimal crop plan under this reform, the model needs to be extended to accommodate a lowland chilli crop (C(LL)) and a highland chilli crop (C(HL)). Table 16.3 below shows the model and the optimal crop plan. The LP problem is now specified thus:



	A	B	C	D	E	F	G
1	Crops	Rice	Chillie	Onion	Resource		Reource
2					Use		Constraint
3	Net Profit	40,000	60,000	50,000			
4	Labour	15	60	50	645	<=	1000
5	Water	1000	700	300	12000	<=	12000
6	Highland	0	1	1	10	<=	10
7	Lowland	1	0	0	8	<=	8
8							
9	Decision variable	8	2.5	7.5			
10	Total Profit	845000					

Fig. 16.5 Optimal solution results

Maximise 40,000 R + 60,000 C(LL) + 60,000 C(HL) +50,000 O
subject to
15 R + 60 C(LL) + 60 C(HL) +50 O $\leq$ 1000 man-days
1000 R + 700 C(LL) + 700 C(HL) + 300 O $\leq$ 10,000 mm
C(HL) + O $\leq$ 10 highland
C(LL) + R $\leq$ 8 lowland
C(LL) $\geq$ 0
C(HL) $\geq$ 0
R $\geq$ 0
$\geq$ 0 The solution to the above problem is given in Table 16.3.

This shows that the farmer could earn a profit of LKR 1,030,952 through the land-use change. The farmer allocated 6.76 acres of lowland to chilli cultivation, which enabled him to increase his profitability.

Scenario 2: Modelling a Provision of Irrigation Water

A similar experiment can be performed to evaluate the change in profitability as a result of increasing the availability of irrigation water by 1000 mm in the scenario 1 farm. This results in the following effects: increase of rice area by 0.47 acres, reduction of lowland chilli by 0.47 acres and increase in highland chilli by 2.14 acres, and reduction of onion by 2.14 acres. As a result of these land-use changes, the farmer's profit has increased by LKR 11,905.

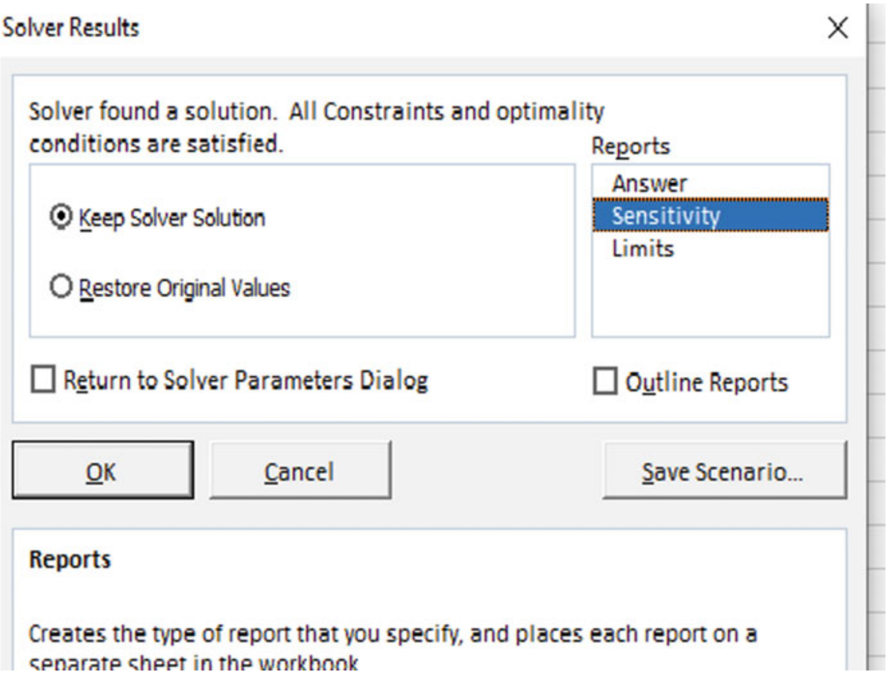


Fig. 16.6 Conducting sensitivity analysis on the results

Table 16.2 An extract of the sensitivity analysis

Cell	Name	Final value	Shadow price	Constraint R.H. side	Allowable increase	Allowable decrease
$E $4	Labour use	645	0	1000	1E+30	355
$E $5	Water use	12,000	25	12,000	3000	1000
$E $6	Highland use	10	42500	10	3.33	4.28
$E $7	Lowland use	8	15000	8	1	3

Scenario 3: Modelling Food Security and Fallow Land Regulation

Due to food security and environmental reasons, land-use planners sometimes impose regulations requiring farmers to set aside a portion of land to lie fallow. Suppose that the above farmer is subject to a similar regulation; he is asked to allocate at least 25 per cent of land for a staple crop like rice and leave three acres of land to lie fallow. In order to obtain the optimal plan under this regulation, our model needs to be extended.

Table 16.3 Solution to the LP problem

Crops	Rice	Chilli LL	Chilli HL	Onion	Resource use		Resource constraint
Net profit	40,000	60,000	60,000	50,000			
Labour	15	60	60	50	1000	<=	1000
Water	1000	700	700	300	12,000	<=	12,000
Highland	0	0	1	1	10	<=	10
Lowland	1	1	0	0	8	<=	8
Decision variable	1.24	6.76	7.57	2.43			
Total profit	1,030,952						

Since there are two types of lands, this requires the introduction of two fallow activities. Table 16.4 shows the model and the optimal crop plan with a food security constraint and a minimum of 3 acres of fallow land.

Table 16.4 shows that when the farmer leaves 3 acres of lowland as fallow lands, he is forced to cultivate 2 acres of rice, and the remaining 3 acres of lowland is cultivated with chilli. The farmer ends up earning only LKR 860,000 owing to the constraints imposed.

16.2.4 Extensions to the LP Model – Bioeconomic Modelling

Multiple competing demands on land have increased the pressure on natural resources and caused demand-driven land-use changes. Agricultural expansion and intensification have increased global food production substantially. Historically, such land-use changes have caused large changes in ecosystem service supply. The decline of non-provisioning ecosystem services (ESS), such as clean water availability or soil fertility, has made ecosystems more vulnerable. Ecosystem functioning and services also depend on biodiversity, which is negatively affected by agricultural intensification and land expansion in general. Typically, these problems in agricultural land use are framed as trade-offs between provisioning ESS (i.e. food, fibre, biomass for energy), regulating and supporting services (i.e. water purification, soil retention, or climate regulation), and cultural services. The basic theoretical and empirical concepts discussed below underpin more sophisticated, integrated bioeconomic modelling applications, such as modelling the impact of policies and climate change on land use and water quality (Zessner et al. 2017) and optimising land use decision-making to sustain agricultural profits, biodiversity, and ecosystem services (Kennedy et al. 2016).

There is an increasing interest in ecosystem services relative to land use where ecosystem services are the benefits people derive from ecosystems. Basically, land use drives ecosystem services, not the other way around. Nevertheless, the thought is that restrictions could be placed on land uses so as not to (seriously) diminish the ecosystem services provided – this in turn raises the issue of how ecosystem services are valued.

Table 16.4 The model and the optimal crop plan with a minimum of 3 acres of fallow land

Crops	Rice	Chilli LL	Chilli HL	Onion	Fallow LL	Fallow HL	Resource use		Resource constraint
Net profit	40,000	60,000	60,000	50,000					
Labour	15	60	60	50			810	<=	1000
Water	1000	700	700	300			11,100	<=	13,000
Highland	0	0	1	1		1	10	<=	10
Lowland	1	1	0	0	1		8	<=	8
Fallow land					1	1	3	>=	3
Food security	1						2	>=	2
Decision variable	2	3	10	0	3	0			
Total profit	860,000								

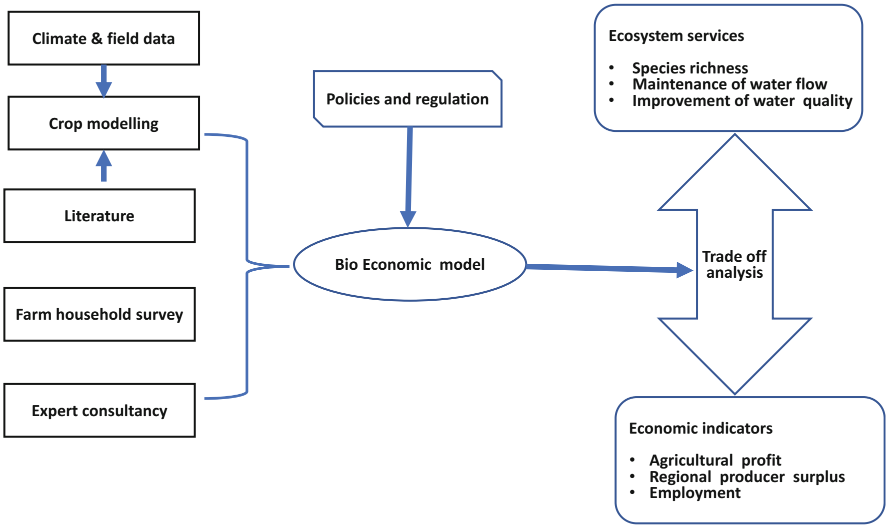


Fig. 16.7 A basic structure of a bioeconomic model

Bioeconomic models are ideal tools to assess the behaviour of a farming household in light of biological and ecological constraints. Bioeconomics integrates two disciplines, economics and biology, which are at the centre of the decision-making of a farm household. Integrating both components requires a collaboration of multiple disciplines to address the dynamic interrelationships between ecological and socio-economic systems, but advances in mathematical programming have made it possible to build more comprehensive models. Bioeconomic models can assist land managers to efficiently adapt land use to changing economic, technological, and regulatory environments. Further bioeconomic modelling has become a useful tool for anticipating the outcomes of policies and technologies before their implementation.

Given the complexity of bioeconomic issues, there is no universal model available. A large variation in bioeconomic models forms a continuum between biological process models, to which an economic component has been added, and economic models, which include some biophysical components. Most of the integrated bioeconomic models include economic, social, and ecological aspects.

This led to the development of context-specific models or the adaptation of existing models. Bioeconomic models could engage either simulation or optimisation and range from farm-scale to catchment, regional, and national models (Castro et al. 2018). A basic structure of a bioeconomic model is presented in Fig. 16.7.

A basic structure of a bioeconomic model is presented in Fig. 16.7. Farm household surveys and interviews with experts from the agricultural extension service and several institutions can be used to specify a representative cropping pattern for average farmers. This cropping pattern serves as the empirical basis for the development of the linear programming model. Farm household surveys are useful to calculate gross margins for relevant crops, quantities of labour, and other inputs required for each cropping activity and the availability of production factors in farm households (land, labour and capital).

Literature can provide technical coefficients for the bioeconomic model and parameters for the crop model. Crop models can be calibrated based on field experiments, agronomic practices, and associated soil parameters. Crop models such as APSIM are useful for simulating new technologies on crop yields, nutrient discharges from root zones, and temporal variation due to climate variability and change. Crop model yields and nutrient discharges are then incorporated into the bioeconomic model. Various policies or regulations with economic and environmental focuses, such as fertiliser subsidy and nutrient discharge limits, can be simulated to carry out trade-off analysis between economic and environmental objectives to make informed decisions. Expert panel advice or hydrological models could be used to estimate crop water demand and seasonal water availability.

The model in Table 16.5 below provides an application of the above concept. In this model, biological response functions of the rice crop have been modelled as three different decision variables. Production functions of the three rice crops have been specified in such a way that crops that require low doses of nitrogen produce relatively lower yields. Yields and usage of nitrogen are translated to the profitability of each crop, but the farmer is also constrained by the availability of nitrogen. Suppose that the farmer is required to set aside 0.5 acres for a legume in order to maintain the fertility of the land, produce a minimum of 560 kg of rice to secure staple food for the family, and cultivate a minimum of 0.25 acres of maize to meet the requirement of a forward contract arrangement in the value chain. Table 16.5 shows the constraints as well as the solution.

The last row shows the optimal crop mix and profits earned. Capital, nitrogen, labour, and lowland are the binding constraints. The farmer just meets the requirements on fertility maintenance, food security, and the forward contractual arrangement. It is evident that of the three types, the farmer should drop the rice crop that is least responsive to nitrogen so as to maximise profits. Black gram is grown in the upland, not in the lowland, to meet the fertility requirement as the lowland is a binding constraint. Green chilli, brinjal, and red onion help him in achieving the maximum profit, which is LKR 1,065,814, under the given circumstances.

Seasonality in resource demand can be easily integrated by augmenting the model by incorporating time-specified resource constraints (rows) such as month-wise labour and water demand and supply. Further, by introducing transfer rows, unused resources could be carried forward to the next period. Household cash requirements for consumption needs can be incorporated as an activity.

These theoretical and empirical concepts underpin more sophisticated integrated bioeconomic modelling applications, such as modelling the impact of policies and climate change on land use and water quality (Ramilan et al. 2011; Zessner et al. 2017) and optimising land use decision-making to sustain agricultural profits, biodiversity, and ecosystem services (Kennedy et al. 2016).

Table 16.5 A simple bioeconomic model

Crops	Rice N150	Rice N100	Rice N50	Maize	Black gram lowland	Black gram highland	Chilli	Brinjal	Onion	Resource use		Resource constraints
Net profit	52,000	44,444	30,000	20,000	2500	2500	350,000	330,000	300,000			
Yield (kg/ac)	3700	3200	2500	3000	1200	1200	4000	9800	3300			
Unit cost (LKR/ac)	57,936	55,436	52,936	60,000	18,000	18,000	256,000	225,400	310,200	900,000	<=	900,000
Nitrogen (kg/ac)	150	100	50	56	4	4	71	70	62	350	<=	350
Labour (md/ac)	29	28	27	25	12	12	72	120	83	300	<=	300
Water req. (mm)	1000	1000	1000	650	300	300	750	800	500	3393	<=	5000
Lowland	1	1	1	–	1	–	1	–	–	2.5	<=	2.5
Upland	–	–	–	1	–	1	–	1	1	2.31	<=	2.5
Fertility constraint	–	–	–	–	1	1	–	–	–	0.5	>=	0.5
Food security constraint	560	560	560	–	–	–	–	–	–	560	>=	560
Value chain restrictions	–	–	–	1	–	–	–	–	–	0.25	>=	0.25
												Total profit
Decision variables	**0.5**	**0.5**	**–**	**0.25**	**–**	**0.5**	**1.5**	**0.6**	**0.98**			**1,065,814**

Linear programming models should never be considered as ultimate tools. Rather, they are always a work in progress, always capable of being improved with new information. However, before they can be used to help predict responses to changes in technology, infrastructure, prices, resource availability, or policies, they need to be validated to assure the users that they do, in fact, *adequately* reflect conditions in the communities being modelled.

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16.3 Take-Home Assignment

Village tank cascade systems, though degraded now, were efficient hydrological systems in the dry zone of ancient Sri Lanka. There were four distinctive zones in these systems for agricultural activities: (a) lowlands, (b) highlands (*chena*), (c) a wetland underneath the tank (*Kattakaduwa*), and (d) an upland patch above the tank. Each zone had one or several components of agricultural and ecological significance. Lowlands were devoted to paddy under rotational cultivation (*thattu maru* or *katti maru*), chena for highland crops (other grains and vegetables in slash-and-burn cultivation), and *Kattakaduwa* for aquatic plants. The upland was allocated for the forest. When each zone is used for its specified purposes, the sustainability of the system was at its maximum.

In order to restore these cascade systems, some argue that land use should be restricted to specific use and tenurial patterns, as in the past, and institutionalised through regulatory measures. If implemented, such regulations would have a multitude of effects on the economy, society, and the environment of the system. Consider that you are the Divisional Secretary responsible for a cascade system. Specify a bioeconomic model that would enable you to compare the resource-use efficiency of the village and the environmental benefits with and without the land-use and tenure restrictions.

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Economic Analysis of Climate Change Adaptations in Agriculture

17

L. H. P. Gunaratne

Abstract

Climate change is a global phenomenon, and agriculture is one of the most affected sectors due to its impacts. Adaptation to climate change in the sector is progressively recognised as an integral part of any policy. The economic analysis of adaptations is much needed in appraising efficient adaptation strategies as to what, where, and when adaptations should be implemented. Such analysis is vital for making informed decisions on the value, finance, and feasibility of adaptation projects and strategies. In this chapter, three prospective approaches are discussed, including their strengths and limitations. Although the agro-economic models are heavily dependent on process-level simulation models, the economic concepts and methods are not well incorporated. However, sound modelling approaches can synthesise knowledge, summarise information, and evaluate climate change adaptations. The cross-section econometric analyses with Ricardian models need adequate climate variation and ignore the price and impacts of inputs, such as irrigation. However, the latter approach provides information on the directions for adaptations to climate change. Of the approaches discussed, despite some issues, cost-benefit analysis is the most valuable analytical tool, if focused and specific, in projecting and monetising the impacts of climate change and identifying the benefits and costs of adaptation.

Keywords

Adaptation · Agro-economic models · Cost-benefit analysis · Ricardian approach

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17.1 Introduction

Climate change has been identified as one of the most pervasive and threatening issues in the world, and there is much concern that it will have unprecedented implications on where people can settle, grow food, and rely on functioning ecosystems essential for the services they provide (United Nations Framework Convention on Climate Change 2012). Climate change brings significant variations in global temperature, precipitation, and other meteorological parameters that occur over a longer period due to natural processes or anthropogenic activities.

Climate change includes changes in maximum, minimum, and average temperatures and extreme weather events, such as heavy rains or droughts, all of which have definite impacts on agriculture. The Intergovernmental Panel on Climate Change (IPCC) warns that in the long run, climatic changes could affect agriculture in several ways, such as alterations in the quantity and quality of crop yields, making demands for increasing water usage (irrigation), and requiring larger volumes of agricultural inputs, such as herbicides, insecticides, and fertilisers (Intergovernmental Panel on Climate Change 2014). At the same time, agriculture contributes to global warming in numerous ways, including through the release of greenhouse gases and the conversion of forests for farming. Agriculture is the most sensitive and vulnerable sector with respect to climate change, in terms of land and water use, livelihood, and food security.

Adaptation and mitigation are two important approaches available to tackle the anticipated impacts of climate change. The IPCC defines mitigation as a human intervention to reduce the sources or enhance the sinks of greenhouse gases, whereas climate adaptation is adjustments to minimize potential harm or to cope adequately with the consequences. Mitigation deals with the causes of climate change, while adaptation wrestles with the effects of the phenomenon. Adaptation is considered the most practicable intervention from the perspective of the developing world and progressively recognised as an important element of any climate change policy. The ability to adjust to minimise the negative impacts of climate change and maximise any possible benefits is known as adaptive capacity. Successful adaptation interventions can reduce vulnerability by building on and strengthening existing coping strategies.

This chapter will focus on the economic analysis of climate adaptation (as opposed to climate mitigation) strategies.

17.2 Climate Change Adaptation in the Agricultural Sector

There are different types of adaptation strategies: local, regional and national, as well as sectoral. The sectoral adaptation strategies include agriculture, energy, water resource, public health, etc., while the type of strategies includes physical, social, market oriented, and regulatory. There are large numbers of climate change adaptation strategies available for use in different fields (Intergovernmental Panel on Climate Change 2007).

Adaptation measures can be supply-side (such as providing more water), demand-side (such as reuse of water), and combinations of both (such as changing crop varieties). Some adaptation measures may be implemented at the individual or farm level, while others require a collective action (e.g. rainwater harvesting) or investments at the agency or government level (e.g. building dams or releasing new cultivars that are more water efficient) (Jawahar and Msangi 2006). Some of the important farm-level adaptation strategies in agriculture include crop diversification, mixed crop-livestock farming systems, use of several crop varieties, changing of planting and harvesting dates, and mixing of less-productive but drought-resistant varieties with high-yield water-sensitive crops (Bradshaw et al. 2004). The assessment of farm-level adaptation measures is vital for the formulation of policies as a tool for managing a variety of risks associated with climate change in agriculture.

17.3 Economic Analysis of Climate Change Adaptation

The economic analysis of adaptation strategies is useful for identifying and evaluating efficient adaptation measures and deciding the necessary actions and their timing as to what, where, and when such adaptations should be practised. These appraisals are useful for making informed decisions on the value, efficiency, and feasibility of adaptation projects and strategies and also for accessing the financing for climate change adaptation strategies. For example, appraisals are required to access several of the financing mechanisms available under the United Nations Framework Convention on Climate Change (UNFCC) to developing countries to implement climate change adaptation programmes.

The economic evaluation of climate change adaptations is somewhat different from a normal economic appraisal as it has to take into account different timescales, various dynamics, and multiple sources of uncertainties. Uncertainties in adaptation can come from sources through incomplete or conflicting information, measurement errors, and subjective opinions. Adaptation investments are dynamic processes that should deal effectively with new climatic and socio-economic conditions. The analysis of the economics of adaptation supports a policy-oriented approach with a greater emphasis on mainstreaming adaptation into current policies and developments.

In this chapter, three useful approaches in the economic analysis of agriculture adaptations, namely cost-benefit analysis, agro-economic models, and structural Ricardian model, are discussed.

17.4 Cost-Benefit Analysis for Evaluation of Adaptations

17.4.1 Cost-Benefit Analysis

Cost-benefit analysis (CBA) is a decision-making tool that acts as a guide for identifying policy options or investment projects to ensure the efficient allocation of financial resources. It is conducted ex ante to determine whether the benefits of a project outweigh the costs of investment or to compare several investment alternatives in terms of anticipated costs and benefits. In the standard CBA, all measurable matrices are expressed in monetary terms and then adjusted for the time value of money. The difference between the summation of the discounted values of benefits and the costs can then be expressed as the net present value (NPV). Additionally, CBA assesses the benefits and costs using two methods: financial and economic. Financial analysis assesses the direct costs and benefits of a single unit; economic analysis attempts to include indirect costs and benefit additionally. The aim of these analyses is to ensure the efficient allocation of resources by providing detailed information to policymakers and public sector stakeholders (Boardman et al. 2014).

17.4.2 Utility of CBA for Evaluating Climate Change Adaptations

Cost-benefit analysis is considered the best approach to assess the economics of adaptation. It is listed as a methodology to use for choosing the preparatory elements of the National Adaptation Plans and to rank and prioritise adaptation options (United Nations Framework Convention on Climate Change 2012).

The outcome of the CBA depends on how accurately the individual costs and benefits are estimated. The stream of benefits should be computed using the prices and quantities applicable to each time period. The annual benefit of the adaptation intervention will be the annual value of the changes in the outcome compared to what it would be without the intervention. In computing the cost stream, the capital cost (at the beginning) and the operating and maintenance cost (annual) should be taken into account.

The cost of every aspect of the adaptation action needs to be gathered when applying CBA for the evaluation of climate change adaptation projects. Costs may include all the budgeted items (machinery, labour, and other inputs). In addition, negative externalities (pollution, damage to the ecosystem, etc.) should be first quantified and then monetised to be included in the cost stream.

Estimation of the benefits of adaptation is much more complex than the estimation of costs. This is mainly due to uncertainties relating to future changes in climate, technology, and prices. For example, despite many sophisticated models, weather prediction remains a very uncertain science. Therefore, estimation of the benefits of adaptation measures is difficult due to the uncertainties of the future. One approach to solve this issue is to measure adaptation benefits against the current climate.

However, this would require an estimation of how much adaptation would be required to respond to the present climate change and the anticipated climate change.

The major steps to be followed in applying CBA for agriculture adaptation projects are given below:

1. Define the scope and boundaries of the analysis of the adaptation project.
2. Describe the 'with' and 'without' scenarios.
3. Quantify and monetise the adaptation benefits and costs every year over the duration of the project.
4. Estimate the annual flow of the benefits of agricultural adaptation projects.
5. Compute selected indicators for agricultural adaptation projects.
6. Perform sensitivity analysis with reference to climate change scenarios, and
7. Make recommendations (Food and Agriculture Organisation 2018).

There are two major situations in evaluations of adaptations: (a) stand-alone adaptation projects or activities where the boundaries are relatively clear and (b) comprehensive adaptation programmes, which include many aspects and cover a broader geographical area and a longer time horizon. Cost-benefit analysis is applicable in both scenarios.

In comprehensive adaptation programmes, there may be several factors that influence the anticipated benefits of the adaptation interventions over time. For instance, there may be changes in the demography and economic situation of the targeted area, in addition to technological changes. These changes may be driven by increases in crop yield with the introduction of newly bred drought-tolerant species or an increase in the percentage of the population that is vulnerable to these changes. Therefore, the estimation of the benefits stream should be undertaken cautiously as there may be indirect as well as direct benefits.

In the analysis of comprehensive adaptations, the first step is the development of scenarios pertaining to climate change, environmental consequences, and socio-economic changes. This should be followed by the calculation of the stream of costs and benefits to compute the net present value.

A potential set of climate change scenarios can be generated from models like the Global Circulation Models (GCMs), where each scenario is treated as a possible outcome. The entire range of possible outcomes under that context provides climate uncertainty. The time is also important here. If the adaptation projects last for 10 years, then the climatic scenarios should be examined for the next 10 years. If climate change is not significant, then one can consider only the present climate conditions.

Additionally, there might be other environmental changes over time. For example, an increase in the daily average temperature during the cultivation season in a particular geographical region may lead to changes in the amount of precipitation affecting the water supply. Therefore, the selected adaptation strategy should be able to address these related environmental changes.

The data pertaining to different climate change scenarios can be freely accessed at the Data Distribution Center of the IPCC (www.ipcc.data.org). However, these need to be processed and interpreted before running a CBA. The IPCC assessment reports include the scenarios developed by running the GCMs.[1]

17.4.3 Issues in Using CBA for Evaluating Adaptations

There are several potential shortcomings in using CBA for evaluating climate adaptations. In reality, CBA applied to climate change adaptation is more complicated than the general or standard CBA as adaptation is a complex human process influenced by uncertainties and constraints.

Furthermore, most of the time, projects are not dealt with by means of dedicated discrete adaptation. Rather, adaptation is integrated into a project, then it may not be that meaningful to analyse the costs and benefits of the adaptation component separately from the rest of the project. It is also important to note that although individuals or societies can autonomously adapt to climate change at least to some extent, CBA does not take autonomous adaptation into account. Additionally, CBA depends on available scientific knowledge on climate change – the magnitude of the change of a particular climate parameter during a period, how ecosystems will change, and so on. In some instances, the scientific information is generated by climate models developed under a set of assumptions. Therefore, the economic evaluations and the validity of these models themselves are based on assumptions.

More significantly, in general, economic analysis has its own limitations. One is that private and public climate change adaptation activities are decided based on many criteria other than economic aspects: community preferences, social organisation, political will, financial resources, etc. In addition, some climate change impacts and the benefits of adaptation cannot be acceptably measured in monetary terms, even by using non-market valuations. However, the results of the economic analysis do have some importance in a broader decision-making context. Analytical approaches, such as multi-criteria analysis and qualitative CBA, are quite capable of accommodating the non-economic aspects of climate change and adaptation.

Despite the shortcomings, CBA is still a useful analytical tool if it is focused properly. In some cases, rigorous models are needed. Activities such as building databases and decision-support systems and the skills to work with them will contribute to many adaptation activities, but it is intrinsically difficult to identify and put a monetary value on that contribution. Incorporating equity considerations into the analysis is not possible with CBA. Carrying out sensitivity analyses is also useful in many contexts.

[1]General Circulation Models, also known as Global Circulation Models (GCM), represent the physical processes in the atmosphere, the ocean, and the land surface. These GCMs provide insights into climate changes on a regional scale. However, the utility of GCMs in regional work is limited due to the coarseness of their scale.

17.5 Agro-Economic Models

Agro-economic models combine crop models that simulate plant growth and development and economic models. The variations due to climate change or adaptation measures as generated by the crop simulation models are interpreted as changes in the supply, predicted as price changes.

Crop simulation models mimic the processes of growth and development of crops as a function of weather and soil conditions and crop management. These models are capable of predicting crop yield, maturity date, etc. based on weather conditions, carbon dioxide levels, and volume of external inputs. The computational part of these crop models relies on existing knowledge of physics, agronomy, and physiology and responses to the environment.

The physiology-based crop simulation models are important tools in extrapolating climate change impacts from a wide range of evidence on soil types, crop management regimens, crops, and climate change scenarios (Asseng et al. 2015). These models are capable of quantifying the temporal and spatial variability of crop yields due to climate change and have the capacity to evaluate different adaptation options in a relatively shorter time period and at a reasonably low cost. Asseng et al. (2015) indicate that these simulation modes play a crucial role in improving our understanding of adaptation to climate change and the effectiveness of alternative adaptation measures. There are a number of crop simulation models available, such as APSIM, CERES, CROPSYST, COUP, DAISY, EPIC, FASSET, HERMES, MONICA, STICS, and WOFOST (Tapio et al. 2016).

These crop simulation models have been used extensively over the past four decades. For instance, the Decision Support System for Agrotechnology Transfer (DSSAT) has been used by researchers worldwide as it is capable of dealing with 16 different types of crops. Similarly, the CERES crop model included in the supported decision system (DSSAT, V.4.0) has been used for assessing the impact of climate change on cropping responses (Meza et al. 2008). The model accommodates changes in CO_2 concentration, fertilisation, irrigation schedule, and the use of different varieties. This model inputs daily maximum and minimum temperature, rainfall, photosynthetically active radiation (PAR), soil and management conditions, and genetic-crop parameters (Jones et al. 2003). Similarly, the Agricultural Production Systems sIMulator (APSIM 2020, https://www.apsim.info/apsim-model/) is a comprehensive model developed to simulate biophysical processes in agricultural systems, particularly as they relate to the economic and ecological outcomes of management practices in the face of climate risk. It is also being used to explore options and solutions for food security, climate change adaptation and mitigation, and carbon trading problem domains.

One important fact about the crop models is that these should be calibrated to fit local conditions. Most of the available crop models cover only the major crops, such as rice, maize, soybean, and wheat, while fruit and vegetables have not received much attention. The crop models are heavily dependent on accurate climate, water, and soil data.

Adams et al. (1990) developed agro-economic models using mathematical programming, where farmers could select the crops that give the highest net revenue. Thus, farmers could choose the crops based on the predicted yield and price changes due to anticipated climate changes. As cited by Akram et al. (2014), the agro-economic models could be used to evaluate adaptation strategies. They have suggested that the process would proceed as follows: (a) compare the observed and the predicted optimal mix yields (under similar geographic and climatic characteristics), (b) observation of the gap between the observed and the maximum possible yields represents the weight of the socio-economic constraints on the land's profitability, (c) test the effect of alternative policies using agronomic models.

Agro-economic modelling should include the following steps: (a) collect climate data for a particular agro-ecological zone for a reasonably long period and the values of the list of parameters specified in the model, (b) obtain crop modelling software and economic optimisation software (e.g. APSIM), and (c) calibrate and run the model. The model should be able to generate which adaptation measure gives the best yields and so on.

Other policy issues, like yield forecasting, industry planning, operations management, and predicting the consequences of management decisions on environmental issues, are also well supported by modelling. Models are not simple mechanisms that can be used just to synthesise information for producing forecasts. Good modelling practice represents a better way of synthesising knowledge about the different components of a system, summarising data, and transferring research results to users.

17.6 Ricardian Approach

Cross-sectional models can be employed to study the relationship between crop production decisions and climate change, assuming that farmers rationally choose their crops and varieties subject to climate and other constraints. Thus, the models can show how farmers adapt to climate change across different climatic zones. This approach is mainly based on primary survey data, followed by econometric model building by examining the behaviour of farmers rather than crop performance. Hence, it does not rely on complex data on the agronomic relationship and provides results on how climate influences farming decisions after removing other factors that affect crop output or net revenue.

The most widely used cross-sectional econometric model is the Ricardian structural model (Bozzola et al. 2017). This hedonic method works under the Ricardian principle, which assumes that land rents reflect expected productivity. The main assumption in the Ricardian model is that land values incorporate all the information about any adaptation that a farmer can undertake. In other words, accepting that farmers adapt to the climate of the place where they live, the Ricardian model captures adaptation implicitly by comparing the net outcomes of farmers in different climates. Thus, in the context of this approach, adaptation is assumed to be complete, in the choice of both inputs and outputs. This approach is capable of examining the long-run impact of climate change, given the likely climate adaptations by farmers

(Bozzola et al. 2017). By directly measuring net revenues, the Ricardian method accounts for the direct impacts of climate on the yields of different crops, as well as the indirect substitution of different inputs, the introduction of different activities, and other potential adaptations by farmers to suit different climates.

The Ricardian approach has been used primarily in the United States to predict the damages from climate change (Mendelsohn et al. 1994; Mendelsohn and Nordhaus 1996; Mendelsohn and Neumann 1999). There have also been a number of other studies on this topic (Dinar et al. 1998; Kumar and Parikh 2001; Reinsborough 2003). These studies indicate that climate change would be slightly beneficial to US agriculture, while it is likely to be harmful to tropical and semi-tropical countries.

In the Ricardian structural model, it is assumed that farmers maximise the net revenue (NR) per hectare as

$$\text{Max NR} = P_i * Q_i\ (R, E) - C_i\ (Q_i, R, E) \tag{17.1}$$

where P_i and Q_i are, respectively, the price and quantity of the commodity; C_i is the relevant cost function; R is a vector of inputs; and E reflects a vector of the environmental characteristics of the farmer's land, including its climate. Given that the farmer chooses input R to maximise NR, one can express the resulting outcome of NR in terms of E alone as

$$\text{NR} = f\ (E) \tag{17.2}$$

One of the main advantages of this empirical approach is that the method not only considers the direct effect of climate on productivity but also includes the adaptation response by farmers to the local climate. Many crops with favourable temperature and precipitation zones either below or above the optimal range will suffer an adverse effect on productivity. This implies that the relationship between net revenue and these climate variables should be hill shaped.

Although the original Ricardian studies used land value as the dependent variable, data on land value are not available in developing countries. Instead, annual net revenue per hectare can be used, assuming that land value is the present value of a future stream of net revenue (Dinar et al. 1998).

17.6.1 Illustration

A study on the economics of climate change adaptation (ECCA) was conducted in Asia by the United Nations Development Programme. The country teams were required to collect cross-sectional data covering the key agro-climatic zones. In the Sri Lankan study, the sampling plan for the island-wide survey was based on the agro-ecological map prepared by the Natural Resources Management Centre of the Department of Agriculture. Within each of the agro-ecological regions, one to three Agriculture Instructor (i.e. extension worker) areas were selected for the data collection based on the spread and area of the agro-ecological regions. Thus, 92 Agricultural Instructor ranges were selected to represent 46 agro-ecological regions. The number of farmers to be contacted for the data collection was decided based on probability proportional to the size. The survey was carried out with the active collaboration of the Provincial Directors of the Department of Agriculture.

In model fitting, it was assumed that each farmer maximises his net revenue (NR) with respect to the exogenous variables, i.e. climate and other characteristics of the farm location (Mendelsohn et al. 1994). Net revenue is regressed on climate and other characteristics of the farm and location in order to estimate the locus of profit-maximising points. The basic Ricardian model was specified as

$$\mathrm{NR} = f\,(T, P, \mathrm{Area}, Z) + U_i \tag{17.3}$$

where NR is the annual summation a farmer would earn in each growing season per hectare, which was calculated as gross revenue minus the cost of cultivation per hectare. The gross revenue is the weighted summation of the yield times the farm-gate price, while the cost includes the expenditure for inputs, such as hired labour, fertiliser, pesticides, and seeds. Land rents, farmer's debts, and family labour were not included in the cost. T is the temperature in Celsius, P is the precipitation in centimetres, Area is the farm size in hectares, and Z is a vector representing terrain, soil, and socio-economic variables. U_i is the error term.

The basic Ricardian models were fitted with the data collected from four ECCA study countries, Bangladesh, Vietnam, Thailand, and Sri Lanka. In this analysis, all NR values are taken in USD, based on purchasing power parity (PPP). Four growing seasons per year were included to capture the seasonal effects following Mendelsohn and Massetti (2017). In each growing season, precipitation and temperature were both measured and expressed as the average figures for the month. Both linear and quadratic terms of the temperature and precipitation were included in the model.

The variables representing soils and the socio-economic aspects were not significant in the country-level analysis and, hence, were dropped in reporting the results. The results for the basic Ricardian regression are shown in Table 17.1. As shown in the table, temperature and precipitation in both the dry season (*Yala*) and wet season (*Maha*) are significant in Sri Lanka. In Thailand and Vietnam, temperature is significant only during the monsoon season, whereas in Bangladesh, this has no effect on net revenue. Again, precipitation in Bangladesh is not significant. The farm area is significant in Sri Lanka, Thailand, and Vietnam. Many of the squared terms in the results are significant because they imply that climate effects are non-linear.

The analysis was extended to compute the marginal effects at the mean of the variable of each country, and a set of climate scenarios was obtained from three climate models for each country (Abidoye et al. 2017). It was revealed that the temperature impacts tend to exert greater influence than the precipitation impacts. Although the monsoons are a critical element of South-East Asian agriculture, the predicted changes in temperature explain most of the variations in the crop yields.

Table 17.1 Results of the country-level basic Ricardian analysis

	Coefficients			
Variable	Bangladesh	Sri Lanka	Thailand	Vietnam
Temperature, dry season	1474 (4026)	6103* (3074.353)	−2699 (2489)	786** (160)
Temperature, dry season squared	−30.0 84.4	−113.5* (55.2)	55 (49)	−15** (3)
Temperature, monsoon season	11,695 (13,203)	−6994* (2828)	10,479* (4698)	−1525** (356)
Temperature, monsoon season squared	−213 (236)	137* (53)	−196** (88)	28** (7)
Precipitation, dry season	−3.44 (4.75)	−8.70** (2.94)	18.45** (8.64)	12.07 (14.54)
Precipitation, dry season squared	0.014 (0.017)	0.019* (0.008)	−0.050* (0.025)	−0.050 (0.09)
Precipitation, monsoon season	−4.62** (1.85)	13.46** (5.13)	4.70 (3.75)	−13.32 (14.57)
Precipitation, monsoon season squared	0.005*** (0.002)	−0.027* (0.011)	−0.012* (0.007)	0.020 (0.030)
Farm area	−5.29 (6.72)	−6.26* (3.15)	−3.82 (2.60)	−10.28* (4.92)
Farm area sq.	0.040 (0.140)	0.085* (0.033)	0.028** (0.010)	0.080 (0.052)
Constant	−176,845 (155,747)	6835 (6858)	−108,528* (42,838)	12,691** (3945)
Observations	358	257	351	275
R-squared	0.063	0.108	0.127	0.28
Terrain	No	No	No	No
Region dummies	No	No	Yes	No

Note: The values in the parenthesis are robust standard errors, *** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$
Source: Abidoye et al. (2017)

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Part V

Sri Lanka Case Studies

Political Economy of Agriculture Policies: Fertiliser Subsidy Reform

18

Nihal Atapattu

Abstract

The specific objective of the chapter is to illustrate how political interests usurped the agenda of the 6-decade-long fertiliser subsidy programme in Sri Lanka. It traces the progression of the programme and highlights the roles of key interest groups in shaping the fertiliser subsidy programme, leading to its eventual domination by political interests.

Keywords

Fertiliser subsidy · Political economy · Agriculture policies · Interest groups · Sri Lanka

18.1 Introduction

Public policies are notably influenced by many interests and interest groups that foresee a benefit by influencing the outcome. Interest groups may have differing, even competing, interests in the outcome of a policy and will compete to influence the decision by dominating the course of policymaking. Interest groups are important in the process of policymaking as they facilitate collective action and citizen participation in government.

Five categories of interests and interest groups can be identified: economic interests, cause groups, public interests, private and public institutional interests, and non-associational groups and interests (Britannica 2020). Economic interests would be the dominant consideration for the relevant interest groups have on input programmes, such as those for fertilizers. The members of these formalised groups

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and associations would gain or lose financial or economic benefits from changes in the policy. This category includes farmers' organisations, business associations of importers, input distributors, and suppliers. The cause groups focus on non-financial/economic issues and promoting a specific cause with a narrow constituency, such as soil health and farm-worker safety. Public interest groups focus on broad issues of general public interest, such as food safety, environmental and ecological protection, etc. Various public and private institutions (parliament, the relevant government departments, think tanks, academic groups, political parties, etc.) will have an interest in farm input subsidy programmes and influencing policy direction. Lastly, policy issues may also spawn informal groups or non-associated groups and interests, which, though lacking a structure, may advocate on policy change through actions such as informal lobbying, protest action, media campaigns, etc.

18.2 Agriculture Policies and Rice Politics in Sri Lanka

In practice, the fertilizer subsidy scheme in Sri Lanka operated as a subsidy on fertilizer for rice. Rice, the staple food of the nation, already had assumed the status of a commodity of great political significance by the time Sri Lanka gained independence in 1948. The focus then was on satisfying consumers. Rice was supplied to consumers at a subsidised rate from 1943, a practice initiated during World War II when select consumers were targeted. Raising domestic rice production was a national priority in the period leading up to and after independence. This was a natural extension of the nationalist aspirations prevailing at the time and a rural development strategy consistent with resource endowments in villages. Thus, land that became available for cultivation after irrigation rehabilitation and irrigation developments was easily assigned to rice production, creating rural employment and increasing the production of an in-demand commodity.

By 1953, rice imports were becoming a burden on the economy, given the rising prices in international markets due to the Korean War and falling export income due to the price boom in export crops. The trade surplus of LKR 345 million in 1951 became a deficit of LKR 200 million in 1952. In 1953, the government attempted to eliminate consumer subsidies on rice by increasing the price of the rice ration from LKR 0.25 to LKR 0.70. This was met with strong public protest, civil unrest, and rioting, leading to the resignation of the prime minister. The rice subsidy was partially restored as a result of the protests. Thereafter, the focus was on increasing domestic rice production, which became established as a solution to varied challenges. Irrigation also became important as the early strategy of expanding the rice area by rehabilitating the ancient irrigation tanks graduated to novel irrigation schemes to bring new land under cultivation.

The green revolution, which brought fertiliser-responsive improved rice varieties to be grown under assured irrigation, enticed farmers to switch from traditional varieties to improved rice varieties. In 1962, the fertiliser subsidy was introduced to accelerate the adoption of new improved rice varieties. Increasing rice production was compatible with the import substitution policy embraced by developing

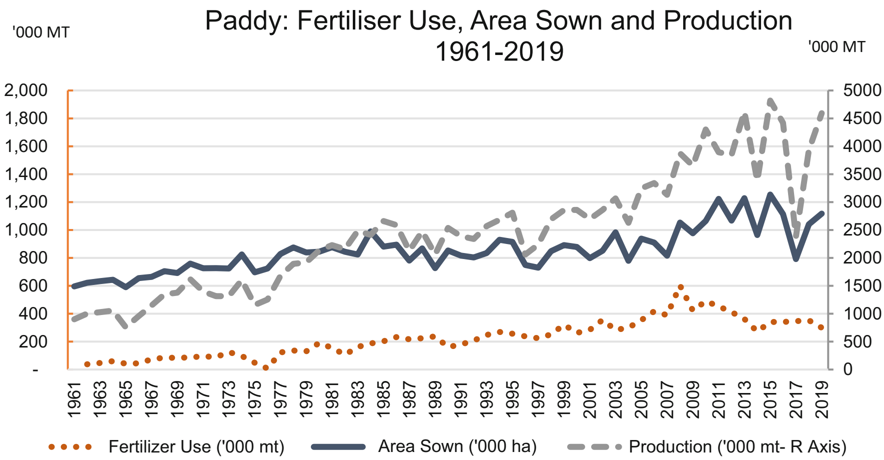

Fig. 18.1 Fertiliser use, area sown, and production of paddy during 1961–2019. Sources: Central Bank of Sri Lanka; Ministry of Finance; National Fertiliser Secretariat (Fertiliser use for 2016–2018 are estimates based on subsidy expenditure and import quantities)

economies during the 1960s to the 1970s. Sri Lanka followed an unparalleled import substitution strategy covering the agriculture and manufacturing sectors until 1977.

Rice cultivation was the major beneficiary of the fertiliser subsidy in terms of coverage of land, numbers of farmers benefitting, and the share of funds allocated to commodities, accounting for over 60% of expenditure over many decades. Other agricultural produce, such as secondary food crops, fruit, vegetables, tea, and coconut, at times had been included in the subsidy programme in response to producer demands, but this was not retained.

The fertiliser subsidy (operational since 1962, excluding a short gap during 1990–1994) coincided with a series of other agriculture support schemes: an extensive array of policy initiatives, including subsidised seeds and planting materials, free provision of irrigation water, subsidised fertilisers, concessional credit, procurement by state parastatals at guaranteed minimum prices, and protection from import competition (Weerahewa et al. 2010). Concurrently, the expansion of the irrigated land area through settlement schemes in the dry zone and state-funded research and extension continued. Of the many assistance programmes aimed at promoting rice production, the guaranteed price scheme and the fertiliser subsidy programme became somewhat intertwined over time, emerging as tools to balance the declining profitability of rice farming due to the rising cost of production and declining real price of paddy.

The area cultivated to paddy and the total production for the period 1961–2019 show strong growth, though with fluctuations. The planted area nearly doubled, and the total production increased fourfold. The use of fertiliser increased steadily over this same period from about 40,000 MT in 1961 to over 600,000 MT in 2008, the highest quantity recorded (Fig. 18.1) before falling to around 300,000 MT. The quantity of fertiliser includes urea, superphosphate, and muriate of potash that respectively supply nitrogen (N), phosphorous (P), and potassium (K). The highest rice production was 4.8 million MT reported in 2015.

The fertiliser subsidy programme has occupied a major share in the developments and subsidy expenditures in the crop sector (Appendix, Table A18.1). The expenditure on fertiliser subsidy increased almost 20 times between 2000 and 2019, that is, from LKR 1765 million to LKR 34,966 million. Investments in other crop development programmes covering tea, rubber, coconut, and several spice crops increased almost sixfold, from LKR 354 million to LKR 1662 million, during the same period.

18.3 Political Economy Analysis of Policies

In discussing the political economy of policymaking, Ichimura (1989) argued that ‘adopted policies are often not the policies that economists recommend as the best or even the second best’ (p. 179). The main reason explained for the huge discrepancies was that policies were made not just based on economic rationale but under the influence of non-economic, social, and political forces. Furthermore, after ratified policies must be implemented in a society accommodating the vested interests of various pressure or special interest groups. Understanding these complexities is, therefore, critical to ensuring rational policymaking.

Political economy models explain economic policy as the outcome of a political struggle taking place within an institutional structure (Alesina and Perotti 1994). These models argue that the traditional view of policymaking by a government or officials acting similar to a neutral social planner cannot explain most policy outcomes. Modern definitions of political economy are concerned about the study of the interactions between politics and economics, with a focus on power and resources, how they are distributed and contested in different country and sector contexts, and the resulting implications for development outcomes (Poole 2011; World Bank 2008). The Organisation for Economic Co-operation and Development’s (OECD’s) Development Assistance Committee described political-economic analysis as the interaction of political and economic processes in a society: the distribution of power and wealth between different groups and individuals and the processes that create, sustain, and transform these relationships over time (Boak 2011).

The political environment of policy formulation has been considered in various other public choice models that incorporate political processes into government decision-making. An approach by Atkinson and Stiglitz (1980) introduced three models: the voting model, bureaucratic model, and interest group model. The voting model views public policies as outcomes of a political marketplace that weighs political pressures in arriving at a policy decision. The larger the size or power of the political coalition, the more the decision is likely to be swayed in its favour. The bureaucratic model, on the other hand, assumes that those who administer government policies are similar to a benevolent dictator (or social planner) prevailing over the electorate. Bureaucratic decisions are likely to rely on perceptions about the broader public welfare. Meanwhile, the interest group model assumes particular groups dominating the policy process to secure positions advantageous to them by influencing the system. In practice, it is common to come across more complex situations with the interplay of several model behaviours simultaneously in action.

18.4 Political Economy of Sri Lanka's Fertiliser Subsidy Policy

From 1948 until 1970, Sri Lanka maintained a relatively open mixed economic policy regime. Public administration was managed by trained, independent, and structured civil service passed down from the colonial administration. Organised civil society organisations active in the policy and economic spheres were largely absent. The influence of organised groups of civil society, including trade unions, was derived largely from their allegiance to political parties.

Economic policymaking after independence has been largely shaped by the political ideologies of governing parties. Governing has switched between the two main political parties, the right-of-centre United National Party (UNP) and the left-of-centre Sri Lanka Freedom Party (SLFP). When first elected to power in 1956, the SLFP-led coalition proceeded to nationalise many privately run activities in ports, energy, transportation, and education. From 1970 to 1977, a coalition of socialist parties led by the SLFP followed an economic policy of strict import substitution and industrialisation. State takeover of businesses controlling the operation of major sectors in the economy diminished the space for lobbying groups, though politically allied trade unions were quite vocal and wielded some influence on governance. But agriculture was largely free of any such organised groups. The UNP returned to power in 1977 and governed for 17 years until 1994, placing Sri Lanka firmly on a market-oriented liberalisation regime (Bandara and Jayasuriya 2007).

Achieving self-sufficiency in rice remained a key policy goal irrespective of the party in power. Guided by its pro-market economic doctrine, the UNP was proactive in reforming various public assistance programmes. It withdrew the rice ration scheme, replacing it with a food stamp scheme in 1979. The termination of the programme providing subsidised rice to consumers came 25 years after the first effort to curtail it by the same party. The new policies lowering state intervention in the procurement and marketing of rice facilitated a more market-oriented rice sector. However, in support of increasing rice production, the UNP government maintained the Guaranteed Price Scheme for paddy and expanded the area developed for rice cultivation by accelerating the implementation of the Mahaweli scheme, a multi-purpose river diversion project. Agriculture enjoyed an economic boom from these investments.

18.4.1 Fertiliser Subsidy: Phase 1

The first phase of the fertiliser subsidy programme ran from 1962 to 1990. The subsidy was initiated under an SLFP government with wide public support in a period when the objective of achieving rice self-sufficiency was still a strong unifying message that resonated across party lines.

There were several amendments to the fertiliser subsidy programme during Phase I. Early adjustments applied to the price of fertilisers. However, prices were determined by the annual allocations set aside by the government for the subsidy and changes in the import cost of fertilisers due to movements in global prices. A major change occurred in 1975 when subsidised fertilisers were made available island-wide without limiting it to rice (Ekanayake 2006; Weerahewa et al. 2010). The change was driven by the import substitution policy of the 1970–1977 SLFP government, which sought self-sufficiency in all food crops, not just rice.

The cost of the fertiliser subsidy rose steadily due to the growing popularity of fertiliser use and the expansion of the cultivated area. Successive governments were willing to accommodate this cost, including the market-oriented UNP government elected in 1977. Soon after gaining power, the UNP government allowed private companies to import fertilisers, a task previously entrusted to state corporations. The UNP government significantly increased the subsidy rates to support the drive for rice self-sufficiency. However, as seen through the various changes introduced to the scheme from the 1980s, the government was becoming increasingly concerned about the escalating subsidy expenditure. Even though the budget allocations for the subsidy were raised to LKR 1 billion in 1981 and were maintained at that level till 1986, the actual expenditure was kept below that level in most years (Henegedara 2002). By 1989, the subsidy allocation had been adjusted downward to LKR 600 million.

The UNP, re-elected in 1989, was under pressure from donors to launch a new wave of economic liberalisation measures as gains from the initial round of market reforms introduced from 1977 had waned. The fertiliser subsidy scheme became a casualty of the new round of economic liberalisation policies, with the programme being terminated on 1 January 1990. As a new president and government had been elected in 1989, the timing was in their favour. National sentiment was favourable as rice production had risen to a level sufficient to meet over 80 per cent of the domestic requirement, with priorities shifting towards the promotion of diversification into other non-rice food crops. However, the decision to terminate the subsidy was a response to the demands of various institutional groups, including development partners who advocated for further market liberalisation as well as government institutes that considered the programme wasteful. While the fertiliser market was freed from intervention, the domestic rice sector was still accorded a high level of protection through duties on rice imports. Further, in addition to the subsidised fertilisers, rice farmers continued to receive subsidised credit, seeds, and irrigation water.

The subsidy withdrawal had an immediate negative impact on fertiliser usage and rice production. The area planted with paddy recorded an immediate decline, and this was reflected in the number of fertilisers utilised and the quantity of rice produced. However, this decline in cultivated area and production appeared temporary. By 1993, the size of cultivated area, fertiliser use, and rice production had reached pre-1990 levels (Fig. 18.1).

18.4.2 Fertiliser Subsidy: Phase 2

The UNP government was removed in the 1994 elections by an electorate that was increasingly unhappy with the inequality brought about by its open economic policies and autocratic rule. The opposition coalition used 'open economy with a human face' as its campaign slogan. The reinstatement of the fertiliser subsidy became a key pledge of the new president and the SLFP-dominated People's Alliance (PA) government elected in 1994. In the run-up to the election, the PA coalition highlighted a streak of farmer suicides, as caused by subsidy withdrawal, and pledged to bring back the subsidy, with all fertilisers made available at a subsidised price of LKR 350 (USD 7) per 50-kg bag compared to LKR 2000 (USD 40) in the open market.

The subsidy for fertilisers was reinstated in December 1994 with a fixed price for all fertilisers as pledged. With that, the subsidy programme underwent a major expansion in both the quantities of fertilisers issued under subsidy and financial costs. The cost to the government of the subsidy shot up from LKR 600 million to LKR 1.9 billion during 1994–1997. As a cost-cutting measure, the government started to roll back the subsidy by eliminating some fertiliser ingredients from the subsidy programme, eventually limiting the subsidised fertiliser to just urea at the pledged price of LKR 350 per 50-kg bag (Weerahewa et al. 2010). While the government wanted not to be seen as fully retreating from its pledge to the farmer community, these measures became highly unpopular. Organised protests from farmer groups to these changes had the blessing of some coalition partners who were strongly in favour of the subsidy.

In 2001, the Sri Lankan economy recorded its first contraction since independence due to attacks on major economic infrastructure carried out by the rebels[1] fighting to establish a separate state in north-east Sri Lanka. The UNP regained parliamentary power in the 2001 snap election, aided by some coalition partners exiting the PA government. The new government was forced to introduce strong austerity measures to recover from the economic shock. It focused all its energies to negotiate a peace agreement with the rebels. As the executive presidency and the parliamentary power were held by political opponents, the UNP administration was short (ending in 2004) and very unstable. While the economic austerity measures caused many hardships, the government failed to utilise a ceasefire to bring sufficient relief to affected groups. Discontent among farmers in the rural areas was growing as the government did little to address the negative impact of the economic setback. It did not introduce any changes to the fertiliser subsidy curtailed by the previous regime.

The fertiliser subsidy was a major issue again in the 2005 presidential election campaign. The United People's Freedom Alliance (UPFA, a new coalition formed by the SLFP-dominated PA with parties of the left) promised to revert to the fertiliser

[1]The rebel group, Liberation Tigers of Tamil Ealam (LTTE) targeted the airport, oil refinery, the central bank and many other economic installations in a series of ground and air attacks.

subsidy introduced in 1994, issuing all fertilisers at LKR 350. The UPFA's promise of a lucrative fertiliser subsidy and other incentives strengthened its support base in the agricultural heartland, sealing the outcome of the presidential election.

The subsidy scheme, branded *Kethata Aruna*, introduced in 2005 was remarkable in many ways. The effective subsidy rate of main fertiliser ingredients was as high as 90–95 per cent. The annual expenditure on the subsidy shot up from less than LKR 2 billion in 2005 to over LKR 30 billion by 2013 (Table A18.1), accounting for 2–2.5 per cent of total government expenditure (Weerahewa et al. 2010) and over 90 per cent of the development subsidies in the crop agriculture sector.

With these burgeoning costs, the pledge of a generous fertiliser subsidy was quickly turned into a promise that was very costly to sustain. However, the strong political support it generated in the rice-based settlement areas in the traditional agricultural heartland made retraction politically risky. Despite the budgetary pressures and many concerns about its effectiveness, the President was resolute about maintaining it at any cost to consolidate his power base. The government's engagement in the civil war also played a decisive role as continuing support from the Sinhala-Buddhist majority was critical for the war effort.

In the 2015 January presidential election, the candidate of the joint opposition campaigned on the promise that the fertiliser subsidy would be continued under its rule. Corruption and reconciliation were major factors that turned the electorate away from the UPFA. Both the presidency and the subsequent parliamentary elections in May 2015 were won by the UNP-led joint opposition. Despite its election campaign promise, the UNP government sought to reform the fertiliser policy in its inaugural budget. The 2015 budget passed a proposal to replace the fertiliser subsidy with a cash grant of LKR 25,000 per ha per year for up to 2 ha. At the same time, the retail prices of fertilisers were to be market determined.

Farmers strongly objected to the cash grant scheme and organised protests incited by opposition political groups. The cash grant was portrayed as a ploy diminishing farmers' choice. The situation was exacerbated by implementation issues (delays in getting bank account information for the 1.1 million farmers eligible for direct deposits of the cash grants, organising fertiliser supply through Agrarian Service Centres and traders, etc.) as the programme was launched with little advance notice. In the 2016 *Yala* season, when the direct cash grant was first provided, LKR 6.5 billion was disbursed. In 2017, LKR 10.3 billion was provided, covering the 2016–2017 *Maha* and 2017 *Yala* seasons. LKR 8 billion was disbursed for the 2017–2018 *Maha* seasons. The cash grant system was removed, and subsidised fertilisers from the 2018 *Yala* season were reintroduced (Government of Sri Lanka, 2019).

The above conversion of the fertiliser subsidy to a cash grant effectively decoupled the quantity of fertilisers applied from the subsidy amount received by the farmer. This would have permitted the removal of distortions created by the supply of subsidised fertilisers as farmers were incentivised to procure only those quantities truly required by the crops based on soil tests. The subsidy payment as a cash grant would have tangibly augmented farmer income, which the fertiliser subsidy did not always do.

The November 2019 election resulted in a change in president and political party. The president-elect from the Sri Lanka Peoples' Front (SLPP), a spin-off of the 2005 UPFA, promised to issue free fertilisers to all farmers and to introduce a new system that brings about a revolution in the use of fertiliser: 'the inorganic and organic fertiliser both will be provided free of charge to farmers. They will be promoted to shift gradually into a complete system using entirely carbonic fertiliser' (Sri Lanka Peoples' Front, 2019). The first season of free fertilisers faced many implementation hurdles, including severe shortages in fertiliser supply.

Table 18.1 tries to match the modifications in the subsidy scheme with specific triggers and changes in the electoral map that steered such modifications.

18.5 Discussion

The evolution of the fertiliser subsidy programme in Sri Lanka demonstrates the interplay of political, social, and economic forces. The political dimension is advanced through the political ideology of the two main political parties and their efforts to harness the social dimension in their battle for power. While initially the fertiliser subsidy policy was broadly supported by both parties, following its termination in 1990, it assumed centre stage in electoral politics, eventually becoming a part of a carefully crafted political strategy by the two parties.

The social dimension of food policy interests is reflected in the national desire for food security, specifically self-sufficiency in rice. This social desire for food security underpins the strong national and rural support for a subsidised fertiliser programme as rice self-sufficiency has been equated with food security. Subsidised fertilisers for rice became the means for politicians and political parties to show solidarity with the concerns of the voters in rural agricultural heartlands, turning it into an electoral pledge. The operation and expansion of the fertiliser subsidy at its peak were bounded by financial constraints alone; concerns about the environmental and ecological costs of the overuse of cheap fertilisers were restricted to a few cause groups with little influence.

Politicisation of the subsidy sidestepped more critical assessments of it, such as did/does Sri Lanka need to be self-sufficient in rice? Did/does rice paddy production need a subsidised fertiliser programme?

The desirability of rice self-sufficiency has been questioned on efficiency grounds. As Sri Lanka is a high-cost producer of rice, tariffs on imported rice have been necessary. The result is that the cost of rice to the consumer is well above that of other countries in the Asian region. There is clear evidence that suggests that Sri Lanka can operate at a lower level of self-reliance through domestic production without risking its food security and that policies favouring self-sufficiency are unnecessary (Tibbotuwawa 2010; World Bank 2013).

The need for continuing the subsidy on rice fertilisers can be questioned. The programme initiated in 1962 was based on the need to facilitate the adoption of the new technologies during the early period of the green revolution. Various studies (Ekanayake 2006; Herath et al. 2013; Weerahewa et al. 2010, Wijetunga 2016;

Table 18.1 Phase 2 of the Fertiliser Subsidy Scheme, 1990–2016

Year	Fertiliser ingredients & crops covered	Political regime	Driver
1990	Termination of the subsidy	UNP, elected in 1977 and re-elected in 1983 and 1989	2nd round of liberalisation, rising cost
1994	Reintroduction of subsidy N (urea and AS), P (TSP), and K (MOP) Price of 50-kg bag fixed at LKR 350	PA president and the government (1994)	Election pledge
1996	Price of 50-kg bag increased to LKR 600		Rising subsidy cost
1997	Subsidy restricted to urea only LKR 350 per 50 kg of urea		
2003	Price level for 50-kg bag was increased to LKR 800	2001–2004: 2-year UNP government; UPFA president	Growing budgetary burden and reform initiative
2004	Price of urea fixed at LKR 600 per 50-kg bag	Re-elected UPFA government	
2005	One fixed price for N (urea), P (TSP), K (MOP) – LKR 350 per 50 kg Paddy – subsidised fertiliser quantity restricted to amounts recommended by the Dept. of Agriculture, for up to 5 ac per farmer	UPFA New president under re-elected UPFA	Renewed election pledge 2013: adjustment of fertiliser recommendation for paddy
2008 2010	Different subsidised rates for paddy and other crops Extended to vegetables and tea (2008) and coconut (2010) at a different price	UPFA	2010 election, other crop interest group pressure
2016 (operated from 2016 *Yala* to 2018 *Yala* seasons)	Cash payment of LKR 25,000/ha/year up to 2 ha for paddy Ceiling price for NPK (LKR 2500 per 50-kg bag) Potatoes, onions, chilli, soya beans, and maize – LKR 10,000/ha (up to 1 ha)	UNP-SLFP Unity government	Market-oriented agriculture reform programme
2018	Reintroduction of subsidised fertiliser issue LKR 500/50 kg for paddy and LKR 1500/50 kg for others		Administrative bungling and internal policy conflicts
2020	Free for paddy farmers	SLPP, which came out of the 2005 UPFA	Election pledge

Sources: Compiled by author based on Ekanayake (2006), Weerahewa et al. (2010), CBSL (1990–2020)

Wijetunga and Katsuhiro, 2017; World Bank 2013) confirm that while the fertiliser subsidy has indeed helped Sri Lanka to increase domestic supply to achieve self-sufficiency, input subsidies may not always be effective in raising the use of inputs and increasing yields. Also, research in Sri Lanka shows low responsiveness to paddy fertiliser use due to the price of fertilisers. Masao and Aluwihare (1990) estimated that removing the fertiliser subsidy would reduce rice yields by only 1–2 per cent since nitrogen demand was relatively inelastic with respect to price. This was corroborated by other studies that reported low elasticities of fertilizer consumption in response to price changes of the three major fertilizers (Ekanayake 2006). These findings suggest that much of the subsidised fertilisers merely displace fertilisers that would have been applied without the subsidy. This raises the issue of the opportunity cost of funds allocated for the subsidy.

The fertiliser subsidy is effectively an income transfer to the farmers, who comprise the majority of the poor in Sri Lanka. However, subsidies have been identified as grossly ineffective means of income transfer to the poor. Several studies have demonstrated the poor operational efficiency of the fertiliser subsidy programme. Wijetunga and Saito (2017) showed that fertiliser subsidies would cause the government to spend LKR 1.38–1.91 to increase farm profits by 1 rupee. Food and Agriculture Organization (FAO) indicates that it costs LKR 1.4–2.4 to give a farmer just LKR 1 (cited in Foster 2013). These findings point to the need to look for better ways of supporting rice farmers.

The evidence proves that rich farmers with larger holdings benefit most from subsidies. The World Bank (2003) estimates that about 51 per cent of the total rice area is cultivated by households in the top 40 per cent of the rural expenditure quintiles, while only 25 per cent is cultivated by households in the lowest two quintiles. Furthermore, high transaction costs have been an issue with subsidy implementation. Farmers have to waste several days, pay bribes, and be at the mercy of corrupt officers to access the subsidy (Tibbotuwawa 2010).

The subsidy expenditures must be weighed against other essential investments in agriculture research and development and poverty alleviation. The fertiliser subsidy expenditure constituted 2–2.5 per cent of all government expenditures and over 90 per cent of all subsidy expenditures in the crop sector from 2000 to 2015. The government, while meeting subsidy obligations from the consolidated fund, was forced to borrow at commercial rates to fund important infrastructure projects. In such a situation, investments in agriculture research and development often end up underfunded.

It is not always feasible to precisely target an input subsidy such as fertiliser. When the subsidised fertilisers were first available to only rice farmers, leakage to other crop sectors, such as high-value vegetables, was widespread as there were no restrictions on the amounts sold under subsidy. Leakages thus undermined the intended objective of promoting rice self-sufficiency. However, a more serious concern overlooked in granting fertilizer and other subsidies to rice was the distortion in the incentive structure resulting from that, thereby displacing more remunerative crops. There is evidence of rice land diverted to other food crop production due to low profits returning to rice cultivation following the increase of the subsidy rate in 2005. The value of subsidised fertilisers constituted a major share of the cost of rice cultivation. Thus, the availability of the subsidy brought back into rice cultivation many lands that are marginal for rice production. Recent studies credit the combined effects of land, labour, fertilisers, and other inputs in increasing paddy production in the country (Wickramasinghe et al. 2009; Wijetunga and Saito 2017).

Subsidy programmes easily lead to rent seeking by firms engaged in subsidy implementation. Failing to reimburse subsidy payments in a timely manner to fertiliser-importing firms during 2005–2015, the government often resorted to paying bank interest on loans obtained by importers to finance imports. In 2013, the government was LKR 16 billion in arrears to five importing firms for fertilisers imported in prior years (Government of Sri Lanka 2015). At the end of 2018, unpaid claims on fertiliser imports amounted to LKR 2.3 billion (Government of Sri Lanka 2020). As a result, the firms decided to reduce their import quantities until the arrears were paid (personal communication). Due to such situations, the actual cost to the government for supplying fertilisers was 2.4 times greater than what it should have cost.

Experience suggests that reforming fertiliser subsidy programmes is not necessarily as destructive as feared. Evidence following the termination of the subsidy in 1990 showed that fertiliser consumption regained, and even surpassed, the levels achieved when fertilisers were subsidised before 1990. It is the sudden shifts in subsidy administration that are disruptive.

Based on the above circumstances, finding mechanisms for delivering assistance more efficiently and effectively became a focus. One such alternative was the issuance of vouchers, which could be redeemed for fertilisers, instead of direct distribution of fertilisers (Weerahewa et al. 2010). The cash grant programme introduced by the government in 2016 bears a resemblance to such a scheme. However, its implementation was rather abrupt as the programme was launched without adequate planning or prior awareness. By effectively decoupling subsidy payments from the physical delivery of subsidised fertilisers, a greater space was created for the government to gradually reform the fertiliser subsidy, ending problems associated with the current scheme. Over time, a more targeted income transfer programme could have replaced the subsidy, eliminating market distortions.

18.6 Conclusion

Experience suggests that input subsidies must always be planned with caution, with a clear consideration of costs and benefits, and revalidated periodically in relation to original or updated intentions. In the absence of such scrutiny, public assistance programmes can easily create situations that distort resource use, become fiscally too expensive to operate, outlive initial purpose, have adverse environmental impacts, and could be captured by interest groups. The failure of the agriculture sector to embrace new realities permitted the fertiliser subsidy policy to be progressively transformed so as to offset effects such as high costs of production, which should have been addressed through other policies.

In examining the fertiliser subsidy, the political-economic dimension has received scant attention despite the interplay of politics, society, and economics in the implementation of the programme. The role of political factors in determining the economic outcomes of the fertiliser subsidy needs careful attention when objective reform is intended. Sri Lanka does not stand unique in this regard. Concerning agriculture policymaking in Ghana, it was reported that political actors must pay attention to national policies that benefit all citizens, as well as provide material resources in exchange for political loyalty (Joughin and Kjær 2010).

When government actions are interpreted as a response to political pressures, those most adept at organising demands are allocated favourable policies. In the Sri Lankan context, even in the absence of organised demands by farmer groups, political parties were courting the support of these communities by competitively offering rewards. Although not organised as interest groups, by voting as a huge bloc, farmers have demonstrated their political power sufficiently strongly to command attention.

Appendix

Table A18.1 Welfare payments and development subsidies (LKR million)

Year	Fertiliser subsidy	Other crop subsidies	Total agriculture development subsidies	Fertiliser subsidy % of total subsidy expenditure
2000	1765	354	2119	83
2001	3649	345	3994	91
2002	2446	386	2832	86
2003	2487	484	2971	84
2004	3571	367	3938	91
2005	6846	485	7331	93
2006	10,700	735	11,435	94
2007	11,000	728	11,728	94
2008	26,450	881	27,331	97
2009	26,935	857	27,792	97
2010	23,028	1036	24,064	96
2011	29,802	1198	31,000	96
2012	36,456	1182	37,638	97
2013	19,706	1518	21,224	93
2014	31,858	1873	33,731	94
2015	49,571	11,029	60,600	82
2016	27,771	2391	30,162	92
2017	30,361	2136	32,497	93
2018	26,879	2317	29,196	92
2019	34,966	1662	36,628	95

Source: Government of Sri Lanka (1980-2020)

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19 Policy Measures to Address COVID-19 Disruptions of the Agri-Food Sector

Jeevika Weerahewa, Dilini Hemachandra, Devesh Roy, and Buddhi Marambe

Abstract

Since the discovery of the first Corona patient in March 2020, the government of Sri Lanka has adopted various measures to contain the disease and reduce its adverse effects on the economy. The chapter proceeds with an overview of the food supply chains of Sri Lanka, followed by an account of the agri-food policy response to the COVID-19 pandemic and, thereafter, a conceptual framework to illustrate the likely effects of the COVID-19 pandemic on agri-food sector. The chapter ends with a few proposals for leveraging the agri-food sector for economic development.

Keywords

Food supply chains · Government policy response · Disruptions · Policies

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19.1 Introduction

Following the diagnosis of the first Sri Lankan with COVID-19 on 11 March 2020, the government implemented control measures that were perhaps the most stringent the country has experienced for an epidemic or pandemic in the past century. Starting 20 March, a 24-hr curfew was imposed on 22 million people, relaxed only in low-risk districts twice a week for a few hours. The curfew was partially lifted on April 20, then re-imposed intermittently until May 10. Civilian life, as well as state and private sector activities, resumed from 11 May.

This response, including the closure of schools, universities, and passenger entry ports and the restrictions on movement across districts, was generally effective. By 03 August, 2020 Sri Lanka reported 2817 confirmed COVID-19 cases and 11 deaths (Ministry of Health and Indigenous Medical Services 2020), a much lower death rate compared with many other countries (485 deaths in Australia, which has a population of 25 million, and 125 deaths in Mali, which has 20 million people, as of 23 August (World Health Organisation 2020)). However, the stringent disaster management strategy came with disruption and costs, leaving a large number of people, particularly in the informal sector, which provides 58.7 per cent of employment, vulnerable.

This chapter showcases the immediate measures implemented in the agri-food sector and proposes a long-term policy framework for the agri-food sector.

19.2 Overview of Sri Lankan Food Supply Chains

19.2.1 Agricultural Exports and Food Imports

Sri Lanka is self-sufficient in the production of rice, its main staple crop, and nearly self-sufficient in the production of several other important food items, such as meat, fish, eggs, vegetables, and fruit. However, the country relies on imports for many essential food commodities. In 2018, Sri Lanka imported USD 2.28 billion (LKR 422.5 billion) of food and beverages (11.8 per cent of total imports). In the same year, imports as a share of the total requirement were 31 per cent for maize, 90 per cent for big onion, 42 per cent for cowpea, 16 per cent for groundnut, 51 per cent for black gram, and 20 per cent for red onion. The country's total requirement for wheat and red lentils, along with 95 per cent of dried chilli, 87 per cent of sugar, and 50 per cent of milk and milk products, is met through imports. Further, potatoes and edible oils – all essential ingredients in Sri Lankan cooking – are also largely provided by imports (Department of Census and Statistics 2018). The country's key agricultural exports include tea, spices, fresh vegetables, fruit, and fish. Figure 19.1 provides imports, exports, and trade balance for key agricultural sub-sectors in 2019.

Table 19.1 provides the food balance sheets with data from 2018 to show the volumes of supply from local and imported sources. It demonstrates the degree of vulnerability of the food economy owing to disruptions in food value chains

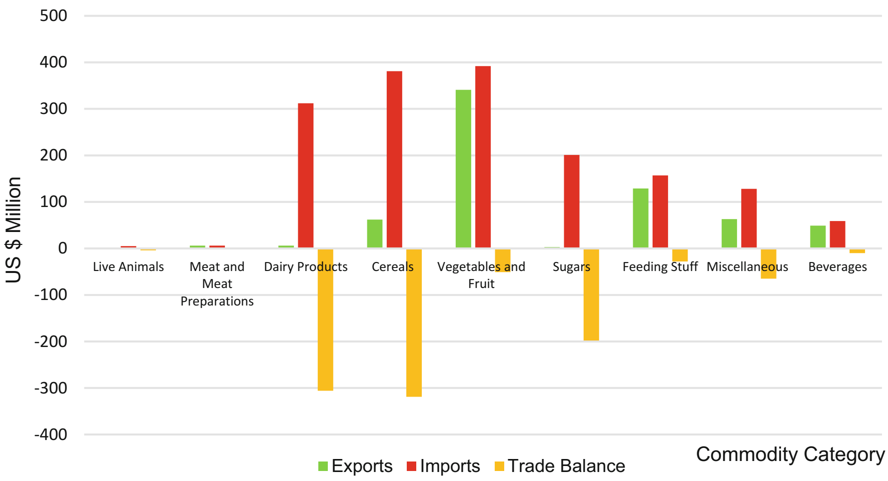

Fig. 19.1 Values of exports, imports, and trade balance of Sri Lanka in 2019 for agricultural items, according to the Standard Industrial Trade Classification (SITC). Source: Central Bank of Sri Lanka, 2019

19.2.2 Agricultural Production

The cultivation of food crops and export crops and animal production in Sri Lanka are largely carried out by scattered smallholders. Seed paddy and planting materials for many other field crops (OFCs) are locally produced. Seeds of OFCs (such as maize and sorghum); exotic vegetables, particularly for production in greenhouses; and other agricultural inputs (fertilisers, pesticides, fuel, machinery) are largely imported. Livestock production is carried out mostly by smallholder farmers; and except for dairy, Sri Lanka is self-sufficient in livestock products. Tea, rubber, coconut, and spices such as cinnamon, pepper, clove, cardamom, and nutmeg are the export crops cultivated in the country. Although the cultivation of export crops is also carried out by small-scale farmers, tea, rubber, and coconut are cultivated in plantations.

There are several constraints to production in the agriculture sector. The scattered nature of production makes it difficult to exploit economies of scale and maintain quality assurance. Many agricultural areas are vulnerable to changes in weather and climate. The sector faces increased wages and reduced competitiveness due to increasing demand for labour by the non-agricultural sectors (i.e. garments, defence, foreign employment through migration) and falling attractiveness of agriculture to the youth, which is over 23 per cent of the total population (Department of Census and Statistics 2012).

Farmer organisations and collective action are weak, resulting in low bargaining power for farmers. Village-level suppliers provide inputs to farmers mainly on credit, and a significant share of produce (mainly rice) is purchased by them.

Table 19.1 Food balance sheet, 2018

	Domestic supply, '000 MT					Domestic demand, '000 MT						Per capita supply			
											Year	Per Day			
	Production	Imports	Stock change	Exports	Total domestic supply	Feed	Seed	Processed	Waste	Other utilities	Food	Food	Calories	Protein	Fat
Grand total													2917	73	58
Vegetable products													2967	54	47
Animal products													220	19	11
Cereals	2900	1658	25	80	4502	169	88	400	195	0	3651	168	1560	34	4
Starchy roots	505	166	0	7	664	0	13	0	44	0	607	28	95	1	0
Sugar crops	645	0	0	0	645	0	10	622	0	0	13	1	0	0	0
Sugar and sweeteners	111	628	3	21	722	0	0	114	0	7	601	28	277	0	0
Pulses	33	228	0	10	251	0	1	0	1	0	250	12	109	7	0
Tree nuts	99	6	0	5	100	0	0	5	0	50	45	2	14	0	1
Oil crops	916	21	0	268	669	0	4	105	1	5	554	26	151	3	14
Vegetable oils	64	234	0	17	281	0	0	0	0	98	183	9	204	0	23
Vegetables	2978	353	0	11	3319	50	1	0	416	0	2848	131	111	5	1
Fruit	1070	96	0	46	1121	76	0	79	117	1	854	39	75	1	0
Stimulants	312	7	0	282	36	0	0	0	0	0	36	2	6	0	1
Spices	111	56	0	14	153	0	0	0	0	7	146	7	56	2	1
Alcoholic beverages	243	2	0	5	240	0	0	0	0	0	240	11	27	0	0
Meat	255	1	0	4	252	0	0	0	0	0	252	12	45	4	3
Animal fat	11	3	0	0	14	0	0	0	0	0	14	1	12	0	0
Milk and milk products	472	522	0	5	989	0	0	71	24	0	894	41	97	5	5
Eggs	99	0	0	0	99	0	1	0	5	0	93	4	14	1	1
Fish and sea food	588	84	0	28	645	0	0	0	0	0	645	30	52	8	2
Miscellaneous	0	14	0	0	13	0	0	0	0	0	13	1	13	0	1

Source: Department of Census and Statistics (2018)

There are credit-bound relationships between farmers and commission agents that operate in dedicated economic centres, bringing about both positive and negative implications for the governance of vegetable supply chains.

19.2.3 Food Processing

The food processing industry has been rapidly growing compared to other industries and the overall economy. The industry covers a wide range of product areas: fruit and vegetables, meat and poultry, milk and milk products, alcoholic beverages, fisheries, plantation crops, grains, confectioneries, chocolates and cocoa products, soya-based products, mineral water, and high-protein foods. Most of the output of the food processing industry is very minimally processed and mainly targeted at the local market. The development of the food processing industry has introduced new value chains and opened opportunities for farmers to earn a stable income by directly linking with the sector. However, it should be noted that the food processing industry is concentrated in urban areas, especially in the Western Province.

The food processing industry remains largely untapped for a variety of reasons, including high packing costs, cultural preferences for fresh food, seasonality of raw materials, as well as lack of adequate infrastructural facilities and quality control mechanisms. Overall, Sri Lanka requires much higher levels of private and foreign direct investment (FDI) in processing and logistics to address deficiencies in its sub-sectors, such as fruit and vegetables, and for increased value addition. While inadequate investment could be due to policy uncertainty and lack of access to finance, other factors, such as poor value chain governance and opportunistic behaviour, are influential as well. One aspect of opportunistic behaviour is reflected in poor commitments to contractual farming agreements by both farmers and integrators. This has hindered vertical integration initiatives and linking smallholder farmers to markets.

19.2.4 Food Distribution and Marketing

Consumers have several options to meet their food needs. There still is a substantial number of households that produce specific items for home consumption. In addition, fresh produce is sold in stalls along busy roadways, small traditional retail outlets, wet markets, Dedicated Economic Centres (DECs), and supermarkets. Wet markets are famous for selling a broad range of fresh fruit and vegetables, including rare seasonal varieties sourced from home gardens and forests. There are 14 DECs around the country. Dambulla, the largest DEC, is a major distribution hub for fresh and dry food sourced from all over the country and distributed through wholesalers and retailers to consumers and processors. Dambulla DEC sells, on average, 26,500 tonnes of fruit and vegetables each week (Food and Agriculture Organisation 2018).

While the quantities of fruit and vegetables channelled through supermarket supply chains are small compared to traditional retail outlets, it has been growing.

Urban and medium-/high-income consumers are increasingly important for supermarkets, and the role played by small retailers and wet markets in selling to this consumer segment is declining. Only a few leading supermarket chains (Cargills Food City and Keells) buy directly from farmers, mostly through their collection centres. Furthermore, studies have revealed that supermarkets tend to buy their vegetable requirements from traditional wholesale markets, especially during glut periods. Because the supermarkets sell vegetables mainly to enhance customer convenience and consumers are sensitive to pricing, there is little provision for other non-price attributes, like food safety.

Despite ample opportunities, domestic value chains have not been sufficiently connected to global value chains.

19.3 Sri Lanka's COVID-19 Policy Responses

Since the discovery of the first Corona patient in March 2020, the government has adopted various measures to contain the disease and reduce its adverse effects on the economy. The government was very aggressive in responding to the very early stages of the outbreak. An island-wide curfew was declared on 20 March when just 59 infected cases were reported. Policy responses affected all sectors and activities, and the government marshalled considerable resources. The government has allocated up to 0.1 per cent of GDP for containment measures, as well as USD five million (0.01 per cent of GDP) to the SAARC COVID-19 Emergency Fund (International Monetary Fund 2020). The President announced cash payments totalling around 0.25 per cent of GDP for vulnerable groups (International Monetary Fund 2020). Table 19.2 presents the timeline of key measures.

Policy responses relating to food supply chains under COVID-19, listed partially in Table 19.2 above, may be summarised under five key interventions: (a) price controls, (b) declaration of agriculture as an essential service, (c) home gardening, (d) amendment to food import regulations, and (e) safety nets. The following sections provide a brief description of each measure. Annex 1 provides links to official announcements.

19.3.1 Price Controls

With the closure of several public institutions, including schools, there was a surge in panic buying, particularly in supermarkets. The escalation of retail prices of food items was one of the first disruptions felt by consumers. The government responded with several policy initiatives. Price controls were placed on several basic food items, such as red lentils (LKR 65/kg or USD 0.35/kg) and canned fish (LKR 100 (USD 0.54) per 425 g tin), on 17 March. To offset the effect of price controls, compensation was announced for importers.

Maximum retail prices (MRP) were imposed on several other food items during the latter half of the countrywide lockdown. Several varieties of rice were brought under MRP on 10 April, and an MRP on turmeric powder for LKR 750/kg (USD

Table 19.2 Timeline of key measures for COVID-19 containment and management of food supply chains in Sri Lanka from March 11–May 11, 2020

Date	Key measures	Authority
12–14 March	• All government schools, pre-schools, and universities were closed until further notice	
	• 12 March: maximum retail price was imposed for broiler chicken meat (Gazette Extraordinary No. 2166/29)	Consumer Affairs Authority
	• 12 March: maximum retail price was imposed for maize (used for any purpose) (Gazette Extraordinary No. 2167/30)	Consumer Affairs Authority
16 March	• Self-quarantine was made mandatory for those who arrived in Sri Lanka during 1–9 March	
17 March	• A relief package was provided to support the people affected by COVID-19; maximum retail price for red lentils and canned fish was implemented through a state retail chain (*Lak Sathosa*)	
	• Maximum retail price imposed for red lentils (Mysore dhal), big onions, and canned fish (Gazette Extraordinary No. 2167/9)	Consumer Affairs Authority
19 March	• Temporary restriction on the import of non-essential goods was imposed (schedule B of the Banking Act Directions No. 1 of 2020) to curtail imports and foreign exchange restrictions	Central Bank of Sri Lanka
20 March	• Island-wide curfew was imposed	
23 March	• Sri Lanka Ports, Customs, and other regulatory bodies were requested to continually issue essential food, fertilisers, etc.	
24 March	• Instructions were issued to refrain from closing stores until the last customer in the queue is able to purchase goods	Sri Lanka Police
25 March	• The cultivation of vegetables, paddy, maize, black gram, green gram, cowpea, and finger millet as well as fishery activities were facilitated without any interruption even during curfew time • A special mechanism was established for the delivery of essential food items to homes in collaboration with cooperatives and retailers	Presidential Secretariat
26 March	• The Presidential Task Force was entrusted with strengthening the agriculture sector by providing services, especially food, through a proper coordination mechanism to import	Presidential Secretariat

(continued)

Table 19.2 (continued)

Date	Key measures	Authority
	essential dry food items and medicines; exporting goods, such as tea and sanitary apparel, and implementing decisions; facilitating farmers for the production of rice, grams, vegetables, fish, dairy and eggs, and crops, including tea, cinnamon, and pepper; and distributing rice, vegetables, and products to people of all districts	
27 March	• The maximum wholesale and retail price was fixed for 25 vegetables	Consumer Affairs Authority
30 March	• A circular was issued to provide essential food items at concessionary rates and allowances to low-income and vulnerable families/persons	Presidential Secretariat (later approved by the Cabinet of Ministers on 8 April 2020)
2 April	• Restrictions on the importation of non-essential goods were declared	
4 April	• Sri Lanka's Colombo tea auction was conducted online for the first time	Colombo Tea Traders' Association & Sri Lanka Tea Board
	• *Saubhagya* National Programme on Harvesting and Cultivation launched to develop 1 million home gardens, coupled with the reimbursement of seed costs up to 1 acre and 50% up to the next 4.5 acres, comprehensive agriculture insurance, and guaranteed price for crops	Ministry of Mahaweli, Agriculture, Irrigation and Rural Development
April 9	• Sri Lanka's coconut auction was conducted online for the first time • The government allocated LKR 600 million for the early purchase of fish harvest	Coconut Development Authority
April 10	• Different rice types/varieties were subjected to price regulations (Gazette Extraordinary No. 2170/7)	Consumer Affairs Authority
	• The services of rice mill owners were declared as essential services	Presidential Secretariat
	• The special commodity levy on palm oil increased	Department of Trade and Investment Policy
11 and 14 April	• The government procured vegetables and fruit stocks from farmers	Presidential Task Force on Essential Services
15 April	• Sri Lanka Railway deployed special trains to transport vegetables, fruit, grains, rice, and other essential commodities cultivated from various parts of the country to ensure the availability of these products during the curfew to prevent the spread of COVID-19	Ministry of Transport Services Management

(continued)

Table 19.2 (continued)

Date	Key measures	Authority
16 April	• Temporary suspensions on the import of certain agricultural items were imposed for a period of 3 months (Gazette Extraordinary No 2171/5)	Minister of Finance, Economic and Policy Development
17 April	• A concessionary loan scheme for farmers was launched	Presidential Secretariat
	• Alternative arrangements were made to procure fruit and vegetables, owing to the closure of the Manning Market in Colombo	Presidential Task Force on Essential Services
20 April	• Island-wide curfew was relaxed in low-risk areas.	
21 April	• MRP on turmeric powder was imposed (Gazette Extraordinary No. 2172/5)	Consumer Affairs Authority
22 April	• The Task Force for Economic Revival and Poverty Alleviation was established in accordance with the power vested in the President by Article 33 of the Constitution of the Democratic Socialist Republic of Sri Lanka (Gazette Extraordinary No 2172/9)	Presidential Directive
23 April	• Guaranteed prices were imposed on 16 crops; the government is to procure the harvest if farmers are unable to sell at guaranteed prices during the *Yala* season 2020	Cabinet Decision
28 April	• Maximum retail price for white sugar fixed by Extraordinary Gazette 2092/64 was rescinded (Gazette Extraordinary No. 2173/6)	Consumer Affairs Authority
30 April	• Further restrictions were imposed on the importation of agricultural items (Gazette Extraordinary No. 2173/12)	Ministry of Finance, Economic and Policy Development
	• Finances were allocated for the importation and distribution of fertilisers, new loan schemes and insurance schemes for crop cultivation were introduced, specialised agriculture cluster villages were established, Green Gardens and harvest selling outlets were put up, and land for special crop cultivations was allocated	Cabinet decision
	• Maximum retail price fixed for Mysore lentils and canned fish was removed (Gazette Extraordinary No. 2173/9)	Consumer Affairs Authority
1–3 May	• Island-wide curfew was lifted • Special commodity status imposed on big onions was rescinded with effect from 1 May 2020 (Gazette Extraordinary No. 2173/12 issued on 30 April)	Ministry of Finance, Economic and Policy Development
11 May	• The resumption of civilian life was declared	

4.0) was imposed on 21 April. Furthermore, maximum wholesale prices (MWP) were announced for 25 vegetables, sweet potatoes, limes, plantains, and ginger on 26 March, along with a maximum markup of LKR 40 (USD 0.21).

Farmers also benefitted. The government procurement programme ensured guaranteed prices for the 16 priority crops promoted for cultivation during the *Yala* season. The guaranteed prices were set above the open market prices to support farm producers.

19.3.2 Declaration of Agriculture as an Essential Service

Agriculture was declared as an essential service, allowing farmers and key allied industries to continue operations during the periods of national lockdown. Exemptions to the curfew allowed planting, transport of planting material, plucking, harvesting, transport for labourers, transport to warehouses, and export activities for food and plantation crops to continue without disruption.

Additional measures were introduced to support the flow of resources and maintain markets for agricultural produce. On the agricultural input side, the government was distributing fertiliser and providing (or reimbursing the cost of) seeds free of charge for up to 0.2 ha of land and at 50 per cent of the cost for the next 1.8 ha as per the pre-existing policy. Also, the cabinet approved USD 760 million to import fertilisers during April to support farmer demand and the requirement of target crops. Further, under the New Comprehensive Rural Loan Scheme (NCRCS), which the government announced on 17 April, loans of up to LKR 5 million were provided to farmers at a 4-per-cent interest rate for the cultivation of 36 crops, including paddy. Moreover, a new loan scheme, *Aswenna*, was introduced, providing up to LKR 3 million through the People's Bank for specific crops. The interest rate of 13.5 per cent for a period of 3 years was later slashed to 9.5 per cent for loans of up to LKR 1 million. Also, the cabinet decided to establish 50 Green Gardens and 200 harvest selling retail outlets, to use 1000 ha of land for organic crop cultivation during the *Yala* growing season, and to increase the extent of special crop cultivation to approximately 4000 ha.

The government took action to support the distribution and marketing of agricultural produce as well. New transport options (e.g. use of railways where possible) and alternate marketing systems (online procurement and delivery systems) were facilitated. The state-owned enterprise for milk collection and processing, Milco, continued its operations during curfew. Arrangements for the collection of raw milk were moved online, and electronic payment systems were initiated.

Distribution points for consumer purchases were considered as well. The Presidential Secretariat formed a task force consisting of provincial and district administrative officers, along with military officials, to ensure the delivery of essential services, including food, with priority given to large urban clusters (like Colombo and Jaffna). Also, the government-owned *Lak Sathosa* stores initiated food distribution with logistical support provided through a private-public partnership via online procurement and delivery. Curfew permits were given to distribution agents for food delivery and the transportation and unloading of fish. The state-owned Ceylon Fisheries Corporation accelerated fish purchases directly from fishermen and was allocated USD 3.16 million to purchase and distribute fresh fish island-wide.

The Colombo tea auction, one of the largest and the oldest ongoing tea auctions in the world, was suspended for 2 weeks from mid-March due to curfew. In response, e-auctions of tea and coconut were initiated for the first time in the 126 and 26 years, respectively, of the tea and coconut trades. Although initially there was panic buying of tea, both tea and coconut auctions seem to have eased the economic situation to some extent. These efforts have also supported food security, especially of those engaged in these value chains and the country as a whole.

19.3.3 Home Gardening

The government encouraged and accelerated the home gardening programme as part of its COVID-19 response. The *Saubhagya* (prosperity) home gardening project was initiated at the onset of the crisis with the distribution of seeds and seedlings to approximately 2 million households. The programme has gained momentum countrywide, benefitting from the work-from-home rule and resulting in time available for people to spend on home gardens. Concurrently, a vegetable cultivation drive was launched to expand production in uncultivated land. However, there are market risks that this cultivation drive can lead to the flooding of markets with vegetables, as occurred in 2009 because of the *Api Wawamu Rata Nagamu Programme*, which was implemented in 2008 using similar strategies.

19.3.4 Amending Food Import Regulations

The government increased control over the import of food and agricultural inputs. Imports were restricted to conserve foreign exchange and to provide further incentives for domestic production. However, alongside the orders restricting imports, the Sri Lanka Ports, Customs, and other regulatory bodies were instructed to ensure that essential food, fertilisers, pharmaceuticals, and fuel reached the relevant supply chain actors. Also, the cabinet issued special orders on 30 April to import and distribute 150,000 mt of fertilisers to cultivate 253,000 acres (approximately 102,395 mt) of land during the *Yala* season.

19.3.5 Safety Net Programmes

Income support programmes from the state were greatly expanded. USD 26 (which constitute 46 per cent of the poverty line) per person per month was provided to the 417,000 recipients of the senior citizens' allowance; 142,000 other needy persons; and those who did not have a permanent income. *Samurdhi* (cash transfer programme for the poor) recipients were given an interest-free loan of USD

52 with a 6-month grace period. Nutritional supplements were delivered directly to expectant mothers and families with malnourished children. Other steps included loan payment deduction and suspension to relieve private businesses that are unable to pay employees' wages. Those who did not belong to the above-mentioned categories but who could be at risk are also expected to receive similar relief.

19.4 Framework to Analyse the Effects of COVID-19 and COVID-19-Induced Policies

19.4.1 Impact of COVID-19 on the Economy

An economy consists of economic agents that interact and exchange goods and services and payments. The simple model of an economy presented in Fig. 19.2 shows interactions among different economic agents: households, firms, the government, financial institutions, and the rest of the world (ROW). Local firms engage in producing goods and services that households and other firms purchase. Households earn by selling the resources they own, i.e. the factors of production, human resources, and capital. Households sell factors of production to local firms and earn wages and rents in return. Some households supply their labour to foreign firms in the ROW, sending part of the incomes earned back to Sri Lanka as remittances. Other exchanges between the local economy and the ROW include the export and import of goods and services. Some of the goods and services produced by local firms are exported to the ROW in return for payment (export earnings); intermediate inputs required for local production and final consumption are imported from the ROW by making payment (import bill). The exchange rate of the currency is the market-clearing price for foreign exchange.

Households save in financial institutions that pay interest on savings. Financial institutions invest the savings in markets and get a return for their investment. The government also is an agent in the economy. Certain households and local firms pay taxes, while others receive subsidies from the government. Tax collections are used to produce various public goods and services provided to households and firms. Given this basic structure of an economy, it may be possible to distinguish which economic agents are affected by COVID-19-induced disruptions and the pathways for the recovery.

The initial effects of COVID-19 follows from the restrictions on movement (such as curfews) imposed by the government to manage the COVID-19 pandemic, which affect the production and distribution activities of firms, resulting in lower demand for labour and capital by firms. The movement restrictions affect both domestic and international systems of exchange in a complementary manner. When the domestic system of exchange is disrupted, it affects what is available for the international exchange of goods and services. Further, exchange with the ROW is actualised in foreign currency earned from exporting goods and services and used to pay for imports from ROW. When export earnings are affected, the economy will be unable to finance its import bills. To reduce the import bill, the government can make foreign goods and services less attractive by imposing a tax and use the revenue to

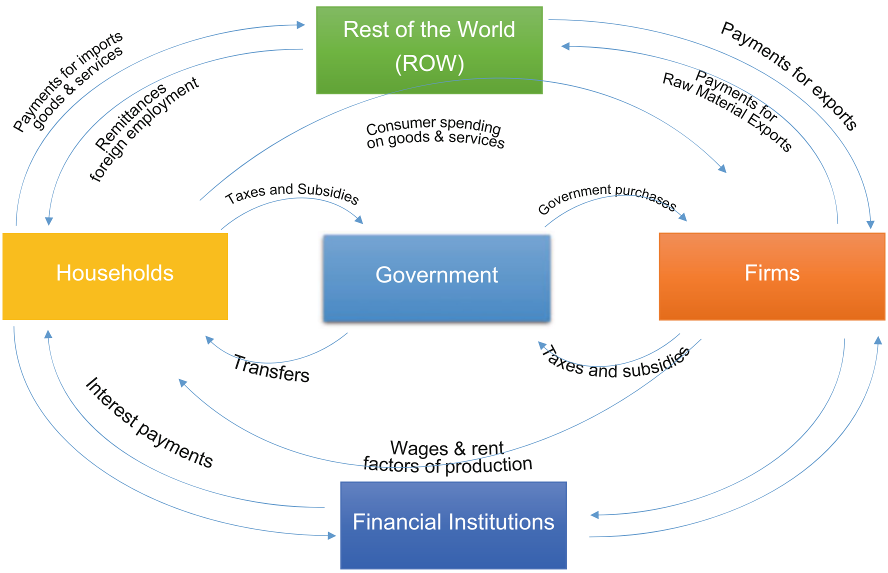

Fig. 19.2 Circular flow of income in an economy

support government expenditure, redistribute among its citizens, or add to its savings.

In this prototype economy, COVID-19 had a direct effect on foreign exchange earnings and the trade tax revenues earned by the Sri Lankan government. Due to border closures, import and export of goods, tourism, and foreign employment were affected. Owing to the movement restrictions imposed within the country, the production of goods and services was affected, leading to lower demand for labour and capital, resulting in job losses.

The government collects taxes from locals and foreigners residing in the country and provides goods and services. The government also redistributes wealth by making transfers to low-income households and other vulnerable groups. During COVID-19, the government initiated various programmes to support affected groups, such as by providing funds to families as their flow of income was disrupted. As government expenditure increased and revenues shrunk, the government's ability to provide goods and services, such as law and order, security, and other public goods was affected.

Due to restricted mobility of the labour force and the difficulty in sourcing inputs due to COVID-19, firms will cut volumes and production activities, leading to unemployment in the country. Reduced income will result in a lower demand for goods and services and, hence, decreased revenue for firms, which will lead to a further reduction in output. Ultimately, the output of the country was affected adversely.

19.4.2 COVID-19 Disruptions to Agri-Food Sectors

Even though Fig. 19.2 does not specifically delineate activities related to agri-food sectors, they certainly are part of the economic activities. While households supply labour, land, and capital for food production, agricultural raw materials are either produced by local firms or sourced from foreign firms. Local firms comprise farm producers, transport agents, food processing plants, traders, and wholesale and retail distributors. Households are the final consumers.

Schmidhuber et al. (2020) stated that the COVID-19 pandemic affects all elements of the food system, from primary supply to processing to trade and national and international logistics systems to intermediate and final demand. The effects on factor markets, i.e. labour and capital, and intermediate inputs are important. Low supplies of pesticides and fertilisers, for instance, are already affecting crop production, leading to protection efforts in countries affected at an early stage and lower yields (productivity), resulting in lower production later in the year.

The pandemic lowers food demand by decreasing the overall purchasing power of households, particularly those households that become unemployed. While neither the final income nor price impacts are fully revealed at this early stage, the low availability of food staples is expected to have adverse effects on the quality of people's diet.

19.4.3 Policies to Mitigate the Effects of COVID-19

Several global agencies have proposed a diverse array of interventions to mitigate the possible adverse effects of COVID-19 on the agri-food supply chains. The Food and Agriculture Organization (FAO) has proposed (a) expanding and improving emergency food assistance and social protection programmes; (b) supporting smallholder farmers to enhance their productivity, market the food they produce, and use e-commerce channels; (c) keeping the food value chain alive by focusing on key logistics bottlenecks; (d) addressing trade and tax policies to keep global trade open; and (e) managing the macroeconomic ramifications (Cullen 2020) as key interventions for mitigation.

A joint statement by the World Health Organization (WHO), FAO, and the World Trade Organization (WTO) highlights the disruptions caused by the pandemic and policy interventions for controlling disease spread; increased barriers to the movement of agricultural and food industry workers, border delays for food containers, arbitrary food safety measures, and export restrictions will lead to the spoilage of perishables, increased food waste, shortage of food on the global market, price spikes, and increased price volatility. International cooperation is recommended to mitigate these effects, along with freer trade and increased information on food-related trade measures, levels of food production, consumption, prices, and stocks (to contain panic buying and hoarding). Similarly, Fan (2020) emphasises the need for transparent dissemination of information to strengthen government management of food markets, prevent panic buying, and guide farmers to make rational production decisions.

Also, there is a need to make full use of the international market as a vital tool to secure food supply. The use of COVID-19 as an excuse for protectionist policies must be discouraged. Furthermore, innovative methods to improve sales through e-commerce (e.g. home delivery of groceries, contactless delivery, etc.) and social safety nets to protect those who are the worst affected and the most vulnerable are other recommendations. According to Vos et al. (2020), governments will need to provide fiscal stimuli and e-commerce, and delivery companies should be encouraged to play a key logistical role in locations under strict lockdown measures to secure continued access to food and avoid collapses in consumer demand.

According to Reardon et al. (2019), in the short run, broad safety nets for Small and Medium Enterprises (SMEs) and workers in the midstream and downstream segments of food supply chains are needed. For example, governments could use cash-for-work schemes to employ workers to distribute emergency food rations, upgrade sanitation in wholesale markets and wet markets, and maintain essential operations in their own enterprises. In the short- and medium-term, the monitoring and strict regulation of wholesale markets, retail wet markets, and processing clusters and the redesigning of their sites for improved health practices may be recommended. Thus, investments to help SMEs to change hygiene practices and site design may help them remain competitive in the long run.

The World Bank (2020) proposes a set of 'Dos and Don'ts' in the crisis. With respect to agriculture and food trade, the 'Dos' include (a) supporting the consumption of essential items and (b) limiting negative impacts on the poorest by reducing import tariffs on all food products, waiving withholding taxes on imports of food products for the duration of the crisis, and refraining from imposing export bans or taxes on critical food staples. Furthermore, it would also be important to support exporters to maintain jobs and foreign exchange earnings by removing all bans, quantitative restrictions, and taxes on exports; waiving withholding taxes on exports; reviewing all export applications, licences, and permits; removing interventions that are not required to maintain market access or protect health, safety, and security; and reimbursing exporters that have lost overseas sales VAT, which was paid on inputs in the expectation that it would be refunded on export for the duration of the crisis. Other measures of support for temporarily affected sectors are suggested to be more effective in maintaining output and less damaging to the economy and the poor. The key 'Don'ts include the imposition of additional trade restrictions to protect domestic industries that may be adversely affected by falling demand.

The Consultative Group for International Agricultural Research (CGIAR 2020) recommends the following policy agenda: (a) introducing enabling policies for spring planting and increasing support for production entities, (b) ensuring the smooth flow of trade and making full use of the international market as a vital tool for securing food supply and demand, (c) ensuring smooth logistical operations of regional agricultural and food supply chains, (d) monitoring food prices and strengthening market supervision, (e) protecting vulnerable groups and providing employment services to migrant workers, (f) addressing issues related to wet markets and livestock-wildlife interface and on how to mitigate future zoonotic disease and supporting one-health approaches, (g) regulating wild food markets to curb a source of disease, (h) measuring impact on small and medium-sized businesses, (i) analysing how much global poverty will increase because of COVID-19, (j) demonstrating the importance of reliable clean water for reducing the spread of the virus, and (k) increasing resilience and mitigation of social disruptions by increasing local food productivity and water access.

The specific policies and programmes to be implemented, the institutional reforms to be undertaken, and the investment options to be financed by a country depend on the structure of the agri-food supply chains of a country and the nature of disruptions due to the COVID-19. The section below provides a way forward for Sri Lanka.

19.5 Way Forward for Sri Lanka

The COVID-19 pandemic hit Sri Lanka while it was still recovering from the negative shock of the Easter Sunday attack in April 2019. The real growth rate of the economy over the last 5 years has been a dismal 3 per cent on average and further decreased to 2.3 per cent in 2019. It is expected that the real growth rate for 2020 will be 1.5 per cent (Central Bank 2019). During the first quarter of 2020, the government's priority was to contain the COVID-19 public health crisis. However, once the situation becomes more manageable, it is essential that measures are taken to revive the economy from the downturn. Since Sri Lanka has had several years of sluggish economic growth and the country's capacity to withstand further shocks is diminishing rapidly, urgent actions to remedy the situation are necessary.

The way forward for the food and agriculture sector during the COVID-19 pandemic must be determined against the conceptual links explained in the previous section, the inherent characteristics of the agri-food sector, and the national development objectives. The following section provides three distinct areas for leveraging the agriculture sector for economic development in the medium to long run.

19.5.1 Increasing the Demand

COVID-19 has negatively affected income generation. Since it is likely to linger in the world for the next year or two, low income and an uncertain future could dampen private expenditure. The low demand for goods and services will affect industries, production, and growth, further reducing income. If left unchecked, this could lead to an economic recession. The government should take the necessary steps to stimulate consumer expenditure and signal positive expectations about the future. It is important that the government introduce a stimulus package to boost expenditure. Producers and businesses should be supported to make sure there is an adequate supply of goods, the lack of which may lead to a rise in inflation. Because of the cross-cutting nature of the pandemic, it is important that not only agriculture and agribusinesses but also all sectors of the economy are supported. While demand has to be created or raised, it is important to maintain price stability as well. Necessary precautions should be taken so that pumping money into the economy to drive up demand will not lead to inflation.

19.5.2 Fiscal Discipline

The Sri Lankan economy has paid the price for the lack of fiscal prudence for many years now. Compared to emerging market peers, Sri Lanka's fiscal deficits have remained high over time, owing to declining government revenues and rising recurrent expenditure. This has been a source of economic instability. Strikingly, the tax revenue to GDP ratio in Sri Lanka is extremely low in comparison to international standards. How much the government can support the expenditure and production of the economy depends on its income, savings, and borrowing ability. As the government already has enormous debts, fiscal consolidation is extremely important.

As a temporary response to the adverse effects of COVID-19 on the economy, tax concessions are required to support businesses and drive demand; however, any adverse impact on tax revenue needs to be offset by appropriate measures. Effective management of government expenditure becomes imperative to curtail the rapid growth of recurrent expenditure while ensuring adequate resources for public investments over the medium term. Amid the fast-growing expenses on interest payments, salaries, wages, subsidies, and transfers, the government's recurrent expenditure could grow sharply. While the government plans to increase recruitment to the public sector (150,000 new jobs under 'Vistas of Prosperity and Splendour', the policy framework to address youth unemployment, poverty, inequality, etc.), it could eventually result in a lasting impact on government expenditure on account of salaries, wages, and pension payments.

Moreover, the rising recurrent expenditure coupled with low government revenue could compromise the much-needed investment in health and education services and physical infrastructure development. Curtailing public investment would result in dampening economic growth over the medium to long term. Thus, further emphasis is needed to enhance public expenditure management. Towards this, rationalising public expenditure in agriculture value chains is essential. Interventions undertaken during the crisis regarding procurement and involving state agencies may now be eased. The heavy subsidy of fertilisers might need to be re-weighed in favour of a cash grant scheme. On the domestic market side, targeted food subsidies for essential food items, price and income supports, input subsidies, and income transfers require better targeting. There should be moves to identify those made more vulnerable by COVID-19 (for example, the urban poor, recipients of the school meal programme, people suffering from non-communicable diseases, factory workers, and communities in remote locations) and make them eligible to receive the relief package.

19.5.3 Targeting Increased Export Earnings

Exports and FDI have been the key drivers of growth in many successful economies in Asia. However, Sri Lanka's progress in terms of exports and FDI has been unsatisfactory compared to its regional counterparts. Sri Lanka has not been able to diversify exports; its share in global trade has declined over time, unlike its East Asian neighbours. Further, since the early 1990s, its export structure has not evolved to the next level beyond apparel, tea, and rubber products. Meanwhile, the volatile economic and political climate, together with the bureaucratic and restrictive investment climate, has deterred FDI inflows to Sri Lanka (Aisen and Veiga 2013). These developments have led to the widening of the external current account deficit, forcing the country to increasingly rely on foreign borrowings to finance such deficits.

Enhancing domestic production and increasing participation in regional and global value chains (GVCs) are of paramount importance in strengthening performance amid significant volatility in the prices of its exports of primary commodities. With import substitution being a popular policy instrument, it is important to appeal to the idea in trade economics of an import tax being an export tax. Taking this crisis as an opportunity, Sri Lanka should be redoubling efforts to increase exports via the following measures.

Removing restrictions on raw materials and input imports while taxed would remove the protection for domestic producers. One of the principal reasons why Bangladesh now has the most mechanised agriculture in South Asia is its liberal policies on agriculture machinery imports. Sri Lanka has policies giving exemption from customs duty, import cess, and VAT to selected agricultural equipment and machinery. However, the eligibility verification process is a cumbersome and highly time-consuming process, limiting uptake. The recovery drive after COVID-19 offers an opportunity for improving ease of business that would make availing these concessions easier.

Moreover, conditional on available fiscal space, the state should provide tax concessions or compensation with a predetermined tenure as a temporary stimulus to export industries.

Post-COVID-19, international trade is likely to be different with inherent tendencies towards erecting barriers. To confront the new reality, Sri Lanka should proactively and pre-emptively try to strengthen trade links. It should strive for an extensive margin, i.e. new products, new markets, new varieties, and prices. China, South Korea, Chile, and even Mynamar, while coping with sanctions, are proof that the expansion and resilience of trade are achieved through extensive margin adjustments. In accessing expansion on the extensive margin, new exporters comprising SMEs will play an important role. Here again, there is a need and opportunity for ease of doing business. The three-tiered registration process involving the Export Development Board (EDB), Internal Revenue Department (IRD), and Sri Lanka Customs (SLC) has been onerous and introduces fixed costs, disadvantaging SMEs. The ease of doing business that determines time and cost to trade needs to be taken up on a priority basis.

Furthermore, urgent measures are needed to meet debt service obligations. The government usually settles debt repayments using foreign reserves. As the government could not raise adequate liquidity owing to the unprecedented adverse market conditions, since 8 April 2020, the Central Bank has continued to provide liquidity from its foreign reserves. With export earnings affected due to COVID-19, Sri Lanka should be cautious about resorting to more external debts to support the domestic economy. It is important to borrow from local sources when necessary. Further, the government should seek non-debt-creating capital inflows to the country. While new export earning avenues should be explored, the import bill should curtail unnecessary imports. The government may negotiate terms of repayment on existing loans and spread the debt across a longer time span to ease out the immediate burden on the country due to COVID-19.

In addition, relying on remittances, tourism, apparel exports, and plantation crops as major sources of foreign exchange has proven to be risky. The country's export portfolio should be diversified in terms of products as well as markets to reduce uncertainty. Some options like IT services could be an option.

It is also important to further enhance domestic food availability and realise gains from innovations in supply chain compression (like e-trading and direct sales to consumers) that have emerged with COVID-19.

It is possible that imports might be constrained for some time. As a protective measure, Sri Lanka should use the crisis-driven opportunity to mitigate the constraints on domestic availability wherever applicable. There should be a drive to ensure raw materials (e.g. seeds, fertilisers, pesticides, packaging materials, etc.) from the most efficient sources. Also, structural changes in agriculture, like relaxing restrictions on the cultivation of crops (restrictions imposed on the cultivation of non-paddy crops in lowlands were relaxed in certain administrative divisions during the crisis period), are long overdue. From the value chain perspective, the focal areas are investment in cold storage facilities and revitalising the extension service. To improve competitiveness, the market information system based in government agencies should be widely available.

Covid-19 also brings to the forefront the importance of attributes like food safety, biosecurity, and animal health in agricultural value chains. Hence, as a path to recovery, the government should provide incentives to connect farmers to markets and engage in value addition and marketing while creating a reward system for healthy agricultural practices.

Annex 1: Cabinet Decisions

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20 Epilogue

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You've reached the end! That you read through a substantial part of this book is testimony to your interest in seeing agriculture deliver more effectively on its promise and development goals in food security, rural development, poverty alleviation, and environmental sustainability. These development goals demand a strategic element to policy analysis and decision-making. Thus, the economic concepts and tools presented in this book come with the fundamental premise that they are most useful when incorporated into evidence-based decision-making.

However, other considerations may come into play in agricultural policy decisions. There are political factors, such as the impact on and reaction of key groups, or specific outcomes favoured by decision-makers, such as increased support to small farmers. Culture is another consideration. A policy solution that prescribes a radical approach contrary to prevailing cultural norms may not be acceptable in a conservative society. On-the-ground realities also come into play. For instance, in a country that highly values the domestic production of its staple food, there can be substantial opposition at all levels to a policy recommendation for a freer international trade (i.e. increased imports). Additionally, there may be diverse and competing interests and objectives within a bureaucracy. A competent economic policy analyst must be aware of all these other considerations, even if unmoved by them.

The existence of such considerations means that the most effective policy analysis is 'local', i.e. done by people with a good understanding of the local situation. For instance, analysis that is oblivious to culture and on-the-ground realities can doom policy recommendations to non-acceptance, unintended consequences, and failure.

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Such issues reinforce the need for competent technical work in economic analysis using data and models to offer policy options, some of which may more explicitly take into account those other considerations.

This is the strength of this book—it offers agricultural policy analysts, agricultural planners, researchers, and students a set of core concepts and tools to examine a wide array of policy situations in agricultural development. We hope that you've found what you needed to make the case (evidence based, of course!) for your policy work in agricultural development.