India Studies in Business and Economics

Supravat Bagli
Gagari Chakrabarti
Prithviraj Guha *Editors*

Persistent and Emerging Challenges to Development

Insights for Policy-Making in India

Springer

India Studies in Business and Economics

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Editors
Supravat Bagli
Department of Economics
Presidency University
Kolkata, West Bengal, India

Gagari Chakrabarti
Department of Economics
Presidency University
Kolkata, West Bengal, India

Prithviraj Guha
Department of Economics
Presidency University
Kolkata, West Bengal, India

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Foreword

It is now widely agreed that the level of development of an economy cannot be measured satisfactorily by such conventional indicators as some measure of the value of the marketed goods and services in the economy, for instance, the gross domestic product (GDP). In recent decades, it has been convincingly argued that the notion of development is a multidimensional one. A reasonably adequate measure of development must pay attention to a whole gamut of issues that were ignored under the GDP-centred approach. The list is mind-bogglingly long and includes not only matters relating to the degree of inequality in the distribution of GDP (or some such aggregate) among the population but also the issues relating to health, education, environment, governance and the various aspects of social justice. Moreover, apart from problems of measurement, there is the crucial task of incorporating these diverse aspects of development into the analytical models that constitute the subject matter of development economics.

A totally new agenda for the development economist has thus been set. Even an indicative list of the directions in which the standard models of the economics of development that have been in vogue until recently need to be extended would include the following two: (1) extending the economy-wide (or macroeconomic) model a la W. Arthur Lewis by bringing the issues indicated in the previous paragraph within the purview of analysis and (2) studying the micro-issues relating to sectors such as foreign trade, health, education and so on that have so far been left out of the picture. Furthermore, so far as the task of testing the theoretical models in the light of observed facts is concerned, care must be taken to apply the latest econometric techniques that are available. Altogether, a huge programme!

In recent years, the Department of Economics, Presidency University, Kolkata, has played an increasingly significant role in the execution of this programme not only through the research efforts of the teachers in their individual capacities but also through collaborative research projects. Quite often, the net has been cast wide to include projects undertaken jointly with teachers and researchers working at other institutions. I am glad to learn that students, both at the postgraduate and at the undergraduate levels, are also encouraged to participate in these activities. Over the past few years, conferences and seminars have also been held with remarkable regularity for the purpose of disseminating the research findings.

Three young teachers of the Department, Supravat Bagli, Gagari Chakrabarti and Prithviraj Guha, have now taken the initiative to edit a collection of papers written as parts of this large programme. The interested reader will find here a rich body of significant research findings. For the convenience of the reader, the papers have been grouped under four broad headings: (a) macroeconomic and structural issues, (b) health and life quality, (c) education and the labour market and (d) issues relating to finance, credit supply, etc. At the very beginning of the book, there is a useful bird's eye view of the issues dealt with in the papers. This will help the individual readers in choosing the particular papers that they wish to take up for a detailed study. It is my great pleasure to recommend the volume of essays to all who are interested in the economics of development.

Asis Kumar Banerjee
Former Vice-Chancellor and Former
Professor of Economics
University of Calcutta
Kolkata, India

Preface

Since the end of the Second World War, the focus of the policy-making and resource allocation for development was primarily on poverty alleviation. Facilitating and enhancing overall economic growth were hailed as the panacea. With the passage of time, however, theories have emerged to challenge this traditional approach. The theories of economic dualism and unbalanced growth, and the theories of market failure pointed towards the aspects that the traditional approached overlooked. The inadequacy of following an income-centric approach towards development was unrevealed in 1990 when the United Nations brought out the first Human Development Report. The Millennium Development Goals further legitimized the claims for looking beyond income and consumption to evaluate level and growth in standards of living. Meanwhile, the econometric toolkit available to the researchers has steadily informed the theories, and this cross-pollination has set up the stage where the issues like inequality, education, health, sanitation, women's empowerment, fair trade, political and institutional constraints have gained relevance.

The Indian growth experience since the early 1990s till about 2015 has been exemplary relative to the world average, and this has been particularly successful in bringing tens of millions of people out of consumption poverty and hunger. This is well documented by the two waves of the nationally representative India Human Development Surveys of 2004–5 and 2011–12. However, the same surveys along with the National Health and Family Surveys or the Consumption and Employment–Unemployment schedules of the National Sample Surveys show that significant ground still needs to be covered before claiming success. The spectrum of such issues is really complex, and this complexity is magnified by the complexities in the nature of the global financial and economic architecture and networks that makes issues across the globe intertwined. It thus seems appropriate to produce a volume which rigorously informs policy-making for mitigating the multitude of disparate challenges. And, this is where the book makes an attempt.

This book brings together a right mix of senior and young economists who use cutting-edge techniques and/or revisit a perennial question with much sharper focus and tools to unravel insights that will surely inform tomorrow's theorization and policy-making. The volume looks at myriad of important questions like spatial concentration of low infant and child health outcomes, trade liberalization and export quality, intergenerational occupational mobility, multidimensional poverty incidence in rural India, robustness of the banking sector, to name a few. The set offers the readers an appropriate combination of empirical and theoretical papers and exposes especially the young researchers to a rich set of ideas and techniques. The book includes papers which use novel and esoteric methods like machine learning, spatial econometrics, system GMM, quintile regression and counterfactual decomposition (QRCD), etc. In a way, it provides a 360° view of challenges to economic development in India. The book will be a useful reference for serious readers not only in economics but also in quantitative sociology, management, etc. The holistic view of the problems and the comprehensive mapping of the challenges faced in actualizing development would appeal to the non-technical readers also.

We further take this opportunity to express our appreciation to those who have influenced this work. A sincere word of appreciation goes to the editorial and publishing team of Springer Nature, particularly to Ms. Nupoor Singh for her cooperation and support. While it is our pleasure to appreciate the suggestions of the anonymous referees, the usual disclaimer remains.

Kolkata, India
May 2021

Supravat Bagli
Gagari Chakrabarti
Prithviraj Guha

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Editors, Contributors and Reviewers

About the Editors

Supravat Bagli is currently working as an Associate Professor at the department of Economics, Presidency University, Kolkata. Before joining the Presidency University Dr. Bagli served the Department of Economics, Sidho-Kanho-Birsha University, Purulia, West Bengal, as an Assistant Professor and Head of the Department. He has been engaged in teaching at undergraduate level since 2005 and post graduate level since 2012. His teaching area extends Microeconomics, Public Economics, Statistics, and Advanced Econometrics. His research interests include rural development, poverty and inequality, microfinance, financial inclusion. He has published one book titled '*Group Centric Microfinance for Financial Inclusion Theories and Empirics*' and over forty research papers in different reputed national and international journals like *Journal of Rural Development, The Indian Economic Journal, The Indian Journal of Economics, The Asian Economic Review etc.* and in different edited books from reputed publishing houses like *Springer Nature, Emerald, IGI Global, Serial Publications.*

Gagari Chakrabarti obtained M.Sc., M.Phil. and Ph.D. in Economics from the University of Calcutta. She is teaching since 2001 and is currently serving Presidency University, Kolkata as an Associate Professor in Economics. Chakrabarti has served as Dean of Students (additional charge) at Presidency University. She has, in her repute, a number of publications in national and international journals and monographs and edited volumes published from international publishing houses such as Springer and Palgrave MacMillan. Her research interest lies in the areas of Financial Economics, Financial Econometrics, Complex and chaotic financial markets and more recently, in emotional intelligence and problems of ethical decision making in workplaces.

Prithviraj Guha is an Assistant Professor in the department of Economics at Presidency University, Kolkata. Dr. Guha received his Ph.D. in Economics from New

York University, USA. Prior to joining Presidency University, Dr. Guha served as a Visiting Assistant Professor at Queens College of the City University of New York. He is an applied researcher specialising in the fields of Development Economics and Political Economy. His research has mostly focused on the socio-political economy of India traversing the questions of electoral competition, state capture, political cycles, targeted government spending, public sector bank lending, health infrastructure capacity, intergenerational occupational mobility and poverty dynamics. Most recently, the Applied Economics Letters in 2021 published his work interconnecting Labour Rights and Human Rights in the context of a cross-country dynamic panel.

Contributors

Rajat Acharyya Department of Economics, Jadavpur University, Kolkata, India

Supravat Bagli Department of Economics, Presidency University, Kolkata, India

Amrita Bhanja Department of Economics, Jadavpur University, Kolkata, India

Supratik Sekhar Bhattacharya Vellore Institute of Technology, Vellore, Tamil Nadu, India

Gagari Chakrabarti Department of Economics, Presidency University, Kolkata, India

Saumya Chakrabarti Department of Economics and Politics, Visva Bharati (University), Santiniketan, West Bengal, India

Dripta Roy Choudhury Centre for Technology Alternatives for Rural Areas (CTARA), IIT-Bombay, Mumbai, India

Sanchita Daripa Department of Economics, University of Burdwan, Burdwan, West Bengal, India

Dishari Dasgupta Department of Economics, Presidency University, Kolkata, India

Jayeeta Deshmukh Presidency University, Kolkata, India

Soumyananda Dinda Department of Economics, University of Burdwan, Burdwan, West Bengal, India

Krittika Dirghangi Department of Economics, Presidency University, Kolkata, India

Mousumi Dutta Department of Economics, Presidency University, Kolkata, India

Papita Dutta Gushkara Mahavidyalaya, Gushkara, Purba Bardhaman, West Bengal, India

Shrimoyee Ganguly Department of Economics, Jadavpur University, Kolkata, India

Arpita Ghose Department of Economics, Jadavpur University, Kolkata, India

Debanjali Ghosh Analyst-Data Sciences, HSBC, Kolkata, India

Saswata Ghosh Institute of Development Studies Kolkata (IDSK), Kolkata, India

Saumaly Ghosh CESP JNU, New Delhi, India

Prithviraj Guha Department of Economics, Presidency University, Kolkata, India

Zakir Husain Economics Department, Presidency University, Kolkata, India

Anirban Kundu School of Management, Presidency University, Bengaluru, Karnataka, India

Sankha Mitra Humanities and Social Sciences Department, Indian Institute of Technology, Delhi, India

Saswatee Mukherjee Department of Economics, Presidency University, Kolkata, India

Ujjaini Mukhopadhyay Department of Economics, Behala College, Behala, Kolkata, West Bengal, India

Bipradas Rit Economics, Jogesh Chandra Chaudhuri College, Kolkata, India

Nirban Roy HSBC, Kolkata, India

Subangi Saha Department of Economics, Presidency University, Kolkata, India

Santosh Kumar Sharma International Institute for Population Sciences, Mumbai, India

Somtirtha Sinha Economics Department, Presidency University, Kolkata, India

Goutam Tewari The AG Church School, Purulia, India

Reviewers

Professor (Dr.) Amita Majumder Professor, Indian Statistical Institute, Kolkata

Professor (Dr.) Anindya Sen Professor, Indian Institute of Management, Calcutta

Dr. Anirudhya Mitra Associate Professor of Economics, Bard College, New York, USA

Professor (Dr.) Anjan Chakrabarti Professor of Economics, University of Calcutta

Professor (Dr.) Anup Kumar Sinha Ex-professor, IIM, Calcutta; Currently Director, Heritage Business School, Kolkata, India

Dr. Arindam Mandal Associate Professor of Economics, Siena College, New York, USA

Professor (Dr.) Basabi Bhattacharya Retired Professor of Economics, Jadavpur University, Kolkata

Professor (Dr.) Sebak Kumar Jana Professor of Economics, Vidyasagar University, Midnapore, West Bengal

Professor (Dr.) Soumyendra Nath Sikdar Retired Professor, Indian Institute of Management, Calcutta

Abbreviations

2SLS	Two-Stage Least Squares
AAs	Activity Agreements
ADF	Augmented Dickey–Fuller
AE	Allocative Efficiency
AIC	Akaike Information Criteria
ALSPAC	Avon Longitudinal Study of Parents and Children
ANMs	Auxiliary Nurse Midwives
ARDL	Autoregressive Distributed Lagged Model
ASI	Annual Survey of Industries
ATMs	Automated Teller Machines
AVA	Agricultural Value Added
BCC	Banker, Charnes and Cooper
BIMARU	Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh
BMI	Body Mass Index
BSR	Basic Statistical Returns
CCT	Conditional Cash Transfer
CDI	Crop Diversification Index
CPC	Customs Procedure Code
CPI	Consumer Price Index
CPI	Corruption Perceptions Index
CPIIW	Consumer Price Index of Industrial Worker
CRS	Constant Returns to Scale
CTS	Computerized Tomography Scan
CUSUM	Cumulative Sum
DEA	Data Envelopment Analysis
DHS	Demographic and Health Survey
DISE	District Information System for Education
DMU	Decision-Making Unit
ECG	Electrocardiogram
ECM	Error Correction Model
EDI	Educational Development Index

EU	European Union
FAO	Food and Agriculture Organization
FCM	Fuzzy C-Means
FGT	Foster–Greer–Thorbecke
FII	Financial Inclusion Index
FSUs	First Stage Units
GAV	Grand Average Value
GCA	Gross Cropped Area
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
GNP	Gross National Product
GVA	Gross Value Added
HAZ	Height-for-Age Z scores
HDI	Human Development Index
HDI	Human Development Indicators
HFC	Hindu Forward Castes
HS	Harmonized System
HVC	High-Value Crops
ICDS	Integrated Child Development Services
IHDS	Indian Human Development Survey
ILO	International Labour Organization
IMF	International Monetary Fund
IMR	Infant Mortality Rate
INPTE	Input-Oriented Technical Efficiency
IPCC	Intergovernmental Panel on Climate Change
IUGR	Intrauterine Birth Restriction
KALIA	Krushak Assistance for Livelihood and Income Augmentation
KM	Kilometre
KYC	Know Your Customer
LDCs	Least Developed Countries
LP	Linear Programming
LPG	Liquefied Petroleum Gas
LR	Likelihood Ratio
LRH	Lender's Risk Hypothesis
LVC	Low-Value Food Crop
MDG	Millennium Development Goal
MHRD	Ministry of Human Resource Development
MMR	Measles, Mumps, Rubella
MNCs	Multinational Companies
MPCE	Monthly Per Capita Consumption Expenditure
MPI	Multidimensional Poverty Index
MRI	Magnetic Resonance Imaging
MSME	Micro, Small and Medium Enterprises

NCAER	National Council for Applied Economic Research
NCO	National Classification of Occupations
NEET	Not in Education, Employment or Training
NER	Net Enrolment Ratio
NFHS	National Family Health Survey
NHA	National Health Accounts
NIC	National Industrial Classification
NOAA	National Oceanic and Atmospheric Administration
NPCMS	National Product Classification for Manufacturing Sector
NSDP	Net State Domestic Product
NSSO	National Sample Survey Office
NSSO	National Sample Survey Organization
NUEPA	National University of Educational Planning and Administration
OBC	Other Backward Classes
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
OOP	Out-of-pocket
OPHI	Oxford University Poverty and Human Development Initiatives
OUTTE	Output-Oriented Technical Efficiency
PCA	Principal Component Analyses
PMJDY	Prime Minister Jan DhanYojana
PPSWR	Probability Proportional to Size With Replacement
QRCD	Quantile Regression and Counterfactual Decomposition
RBI	Reserve Bank of India
RCA	Revealed Comparative Advantage
RIF	Recentered Influence Function
ROI	Regional Openness Index
SAMPURNA	Sishu Abond Matru Mrityuhara Purna Narakaran Abhiyan
SC	Scheduled Castes
SDG	Sustainable Development Goal
SRG	Socio-Religious Groups
SRS	Sample Registration System
SRSWR	Simple Random Sampling without Replacement
ST	Scheduled Tribes
SWTS	School To Work Transition Surveys
TCGN	Trade Credit Guarantee Networks
TE	Technical Efficiency
UK	United Kingdom
UNDP	United Nations Development Programme
UNFPA	United Nations Population Fund
UP	Uttar Pradesh
USA	United States of America
USG	Ultrasound Sonography
UTs	Union Territories
UVR	Ultraviolet Ray

VRS	Variable Returns to Scale
WHO	World Health Organization
WPI	Wholesale Price Index

Chapter 1
Introduction

Supravat Bagli, Gagari Chakrabarti, and Prithviraj Guha

1.1 Context

Since the end of the Second World War, policy-making and resource allocation for economic development around the world have focused primarily on poverty alleviation. The principal strategy to achieve this goal has been to facilitate and enhance the overall economic growth. The challenges towards this traditional approach started emerging steadily ever since, starting with the theories of economic dualism and unbalanced growth, the theories of market failure because of institutional and informational imperfections, and then, in 1990 the United Nations brought out the first Human Development Report which recognised the inadequacy of income-centric understanding of development. Thereafter, the Millennium Development Goals (MDGs) were proposed which further legitimised the claims for looking beyond income and consumption to evaluate level and growth in standards of living. Recently in 2015, the member countries of UN collectively set a set of goals—known as Sustainable Development Goals (SDGs)—to safeguard peace and prosperity of the mankind in a sustainable manner.

SDGs also emphasise on eradicating all kinds of deprivation in food consumption, in access to clean water, energy and sanitation, in access to healthcare facilities and in education facilities juxtaposed with ensuring responsible production for economic growth, reducing inequality, taking action against climate change and working to preserve life on oceans and forests. Meanwhile, the econometric toolkit available to the researchers has steadily informed the theories and this cross-pollination and has

S. Bagli · G. Chakrabarti · P. Guha (✉)
Department of Economics, Presidency University, Kolkata, India
e-mail: prithvi.econ@presiuniv.ac.in

S. Bagli
e-mail: supravat.econ@presiuniv.ac.in

G. Chakrabarti
e-mail: gagari.econ@presiuniv.ac.in

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brought us today to a stage where the importance of the issues like inequality, education, health, sanitation, women's empowerment, fair trade, political and institutional constraints is now widely recognised across the academia.

The Indian growth experience since the early 1990s till about 2015 has been exemplary relative to the world average, and this has been particularly successful in bringing tens of millions of people out of consumption poverty and hunger. This is well documented by the two waves of the nationally representative India Human Development Surveys of 2004–5 and 2011–12. However, since 2015 Indian economy has been facing an excessive slowdown. Balakrishnan (2014) has explained that slowdown in agricultural sector and fiscal policies were more responsible compared to the external factors for reversal movement of Indian economy. Current growth rate is close to Hindu growth rate; industrial production is falling; banking sector is running through hard times; agriculture is in a stagnant position; inflation rate is above the targeting rate; unemployment rate is historically high; indicators of exports, imports and government revenues have fallen noticeably (Subramanian & Felman, 2019; Government of India, 2020–21). During the last five years, the government has taken some major steps like a huge corporate tax cut, privatisation of some major public sector undertakings in the hopes of private sector investments. Meanwhile, Reserve Bank of India reduces interest rates recurrently in the hopes of reviving credit expansion. But due to lack of effective demand for our goods and services in the global market, investment is not increasing and thereby banking sector fails to expand credit. No doubt current COVID situation has triggered the pace of slowdown. Thus, the recent situation of Indian economy is frustrating. No doubt India has traversed long way for improving the literacy of its people through public policies since last three decades. But still the quality of overall education and its socio-regional disparity, and efficacy of government expenditure for education are questionable. Moreover, in respect of access to decent occupation, child health, hunger level, India is not in a good position in recent years (Global Hunger Index, 2020). Access to formal financial services, green energy for cooking, electricity and improved sanitation have been increasing since the eve of this millennium. However, there is wide socio-regional disparity in India in respect of accessibility and utilisation of these services. In this volume, we thus have tried to explore the explored constraints behind the effective sustainable development of India. The corpus of the volume offers a blend of analytical theorisations and empirical analyses based on multiple novel datasets on these issues. The IHDS surveys along with the National Health and Family Surveys or the Consumption and Employment–Unemployment schedules of the National Sample Surveys, RBI data, recent data on issues relating to Indian economy from World Bank, UNDP and primary survey data show that significant ground needs to be covered before claiming success or failure of India in the context of selected SDGs. Therefore, it is only appropriate to produce a volume which rigorously informs policy-making for mitigating the multitude of disparate challenges.

The size of the extant literature on the development experience around the world in general and India in particular is by no means insignificant. However, the spectrum of complexities being so rich and the lived realities of people that these issues are concerned with being so diverse as well, no question can ever be deemed settled especially when we take the microperspective. Simultaneously, the global financial and economic architecture is no less complex in the breadth of its networks and naturally permeates the globe so that some public heath failure in India is necessarily a global issue and likewise a financial crisis in Europe is definitely a problem for India as well. So, when we look at the set of perennial questions, e.g. wage or income inequality, access to credit, etc., we can always look for validation of existing theories in a novel setting or via more modern empirical techniques. These explorations invariably reveal germination of new trends and new questions which should be on the agenda of tomorrow's theorists.

In this particular regard, this volume offers immense potential by bringing together a right mix of senior and young economists who use cutting-edge econometric techniques and/or revisit a perennial question with much sharper focus and tools to unravel insights that are important and will surely inform tomorrow's theorisation and policy-making. The volume looks at myriad of important questions like spatial concentration of low infant and child health outcomes, trade liberalisation and export quality, intergenerational occupational mobility, multidimensional poverty incidence in rural India, efficiency of educational institutions, wage inequality, robustness of the banking sector, to name a few. The set offers the readers an appropriate combination of empirical and theoretical papers and will expose especially the young researchers to a very rich set of ideas and techniques. The book includes papers which use novel and esoteric methods like machine learning, spatial econometrics, double hurdle model, system GMM, quantile regression and counterfactual decomposition (QRCD), dynamic panel data analysis, etc.

1.2 The Coverage

Like there exists manifold challenges in achieving and sustaining economic development, this volume too has therefore been divided into four parts so that the reader's focus and time can be better utilised. They are: Part I. The Macroeconomy: Foreign Trade, Structural Transition and the Environment, Part II. Health and Standard of Living, Part III. Education, Human Capital and Evolution of the Employment Quality in India and Part IV. Banking and Credit: Access, Efficiency and Stability. These four parts are anchored and preceded by this introductory chapter. The chapter explains and describes the volume's narrative arc and argues how the collection is more than the sum of its parts.

Part I of this book emphasises the macro- and structural issues pertaining to the Indian economy. The included papers look at the roles of international trade, structural imbalance and transformation and the environment. The first chapter of Part I contributed by S Ganguly and Professor Rajat Acharyya (Chap. 2) adds analytically to the substantial literature on the quality dimension of exports of the developing countries. Using an elegant general equilibrium framework, they explain the observed phenomenon of asymmetric export quality variations based on the stylised facts revealed by the IMF data. The authors prove differential intensities of skilled labour or capital in quality improvement determine the impact of two types of trade liberalisation on quality upgradation of exports. A reduction of tariff on the input directly used to produce the quality-differentiated export good will induce quality upgrading only when higher qualities are relatively more intensive in imported input than skilled labour. If tariff on the input used in production of homogenous traded goods is lowered, on the other hand, export quality would be upgraded for those exports whose higher qualities are more intensive in skilled labour than capital. Improvement in quality of the export good, if at all, may also raise the value of such exports, despite a fall in volume of exports, under reasonable conditions.

Chapter 3 by A. Kunduand and Professor S. Chakrabarti presents an analytical model of formal–informal dynamic interaction predicting a particular type of transformation of the agricultural sector in India. They claim that changing cropping pattern from low-value crop cultivation to high-value crop cultivation retards the growth of both the urban and rural segments of informal sector. Using NSSO data, they empirically examine the root cause of conflicts and complementarities between formal and two segments of informal sector in India through this lens of expropriation of agricultural resource. This questions the notion of inclusive transformation of/within the informality. Perhaps, the very structure of contemporary capital that expropriates resources from the informality and simultaneously acquires cheap inputs from there is the cause of the painful persistence of this informality, especially that overwhelming rural segment of the informal sector.

In Chap. 4, S. Ghosh concentrates on the relatively neglected component of the health industry—production and export of medical devices, which covers a vast range of products with immense potential for exports. After giving a competent overview of the relatively sparse literature, the author presents a good discussion of the structure, production pattern and export import profile of this sector. It comes out that India's share in global trade is minuscule and mostly confined to the low end of the value chain (surgicals and disposables). Good economic analysis will provide immensely valuable service to policy-makers at the national level. In the light of the policy success in making India a major force in the global pharma market, there is no reason why that cannot be replicated in this field also. The longitudinal study points out the sources of future growth and therefore employment prospects and possible policy roles by additionally pointing out the past failures and their reasons.

Using time series data for the period 1960–2016 from central database of the World Bank, Bipradas Rit (Chap. 5) provides a comparative study of the effect of climate change on the agricultural output across the seven South Asian countries. The paper's contribution is not insignificant because hundreds of millions of people in the region, especially in India, remain dependent on agriculture whose sustainability and potential to provide income security to these people gets steadily limited as climate change affects cropping in multiple ways. The paper examines whether there is any equilibrium long-run relationship among value added by agriculture, CO_2 emissions, land under cultivation of cereal crops and rainfall using the ARDL bounds test and error correction model. However, the study concludes that there is no any evidence of the adverse impact of climate change on agriculture in South Asia and five selected countries.

While Part I provides us with perspectives which are both perennial and macroeconomic, the present volume believes that the policy interventions to surmount these challenges have to be tailor-made with micro-informational inputs. Hence, the subsequent chapters are clubbed accordingly. Although these sectional groupings are suggestive of the challenges in the economic grass roots, essentially, they prescribe the appropriate domains of intervention for the Indian policy framers. The focus of Part II is to assess health and life quality of Indian households. It starts with the book's Chap. 6 contributed by S. Daripa and Professor S. Dinda) which studies are important research issue focusing on Sustainable Development Goals for the year 2030. Using 68th round NSSO data (2011–2012), this study investigates the hurdles in fuel choice and actual consumption decision of Indian rural households and their socio-economic determinants. The authors estimate a double hurdle model, and the findings provide important health implications for rural India as the determinants may also be instrumental in accentuating income and consumption poverty via the human capital channel. Empirical findings indicate that income significantly determines quantity consumption, not firewood choice decision. Firewood consumption decreases with rising education level of household head. Women-headed households consume less firewood. Increased awareness through education and removing social barriers might help to reduce firewood consumption and take India towards Sustainable Development Goal.

In Chap. 7, S. Ghosh and his co-authors look into the problem of stunting in adolescent children via study across the districts in India to isolate the key determinants of this regressive outcome and to explain its high regional disparity. This chapter presents a detailed analysis of the relative contribution of different endowments (or covariates) and returns to those endowments (effects of implementation of various policies and programmes) contributing to disparities of childhood stunting in India. The authors use NFHS 4 (2015–16) unit-level data and group the states of India into six regions, viz. northern, southern, north-eastern, central, eastern and western regions. The results, using unconditional quantile regression-based counterfactual decomposition, indicate that covariate effects (endowments) and coefficient effects (returns to endowments) vary across regions and quantiles when compared to the benchmark region of southern states. This has major policy implications.

Chapter 8 (Dasgupta et al.) endeavours to explain interstate variation in infant mortality rate (IMR) in India first via exploration using spatial technique then performing confirmatory analysis employing panel data regression models. A state-wise analysis of IMR based on data from Sample Registration System (SRS) bulletins for the period 2005–2018 reveals that although there has been reduction in rural–urban gap, states like Assam, Madhya Pradesh and Rajasthan are lagging the all-India average. Panel data analysis, for 21 major states, reveals that per capita income, urbanisation, female literacy, per capita availability of milk and immunisation are the significant macro-determinants of IMR of Indian states. Although states have introduced several policies like Kanyashree Prakalpa (West Bengal), Karunya Health Scheme (Kerala) to address issues like female education, health security, etc., the authors recommend an integrated and holistic approach for all lagging states to ensure an improvement in infant mortality indicators.

Chapter 9 (S. Bagli and D. Ghosh) examines a less researched aspect of maternal health by determining the causal factors for the incidence of wasted pregnancies for the Indian women, via the application of logistic regression model in the nationally representative IHDS-2 dataset. This chapter assesses the effects of antenatal care along with choice of the place of delivery, reported physical health condition and the incidence of getting anaemia of mother on incidence of wasted pregnancy for Indian women. The study reports that access to antenatal care and access to hospital for delivery place significantly reduces the probability of wasted pregnancy. Incidence of anaemia and reported poor physical health increases the risk of wasted pregnancy in India. Backward Classes and Dalits have a major disadvantage in respect of both physical health and healthcare utilisation. Place of residence, age at marriage, per capita income, education, media exposure of women are important for getting access to healthcare facilities which are instrumental for reducing wasted pregnancy.

In Chap. 10, S. S. Bhattacharya employs machine learning approach of fuzzy C-means clustering to the district-level Indian Census data of 2011 on household assets and amenities ownership and obtains an interesting pattern of socio-economic and regional grouping of standard of living. The quality of living has been captured through 26 attributes for each district. The clustering analysis of the data with various choices of number of clusters has been carried out and the results discussed. It identifies geographical spread of clusters in various states of India and helps to identify regional imbalances. These results can be used to orient investment plans for various sectors such as education and housing, digital connectivity infrastructure, establish ease of living ranking indices for districts which, in turn, can establish a rational basis for coordinated development of Indian regional economies.

The paper of S. Bagli and G. Tewari in Chap. 11 provides a systematic exploration of multidimensional poverty incidence in a novel dataset of rural hamlets in Purulia, western most district of West Bengal, India, and reveals an interesting pattern of variation across the socio-economic groups. It applies the methodology, developed by Oxford Poverty and Human Development Initiative (OPHI), recognised by UNDP for measuring multidimensional poverty index (MPI) considering 12 indicators under the dimensions of health, education and quality of life. MPI for Purulia district (0.161) is significantly higher than the MPI for whole India (0.121) in 2018. Among the selected indicators, deprivation of access to improved cooking fuel and deprivation of access to improved sanitation are two leading contributors to the district MPI followed by the indicators, regarding material of residence, suffering from hunger. Therefore, the study messages to the policy-makers for further expansion of infrastructure regarding food security and sanitation facility are urgent policy recommendation for curbing the incidence and the intensity of multidimensional poverty in rural India particularly in Purulia district.

Part III has its primary focus on education and the labour market. Wide recognition of the importance of human capital formation coupled with the egalitarian goal under SDGs to reduce inequalities in opportunities and earnings encourages the researchers to evaluate the impact of differential public allocation to school education and tertiary (higher) education on employment, skill and income. With this backdrop, Part III of this book includes four chapters. A. Bhanja and Professor A. Ghose in Chap. 12

estimate Input-Oriented Technical Efficiency (INPTE) for primary schools in twenty districts of West Bengal during the period 2005–06 to 2013–14. Nonparametric data envelopment analysis (DEA) has been used to estimate INPTE. Both quantitative (net enrolment ratio) and qualitative (share of students passed with 60% or higher marks in examination) aspects of outputs are used to measure INPTE. Based on INPTE calculations, the paper estimates a random effect panel model to determine role of various policy variables affecting INPTE. This study reports that high literacy rate may not result in high INPTE. Percentage of single teacher schools reduces INPTE, whereas percentage of schools having girl's toilet, percentage of girls getting free textbook to boys and per capita net district domestic product improve the INPTE of the primary schools in West Bengal. The results clearly have implications for the evaluation of government expenditure towards primary education and related aspects and thereby for the future market of skilled workforce in the country.

Formulating a three-sector intertemporal general equilibrium model, U. Mukhopadhyay (Chap. 13) has analysed the effects of differential allocation of public funds on pre-tertiary and tertiary education, on skilled–unskilled wage gap in the economy. Skill formation is endogenous and supplies of unskilled and skilled labour are determined by intertemporal utility maximising behaviour of the households. Analysis indicates that both subsidies on pre-tertiary and tertiary education are beneficial for reducing wage inequality irrespective of the level of skill formation if the low-skill sector is more capital intensive vis-à-vis the high-skill sector. However, if the high-skill sector is more capital intensive, subsidy on tertiary education may reduce the skilled–unskilled wage inequality only when the skilled labour stock is higher, while pre-tertiary education is likely to be favourable during the period of skill formation only if the returns to education are sufficiently high. The government policies pertaining to public fund allocation on education should take into account the relative factor intensity conditions and the level of skill formation in the economy. Thus, the optimal policy choice balances a trade-off and, therefore, poses a challenge for education and development of the country.

In Chap. 14, S. Sinha and Professor Z. Husain have conducted an inquiry into the nature and causes of the phenomenon and incidence of Not in Education, Employment or Training (NEET) by analysing data from several rounds of the Employment–Unemployment Survey of the NSSO, India. A binary logit model has been used to estimate the incidence of NEET and its determinants.

In addition to the determination of factors affecting NEET in India, the authors also estimate the burden of this negative phenomenon of the Indian labour force. They estimate the total loss in earnings of the NEET individual taking the average income of the individual in labour force as potential earning of the NEET individuals. A systematic analysis of the NSSO data of two time points reveals that being a female and being married increase the odds of being a NEET significantly. Apart from this, family affluence, age, education level and socio-religious community of the individual were all found to be significant determinants of NEET. Finally, the total income loss to the NEET was about 2% of GDP in 2004–05 and about 7% in 2011–12.

Chapter 15 (P. Guha and N. Roy) uses data from the second round of the nationally representative India Human Development Surveys to estimate the extent and pattern of inter-generational occupational mobility via computation of multiple indices. The authors employ logistic regressions to establish the significant determinants of upward mobility and find stagnation with respect to certain geographical regions and socio-religious groups and indicate the challenges yet to be surmounted by extant public policies. They explore occupational mobility in India sticky, and there has been significant upward mobility if we look towards a relatively younger generation. Upward mobility in the east and north zones compared to south and west zones in India is significantly higher. The Backward Castes have also recorded higher levels of mobility and upward mobility vis-a-vis the forward castes indicating that they are climbing the occupational ladder.

The most acknowledged reason for economic underdevelopment or recent worldwide slowdown is arguably the imperfect and inadequate financial markets leading to binding credit constraints and, therefore, suboptimal growth of production and consumption. Moreover, recent incidence of insolvency and bankruptcy in India impair faith of the common people on the banking system and accelerate the twin balance sheet problem of the banks and the companies in India facing lack of demand. Against this backdrop, a vicious circle of low savings and low demand for loans and default of the existing borrowers has been identified as a cause of recent slowdown in India. Part IV of the book addresses the issues by putting together four studies under the subtheme—Banking and Credit: Access, Efficiency and Stability. Chapter 16 by Gagari Chakrabarti recognises that the risk of banking sectors might escalate with strengthening financial globalisation and the situation could worsen during financial crises analysing the balanced panel data for sixty-four countries for a period ranging from 1996 to 2017 from Global Financial Development Database (2018), World Bank. It explores the issues behind the risk of default of the commercial banking sector in different countries that stand at different stages of financial, investment and trade openness. It applies the tool of dynamic panel data analysis on the banking sector where the causal factors behind bank defaults in the presence of globalisation are explored and established via system GMM estimation. Trade openness, financial freedom and investment freedom indices are constructed via principal component analysis. Banks appear less fragile where deregulations come with free investment and business opportunities. Growth and transparency at governmental level improve bank stability but only in countries that operate at moderate levels of openness, growth and transparency. The study asserts that the efficiency of minimally regulated market may still be maintained if global market risks are managed efficiently.

In Chap. 17, Jayeeta Deshmukh analyses credit networks in a semiformal garments manufacturing industry of Metiabruz, Kolkata, in India by characterising the network architecture by gleaning information from a primary survey and then further testing the network properties by checking for its efficiency and stability. It proves how the stability of trade credit guarantee networks, in the absence of enforcement problems, can rule out strategic default. Moreover, size of the guaranteed amount that could have been if they were directly linked does not decline as long as the two players are linked through common friends or even a sequence of friends of friends. She establishes that there does not exist any tension or conflict between stability and efficiency; cycle-free networks, i.e. star networks, line networks or tree networks, are both strategically stable and efficient in the context of the semiformal garments manufacturing industry of Metiabruz, Kolkata.

Another theoretical study by Saswati Mukherjee (Chap. 18) explores efficiency and stability of credit market equilibrium in a dynamic setting which is characterised by asymmetric information and risk of strategic default. As opposed to Lender's risk hypothesis, this paper dealing with informal credit market in infinitely repeated lending framework with adverse selection and strategic default shows that interest rates are higher when the default risks are lower. Further, some comparative static exercises explore the impact of parametric changes on the market interest rate. The paper proves that the higher interest rate equilibrium will prevail if the proportion of borrowers with greater access to alternative credit sources in the population falls below a critical level and vice versa. In addition, higher return from any successful venture, lower amounts of loan, higher probability of success of any project, increasing future orientation of the borrowers with greater access to alternative credit sources and lower valuation of future incomes of the lender and borrowers with no alternative credit sources reduce the market interest rate. Therefore, availability and accessibility to alternative credit sources might reduce the interest rate in the credit market that accelerate the demand for loan. In the concluding chapter, Papita Dutta examines achievements of Indian states and union territories towards financial inclusion during the 2010s. Pursing banking data published by the Reserve Bank of India, the author has computed financial inclusion indices across sub-national units covering three dimensions—availability, accessibility and applicability of formal financial services. The weighted geometric mean of the normalised indicators is considered as financial inclusion index. The principal component analysis has been conducted to derive the weights of the indicators. She has applied cluster analysis to scrutinise the pattern of financial inclusion across the states and union territories to unravel the effect of the government initiatives. The PMJDY has effectively accelerated the access to formal banking services. However, during the post era of PMJDY the propensity to formal savings as well as credit income ratio decreases. The fact is true for most of the major states in India. The study explores that most of the southern states have performed relatively better while the north-eastern states lie behind among the states and union territories in India. Moreover, level of financial inclusion of the sub-national units has low mean but high disparity in 2011–12 which persists even in 2018–19.

1.3 Concluding Remarks

This book is relevant contribution to understand the achievements of India in respect of the role of international trade, and inclusive development policies for achieving the MDGs and how long it has to traverse to reach the SDGs. The major findings of the analysis and discussion can be summarised in this section. Under certain conditions lowering tariff on the input export quality would be upgraded. India's share in global trade of medical devices is negligible and mostly confined to the low end of the value chain (surgicals and disposables). It messages to policy-makers for searching the sources of future growth and therefore employment prospects. The nature of contemporary capital that expropriates resources from the informality and simultaneously acquires cheap inputs from there is the cause of the painful persistence of this informality. A systematic study concludes that there is no significant evidence of the adverse impact of climate change on agriculture as a whole in South Asia and five selected countries. Therefore, to accelerate the 'Make in India' scheme imposing high level of import tariff may not be success. We have to emphasise on the immerging and unexplored field for improving the volume of export. The very structure of capital not the climate change is a serious problem backwardness of agriculture. The policy-makers should look into the fact for implementing policy for inclusive agriculture in India.

An empirical study concludes that household income is immaterial to take decision regarding the nature of cooking fuel to be used in the Indian households. Firewood consumption decreases with higher education level of household head. The finding is highly significant for female head. Thus, education and women's empowerment might help to use green energy for cooking and take India towards Sustainable Development Goal. The relative contribution of different endowments and returns to those endowments contributing to disparities of childhood stunting in India have been explained. Per capita income, urbanisation, female literacy, per capita availability of milk and immunisation are important for reducing IMR of Indian states. We find access to healthcare facilities like antenatal cares, delivery at healthcare centre, anaemia which are responsible factors for wasted pregnancy for Indian women. These findings would help the policy-makers to reduce the depth and disparity of child health in India. Expansion of infrastructure regarding food security and sanitation facility is urgent policy recommendation for curbing the incidence and the intensity of multidimensional poverty in rural India particularly in Purulia district.

High literacy rate may not result in high efficiency of primary schools in West Bengal. Single teacher schools are important constraint for improving the efficiency of the primary schools. Public fund allocation on education should take into account the relative factor intensity conditions and the level of skill formation in the economy. Thus, the optimal policy choice poses a challenge for education and development of the country. The group of NEET causes about 2% of GDP loss in 2004–05 and about 7% in 2011–12. Gender, family affluence, age, education level and socio-religious community of the individual are important factors contributing to the group of NEET. Occupational mobility in India is found to be sticky, but there has been significant upward mobility among the relatively younger generation.

Growth and transparency at governmental level improve bank stability but only in countries that operate at moderate levels of openness, growth and transparency. Informal trade credit guarantee network may help to get access to cheap credit. It has been established that availability and accessibility to alternative credit sources might reduce the interest rate in the credit market that accelerate the demand for loan. The level of financial inclusion of the sub-national units has low mean but high disparity in 2011–12 which persists even in 2018–19. It shows the policy paralysis of the government, because PMJDY put emphasis more on supply side not on demand side. Therefore, to accelerate the financial inclusion we need to frame policy for improving the effective demand for loan.

Therefore, the book provides a clear message to the policy-makers for further development in India reducing the gap of the current situation from the goal posts. Moreover, putting forward several cutting-edge research questions and novel ideas of analysis under the main themes the book encourages the readers to undertake research projects to combat the research gap still uncovered in this volume.

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Part I
The Macroeconomy: Foreign Trade, Structural Transition and the Environment

Chapter 2
Asymmetric Quality Effect of Input Trade Liberalization

Shrimoyee Ganguly and Rajat Acharyya

2.1 Introduction

Low qualities of goods produced by the developing countries often adversely affect their merchandise export growth in the advanced and richer countries. Developing countries like Brazil, China, India and Mexico, despite their diversified export baskets, are no exceptions to this low-quality phenomenon either. There is a substantial literature that highlights on this low-quality phenomenon constraining exports' prospects of the developing countries (Baldwin & Harrigan, 2011; Hallak, 2006; Johnson, 2012; Manova & Zhang, 2012a; Sutton, 2001). Recent growth literature also suggests that low quality of exports makes export-led growth weaker (Agosin, 2007; Hausman et al., 2007; Hesse, 2008; Rodrik, 2006). Among the many alternative plausible explanations, one major argument put forward for the low-quality phenomenon is restrictive trade policies pursued by the developing countries. High tariffs on imports of intermediate goods induce the domestic producers in these countries to substitute these inputs by indigenous inputs, which are of inferior qualities. This results in inferior qualities of final goods as well compared to qualities of similar goods produced in the developed and/or richer nations. A sizeable recent empirical literature emphasizes upon this, highlighting the role of input trade liberalization as incentivizing quality upgrading of exports (Verhoogen, 2008; Manova & Zhang, 2012b; Kugler & Verhoogen, 2012; Bas & Strauss-Khan, 2013; Hu et al., 2017). For example, using Chinese trade transaction data, Bas and Strauss-Khan (2013) find

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S. Ganguly (✉) · R. Acharyya
Department of Economics, Jadavpur University, Kolkata 700032, India
e-mail: shrimoyeeganguly.rs@jadavpuruniversity.in

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that those firms who were sourcing high-quality inputs from the developed countries experience a rise in export prices and upgrade quality of products they are exporting to the high-income countries. They also find that firms take advantage of the input trade liberalization to increase both the number of input varieties they import and the price of their imported varieties which suggests a within-firm quality upgrading of imported inputs.

Of course, if quality and intensive use of imported input or intermediate goods is the only key factor for quality upgrading, then input trade liberalization incentivizing exporters to upgrade quality of their export goods is a foregone conclusion. But, the trends in asymmetric quality variations across different products group for India, as revealed by the IMF data, do not corroborate with this argument.

Not only variations in quality of manufacturing goods have been non-monotonic, but such variations have been asymmetric across different product groups. Moreover, such asymmetric variations are more pronounced after the mid-1980s that marks the beginning of the liberalization of import of capital and intermediate goods by India. For example, the data in Fig. 2.1 shows that quality of leather and leather manufactures, which had a higher value than that of all the other products being considered, started to decline steadily from the mid-1980s till 2000. Quality of chemical materials and products and medicinal and pharmaceutical products, on the other hand, which are heavily dependent on import of chemical elements and compounds as primary inputs for quality upgrading, had a somewhat smooth, subdued but increasing trend from the late 1970s. Again, if we look at electrical machinery, apparatus and appliances, its product quality did not vary much even during the periods of trade liberalization. In sharp contrast to these trends, quality of petroleum and petro-products and

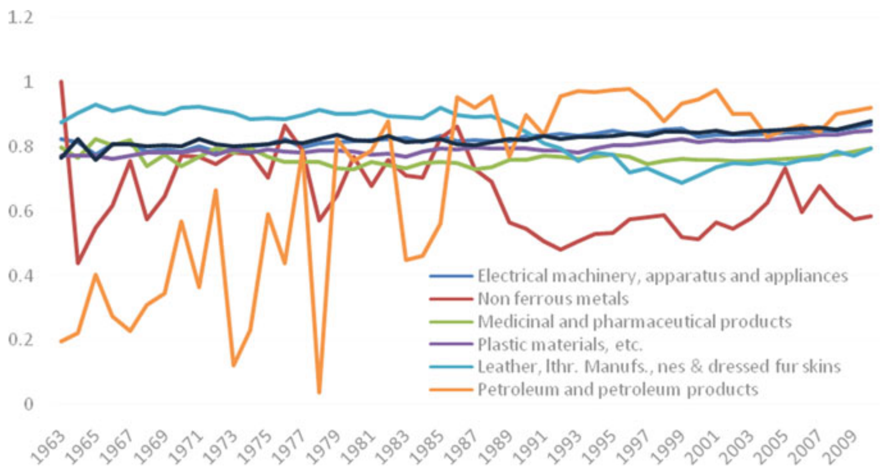

Fig. 2.1 Asymmetric quality variations across product groups (SITC 2 digit level) for India. *Source* Authors' calculation based on IMF, 2014 (http://www.imf.org/external/np/res/dfidimf/diversification.htm)

non-ferrous metals had been extremely volatile till the mid-1980s. But during 1986–1992, while quality level of non-ferrous metals faced a steep decline and later started picking up, that of petroleum and petroleum products kept soaring up with some down spikes here and there. While leather and leather manufactures shared a similar trend with non-ferrous metals from the mid-1980s to the mid-1990s, medicinal and pharmaceutical products, chemical elements and compounds and electrical machinery, appliances and apparatus had moved contrary to that of non-ferrous metals during that period. These observations can further be captured through pair-wise correlation values as reported in Table 2.1. These correlation values are calculated for the period 1980–2000 during which asymmetric quality variations across product groups are more pronounced. Note that, while the positive correlation value for a pair of products suggests that their quality levels have moved mostly in tandem (or in the same direction), negative correlation values indicate asymmetric quality variations of the concerned pair of product groups. Interestingly, as reported in Table 2.1, by this first-hand indicator of statistically significant negative correlation values, asymmetric quality variations are revealed by the data for most of these product groups under consideration. These observations may suggest that input trade liberalization may have affected, if at all, quality of Indian goods asymmetrically. Of course, detailed empirical analysis would be required to arrive at a more conclusive evidence.

One reason for asymmetric effects across different products may be that, in addition to imported inputs, other domestic factors like skilled labour and/or capital have been important as well for quality upgrading. Input trade liberalization raises domestic factor costs through expansion of production and consequent increase in the demand for scarce domestic factors of production. So, if intensity of imported input *relative* to skilled labour or capital for quality upgrading varies from one product to the other, then the non-monotonic movements in quality are not unexpected. Two observations are in order here. First, off late, some studies have observed robust evidences on the intensive use of domestic inputs like skilled labour and/or capital in producing higher-quality export goods (Brambilla & Porto, 2016; Brambilla et al., 2012, 2014; Schott, 2004).[1] Yu (2013) considered similar domestic factor cost for quality upgrading and had shown that heterogeneous exporting firms downgrade quality to lower export prices and absorb the adverse shock of an exchange rate appreciation on domestic factor cost. Second, import intensity relative to skill and or capital does vary for goods like gems and jewellery, chemicals and pharmaceutical products, scientific instruments, etc., produced by India.

From such a perspective, we examine whether input trade liberalization can offer a plausible explanation for the observed asymmetric quality variations across different products. We address this issue theoretically in terms of a general equilibrium framework with all domestic factors of production being fully employed to bring out implications of scarcity of domestic resources like skilled labour and capital. In

[1] Schott (2004), for example, found that export unit values, which are used as proxy for quality of exports, increase systematically with per capita income and relative endowments of physical and human capital of the exporting countries.

Table 2.1 Correlation matrix

	Electrical machinery	Non-ferrous metals	Medicinal and pharmaceutical products	Plastic materials	Leather and leather manufactures	Petroleum and petroleum products	Chemical materials and products
Electrical machinery	1						
Non-ferrous metals	−0.5944*	1					
Medicinal and pharmaceutical products	0.5547*	−0.7302*	1				
Plastic materials	0.6589*	−0.3945	0.3212	1			
Leather and leather manufactures	−0.8092*	0.7687*	−0.5841*	−0.7447*	1		
Petroleum and petroleum products	0.4050	−0.4614*	0.3800	0.4905*	−0.5409*	1	
Chemical materials and products	0.7336*	−0.6233*	0.5661*	0.6217*	−0.8521*	0.3889	1

Note Correlation values are calculated for the period 1980–2000
Values with asterisk (*) indicate statistical significant at 95% confidence interval
Source Authors' calculations using Stata 13

this regard, we closely follow the theoretical analysis of Acharyya and Jones (2001)[2] and Ganguly and Acharyya (2020). Our analysis, however, is more generalized as we allow for quality upgrading requiring more intensive use of skilled labour, capital and the imported input, though in varying degrees.[3] This enables us to analyse differential or asymmetric effects that input trade liberalization may have on quality variations of export goods that differ in respect of relative skill or capital or imported input requirement for their quality upgrading. The small open economy under consideration produces three goods: a composite traded sector (T) that clubs all homogenous traded goods, a homogenous non-traded sector (N) and a quality-differentiated export good (Z). All these goods use the same capital (K). Along with capital, the homogenous goods, T and N, are produced using unskilled labour (L), while the quality-differentiated good Z uses skilled labour. In addition to the domestic factors, two imported inputs are used, both being subject to ad valorem tariffs: M in sector T and I in sector Z. Such a diversified trade pattern is not at odds with observed export baskets of China and India, for example, as availability of specific types of skilled labour has made these countries' export skill-based products like chemicals, software, office equipment, transport equipment and scientific instruments, alongside trade in low-skill or unskilled-intensive products like agricultural goods, cotton textiles, leather manufacture, etc. In such a set-up, we establish the following results. First, as anticipated, input trade liberalization in terms of reduction of tariff on input I used by good Z improves quality of the export good Z only if higher-quality variety of it requires additional imported input to a larger extent than additional skilled labour. Reduction of input tariff lowers the marginal cost of quality for any given skilled wage. At the same time, input trade liberalization augments production of skill-based export goods, which in turn raises the skilled wage. This raises the marginal cost of quality upgrading. Hence, overall, the marginal cost of quality will fall and quality will be upgraded if *relatively* more imported input is required for upgrade quality. Second, when the tariff on the imported input used in the composite traded good is lowered, the import intensity of good Z is no longer relevant. Now, quality will be upgraded if, for any given import requirement, higher qualities of good Z require relatively more skilled workers than capital. The importance of skill intensity relative to capital intensity follows from the fact that now tariff reduction raises the rate of return to capital and lowers the skilled wage. Third, if the country adopts an equiproportionate across-the-board tariff reduction, then even when reduction of the two tariff rates has opposite effects, the quality of good Z can increase under a reasonable condition. Fourth, value of exports of good Z can increase when its quality is upgraded despite a corresponding fall in the volume of its exports.

Rest of the paper is organized as follows. In Sect. 2.2, we set out our analytical structure and describe determination of quality of the export good. Section 2.3

[2] The underlying theoretical structure was originally used by Gruen and Corden (1970), which has been later developed in Acharyya and Jones (2001) and more recently Marjit et al. (2020).

[3] Ganguly and Acharyya (2020) highlight on implications of emigration of unskilled workers and taxing remittances by them to finance a production subsidy.

examines the effects of reduction of tariff on imported input I used in the quality-differentiated export sector and on the imported input M used in the composite traded sector. In Sect. 2.4, we consider implication of equiproportionate across-the-board lowering of input tariffs. Section 2.5 derives the condition under which quality upgrading raises the value of exports despite a fall in the volume of exports. Section 2.6 briefly outlines an empirical test of the theoretical exercise as a future analysis, and finally, we conclude the paper in Sect. 2.7.

2.2 The Model

Consider a small open economy producing a set of homogeneous goods—a composite traded good (T) and a non-traded good (N)—and a quality-differentiated export good (Z), whose quality is observable to all and indexed by $Q \in [0, \overline{Q}]$.[4] The two homogeneous goods are produced by unskilled labour (L) and capital (K). The composite traded good T also uses an imported input (M). Good Z, on the other hand, is produced by the same capital along with skilled labour (S) and a different imported input (I). Domestic markets for all the commodities and factors of production are perfectly competitive. Thus, the rate of return to capital (r) and two money wages, unskilled wage (w) and skilled wage (w_S), are fully flexible and adjust to clear the relevant factor markets. Production technologies for T and N follow CRS and per unit input requirements (a_{ij}, $i = L, K, M, j = T, N$) are technologically given.

Perfect competition in the composite traded good and non-traded good sectors leads to the following zero-profit conditions:

$$P_T^W = a_{LT}w + a_{KT}r + a_{MT}(1+t)P_M^W \tag{2.1}$$

$$P_N = a_{LN}w + a_{KN}r \tag{2.2}$$

where $t \in [0, 1]$ is the ad valorem tariff rate on the imported input M; P_T^W and P_M^W are the world prices of T and M that are exogenously given to this small economy; and P_N is the locally determined price of the non-traded good. Assuming homothetic tastes, the market-clearing condition of the non-traded good, which also implies that trade is balanced for this small open economy, can be specified as:

$$\frac{D_N}{D_T} = f\left(\frac{P_N}{P_T^W}\right) = \frac{X_N}{X_T} \tag{2.3}$$

where X_N and X_T are the output levels of non-traded good and composite traded good, respectively.

[4] This rules out the problem of information externality associated with unobservable and uncertain product quality (see Akerlof 1970).

The world price of the quality-differentiated export good Z, P_Z^W, is also exogenously given for any particular quality of it. But, as foreign buyers are willing to pay a higher price for a higher quality of this good, so the world price increases (at an increasing rate) with the quality of good Z:

$$P_Z^W = P_Z^W(Q), P_Z^{W\prime}(Q) > 0, P_Z^{W\prime\prime}(Q) > 0 \tag{2.4}$$

Regarding production technology for good Z, we assume that a higher-quality variety of Z requires more intensive use of both the domestic factors, capital and skilled labour, as well as imported input I, though in different proportions. But, for any given quality, per unit requirements of S, K and I are fixed. More precisely, we assume that

$$a_{iZ} = a_{iZ}(Q), a'_{iZ}(Q) > 0, a''_{iZ}(Q) > 0, \; i = S, K, I \tag{2.4a}$$

Note that the sign of the second partials reflects diminishing returns to each of the factors in quality upgrading.

Perfect competition in Z production means all firms earn zero profits for any given choice of quality:

$$P_Z^W(Q) = a_{KZ}(Q)r + a_{SZ}(Q)w_S + a_{IZ}(Q)(1+\tau)P_I^W \tag{2.5}$$

where P_I^W is the exogenously given world price of the imported input and τ $(0 < \tau < 1)$ is the ad valorem rate of tariff imposed on the imported input I.

Profit maximizing choice of quality is driven by the marginal condition that equates the marginal revenue from raising quality to the marginal cost of quality upgrading:

$$P_Z^{W\prime}(Q_0) = a'_{KZ}(Q_0)r + a'_{SZ}(Q_0)w_S + a'_{IZ}(Q_0)(1+\tau)P_I^W \tag{2.6}$$

where Q_0 is the profit maximizing quality level for any given rate of input tariff and relevant factor prices.

Finally, we close the model with the full employment conditions of the domestic factors that are ensured by flexibility of rates of return to capital and informal wage:

$$\overline{K} - a_{KZ}(Q)X_Z = \tilde{K}(Q) = a_{KT}X_T + a_{KN}X_N \tag{2.7}$$

$$\overline{L} = a_{LT}X_T + a_{LN}X_N \tag{2.8}$$

$$\overline{S} = a_{SZ}(Q)X_Z \tag{2.9}$$

where X_T, X_N and X_Z denote the output levels of the composite traded, non-traded and quality-differentiated export goods, respectively.

Above set of eight equations in Eqs. 2.1–2.3 and Eqs. 2.5–2.9 determines the eight variables in our system: $w_S, w, r, Q, P_N, X_T, X_N$ and X_Z. To understand the working of the model, first consider how the profit maximizing quality (as given in the marginal condition (Eq. 2.6)) depends on the factor prices. For any given skilled wage and tariff on I, a ceteris paribus rise in the rate of return to capital raises the marginal cost of quality. On the other hand, the rise in capital cost causes production of good Z to contract at the initial level of its quality. Consequent fall in the demand for skilled labour lowers its wage. This in turn lowers the marginal cost of quality. So while the marginal cost of raising quality rises on account of the rise in r, it falls on account of the fall in w_S, at the initial level of quality Q. Consequently, quality of good Z will be upgraded if higher qualities are relatively more intensive in skilled labour than capital and downgraded otherwise. Algebraically, as shown in the appendix:

$$\frac{\mathrm{d}Q}{\mathrm{d}r} = -\frac{P_Z^W(Q)\theta_{KZ}}{\delta Qr}(\gamma_{SZ} - \gamma_{KZ}) \tag{2.10}$$

where θ_{KZ} is the share of capital in unit production cost of good Z; $\delta \equiv \left[eP_Z^{W\prime\prime}(Q) - w_S a''_{SZ}(Q) - r a''_{KZ}(Q)\right] < 0$ by the second-order condition for profit maximization; and $\gamma_{SZ} = \frac{\partial a_{IZ}}{\partial Q}\frac{Q}{a_{IZ}}$ and $\gamma_{KZ} = \frac{\partial a_{KZ}}{\partial Q}\frac{Q}{a_{KZ}}$ are quality elasticity of per unit requirements of skilled labour and capital, respectively, in production of Z.

Note, $\gamma_{SZ} > \gamma_{KZ}$ implies that a higher quality of Z requires *relatively* larger units of skilled labour than capital. So, the profit maximizing choice of export quality is inversely related to the rate of return to capital when $\gamma_{SZ} < \gamma_{KZ}$ and positively related to it when $\gamma_{SZ} > \gamma_{KZ}$. We represent this relationship by the Π_Z curve in Fig. 2.2, which is the locus of all combinations of r and Q that satisfies the marginal condition (Eq. 2.6).

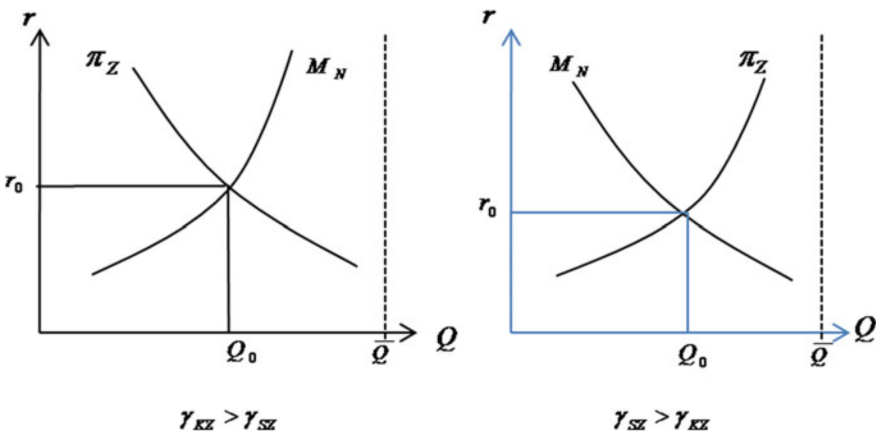

Fig. 2.2 Simultaneous determination of r and Q

There is also a reverse causation from a change in export quality to a change in the rate of return to capital. Given the world price of the composite traded good, the rate of return to capital, along with the unskilled wage, is determined by the locally determined price of the non-traded good. This is evident from the zero-profit conditions (Eqs. 2.1 and 2.2). However, the price of the non-traded good depends, among other things, on the level of export quality of Z. That is, any change in Q will affect the rate of return to capital through changes in price of non-traded good in the local market. For example, a ceteris paribus increase in quality of Z will require additional capital by the extent $\hat{a}_{KZ} = \gamma_{KZ}\hat{Q}$.[5] On the other hand, as higher quality also requires additional skilled labour, output of Z must fall to make such additional skilled workers available for quality upgrading. Consequently, capital demand falls due to this scale contraction by the extent $\hat{Z} = -\gamma_{SZ}\hat{Q}$ at the margin. Hence, overall, the capital requirement in the production of good Z will rise the following quality upgrading if $\gamma_{SZ} < \gamma_{KZ}$ and will fall otherwise. In the latter case ($\gamma_{SZ} > \gamma_{KZ}$), for example, capital released by the Z sector moves to the (T, N) nugget. Assuming the composite traded good to be relatively capital intensive compared to the non-traded good, this larger availability of capital causes output of the composite traded good to rise and that of the non-traded good to fall. Consequent excess demand for the non-traded good raises its price. With P_T^W and P_I^W unchanged, this rise in P_N will then raise the unskilled wage and lower the rate of return to capital by the standard price magnification effect.[6] So, a rise in quality of Z will cause the rate of return to capital to fall when $\gamma_{SZ} > \gamma_{KZ}$, for any given rates of input tariffs. Similar reasoning can be used to show that when higher-quality variety of Z is relatively more capital intensive ($\gamma_{SZ} < \gamma_{KZ}$), a rise in export quality will raise the rate of return to capital. Algebraically, as shown in the appendix,

$$\frac{\mathrm{d}r}{\mathrm{d}Q} = \frac{\lambda_{KZ}(\gamma_{KZ} - \gamma_{SZ})\theta_{LT}}{\varepsilon_N|\theta||\lambda|}\frac{r}{Q} \tag{2.11}$$

where ε_N is the absolute price elasticity of demand for N; $|\theta|$ and $|\lambda|$ are the determinants of cost share and employment share matrices for the (T, N) nugget, respectively; θ_{LT} is the share of unskilled labour in unit cost of production of T; and λ_{KZ} is the share of sector Z in total employment of capital.

We represent this relationship between Q and r by the M_N curve in Fig. 2.2, which is positively sloped if $\gamma_{SZ} < \gamma_{KZ}$ and negatively sloped if $\gamma_{SZ} > \gamma_{KZ}$.

The equilibrium quality Q_0 of the export good/service Z and the rate of return to capital r_0 are thus determined simultaneously at the intersection of M_N and Π_Z curves for any given rates of input tariffs.

[5] Hat over a variable denotes proportionate change, example, $\hat{a}_{KZ} = \frac{da_{KZ}}{a_{KZ}}$.

[6] See Caves et al., (2007, or any other edition).

2.3 Sector-Specific Input Trade Liberalization

Now, we proceed to analyse the effect of sector-specific input tariff liberalization policies on the equilibrium choice of export quality. In the first subsection, we begin with liberalization of tariff on the imported input (I) that is used directly in production of the quality-differentiated export good Z. In the next subsection, we consider lowering of tariff on M that is used in the composite traded sector.

2.3.1 Liberalization of Tariff on Imported Input I

Consider a reduction in the rate of tariff imposed on the imported input I that is used in production of quality-differentiated export good Z: $\hat{\tau} < 0$. At the stroke of the pen, it lowers the unit cost of producing good Z for any given world price of the imported input P_I^W and $P_Z^W(Q_0)$ corresponding to the initial equilibrium level of export quality Q_0. At the initial equilibrium skilled wage and rate of return to capital, lower unit cost of production encourages producers of Z to expand the scale of production. Consequent increase in demand for skilled labour raises its wage. But, the rate of return to capital does not change at the initial equilibrium quality level and corresponding price of the non-traded good. Thus, the reduction in the input tariff rate raises only the skilled wage at the initial equilibrium level of quality of Z:

$$\hat{w}_S = -\frac{\theta_{IZ}}{\theta_{SZ}}\rho\hat{\tau} \tag{2.12}$$

where $\rho = \frac{\tau}{1+\tau}$, and θ_{IZ} and θ_{SZ} are shares of imported input and skilled labour in unit cost of production of good Z.

From the marginal condition (Eq. 2.6), it then follows that the marginal cost of quality will rise if higher qualities are *relatively* more intensive in imported input than skilled labour. The change in quality will now change the output composition and the price of the non-traded good in the way spelled out above. The latter will now change the rate of return to capital and correspondingly the skilled wage. However, at the new equilibrium, change in the quality of Z exports will be governed by the same initial condition of whether higher qualities are *relatively* more intensive in imported input than skilled labour. Algebraically, as shown in appendix,

$$\hat{Q} = \frac{1}{\Delta}\frac{P_Z^W}{\delta Q^2}\frac{\varepsilon_N\theta_{IZ}|\theta|}{\theta_{LT}}(\gamma_{IZ} - \gamma_{SZ})\rho\hat{\tau} \tag{2.13}$$

where $\Delta = \left(\frac{\lambda_{KZ}\theta_{KZ}(\gamma_{SZ}-\gamma_{KZ})^2}{|\lambda|}\frac{P_Z^W}{\delta Q^2} - \frac{\varepsilon_N|\theta|}{\theta_{LT}}\right) > 0,\ \delta < 0,\ |\theta| < 0, |\lambda| < 0$ and $\gamma_{IZ} = \frac{\partial a_{IZ}}{\partial Q}\frac{Q}{a_{IZ}}$ is the quality elasticity of per unit requirement of the imported input I in production of Z.

Hence,

Proposition 2.1 *Reduction of tariff on imported input that is directly used in production of quality-differentiated export goods upgrades export quality when higher qualities are relatively more intensive in the imported input than skilled labour and downgrades otherwise.*

Proof Follows from Eq. 2.13. For details, see appendix.

Graphically, as the reduction in input tariff rate raises the skilled wage at the initial quality level, so the Π_Z curve in Fig. 2.2 will shift—to the right when $\gamma_{SZ} < \gamma_{IZ}$ and to the left when $\gamma_{SZ} > \gamma_{IZ}$. The change in export quality raises the rate of return to capital if $\gamma_{SZ} < \gamma_{KZ}$ and lowers it if $\gamma_{SZ} > \gamma_{KZ}$ along the M_N curve. In either case, this only dampens the initial magnitude of change in export quality to some extent.

Proposition 2.1 implies that input trade liberalization does have asymmetric effects on the quality levels for different product groups that differ in terms of intensive use of imported input relative to the intensive use of skilled labour for quality upgrading. For products whose higher qualities are relatively more intensive in skilled labour than imported input ($\gamma_{SZ} > \gamma_{IZ}$), quality levels are actually downgraded after input trade liberalization. Quality levels are upgraded only for products whose higher qualities are relatively more intensive in imported input than skilled labour ($\gamma_{SZ} < \gamma_{IZ}$).[7] Thus, the observed asymmetric quality variations across different products for India, particularly since the mid-1980s, can be explained by input trade liberalization when we take into account intensive use of domestic factors like skilled labour and capital, along with the intensive use of an imported input.

2.3.2 Liberalization of Tariff on Imported Input M

Now suppose the tariff on the imported input M that is used in the composite traded sector is lowered, i.e. $\hat{t} < 0$. This raises the effective price received by the producers of the composite traded good or the effective marginal revenue earned per unit: $(P_T^W - a_{MT}(1 + t)P_M^W)$. At the *initial level of export quality and corresponding price of the non-traded good,* the higher effective price of the composite traded good raises the rate of return to capital (and lowers the unskilled wage) through the price magnification effect, given the factor intensity assumption that the composite traded good is relatively capital intensive. By Eq. 2.10, higher rate of return to capital downgrades quality if $\gamma_{KZ} > \gamma_{SZ}$ and upgrades quality if $\gamma_{KZ} < \gamma_{SZ}$. Change in the quality will have a feedback effect on the rate of return to capital as spelled out

[7] Export items like gems and jewellery, precious stones and diamonds and petroleum products are highly import intensive. Higher qualities of such goods also depend more on imported input than skilled labour so that we can expect for such goods. On the other hand, higher qualities of goods like beverages and various services that are exported by India, for example, ITeS, banking, insurance and other financial services, will usually require relatively more skilled labour than imported inputs so that we can expect for them.

earlier. This will affect the quality further. After taking into account all such induced effects, the change in quality of good Z can be obtained as (see appendix):

$$\hat{Q} = -\frac{1}{\Delta}\frac{P_Z^W}{\delta Q^2}\frac{\varepsilon_N\theta_{LN}\theta_{KZ}\theta_{MT}}{\theta_{LT}}(\gamma_{SZ} - \gamma_{KZ})\beta\hat{t} \qquad (2.14)$$

where $\beta = \frac{t}{1+t}$, $\delta < 0$, $\Delta > 0$.

Hence,

Proposition 2.2 *Reduction of tariff on the imported input used in production of homogenous composite traded good incentivizes upgrading of export quality when higher qualities are relatively more intensive in skilled labour than capital.*

Proof Follows from Eq. 2.14; for details, see appendix.

Graphically, referring back to Fig. 2.2, as the reduction in input tariff raises the rate of return to capital at the initial quality level, so the M_N curve shifts up along the Π_Z curve. If the Π_Z curve is downward sloping (as under $\gamma_{KZ} > \gamma_{SZ}$), then quality of good Z falls; otherwise, the quality of good Z rises. Note that again we may have asymmetric quality effects of an input trade liberalization.[8]

2.3.3 Choice of Sector-Specific Input Trade Liberalization

Propositions 2.1 and 2.2 suggest that if the government targets sector-specific input trade liberalization, then there may be cases where one type of input trade liberalization may be preferred over the other. Note that there will be symmetric effect of the two types of sector-specific input trade liberalization only in two situations. First, export quality will be upgraded for all export goods whose higher qualities are most intensive in the imported input and least intensive in capital in the sense that $\gamma_{IZ} > \gamma_{SZ} > \gamma_{KZ}$. And second, export quality will be downgraded for all export goods whose higher qualities are most intensive in the capital and least intensive in the imported input in the sense that $\gamma_{IZ} < \gamma_{SZ} < \gamma_{KZ}$. In these two cases, there will not be much of a choice over which of the two input tariffs to be reduced: $\hat{t} < 0$ or $\hat{\tau} < 0$. However, in all other cases, the two types of sector-specific or selective input tariff liberalization will have contrasting effects on the choice of quality of Z exports. For example, if $\gamma_{IZ} > \gamma_{KZ} > \gamma_{SZ}$, then while input trade liberalization in sector Z itself induces quality upgrading, input trade liberalization in sector T downgrades quality. On the other hand, the latter type of input trade liberalization is beneficial if $\gamma_{IZ} < \gamma_{KZ} < \gamma_{SZ}$. Table 2.2 provides a summary of the effect on choice of quality of Z under different such possibilities.

[8] Higher qualities of goods like aerospace, scientific instruments, defence equipment, household and office equipment, electrical appliances, agro-based products are more capital intensive, whereas higher qualities of goods and services like software, jewellery, diamond cutting and polishing, ITeS and financial services are more skill intensive ($\gamma_{KZ} < \gamma_{SZ}$).

Table 2.2 Quality choice under selective input trade liberalization

Factor intensity ranking of higher qualities of Z	$\hat{\tau} < 0$	$\hat{t} < 0$
I. $\gamma_{IZ} > \gamma_{SZ} > \gamma_{KZ}$	$\hat{Q} > 0$	$\hat{Q} > 0$
II. $\gamma_{IZ} < \gamma_{SZ} < \gamma_{KZ}$	$\hat{Q} < 0$	$\hat{Q} < 0$
III. $\gamma_{IZ} > \gamma_{KZ} > \gamma_{SZ}$	$\hat{Q} > 0$	$\hat{Q} < 0$
IV. $\gamma_{SZ} < \gamma_{IZ} < \gamma_{KZ}$	$\hat{Q} > 0$	$\hat{Q} < 0$
V. $\gamma_{SZ} > \gamma_{KZ} > \gamma_{IZ}$	$\hat{Q} < 0$	$\hat{Q} > 0$
VI. $\gamma_{SZ} > \gamma_{IZ} > \gamma_{KZ}$	$\hat{Q} < 0$	$\hat{Q} > 0$

Therefore, if one is to target quality upgrading of a particular export good/service, then examining the factor intensity ranking of its higher qualities is crucial for to the choice of sector-specific input trade liberalization.

2.4 Across-The-Board Input Trade Liberalization

Often developing countries pursue across-the-board trade liberalization by choice either as part of the globalization strategy or as per the requirement and commitment for accession to the WTO. India also pursued trade liberalization policies since the late 1990s that covered a large number of sectors. To analyse the implications of such across-the-board input trade liberalization for choice of export quality, let us consider a simple specification: the initial rate of tariff t and τ, imposed on M and I, respectively, was the same, i.e. $\beta = \rho$. Then, lowering of the initial tariff rates by the same percentage ($\hat{t} = \hat{\tau} < 0$) would imply: $\beta\hat{t} = \rho\hat{\tau} = \hat{\alpha}$ (say). The expression for change in export quality in that case will be as under:

$$\hat{Q} = \frac{1}{\Delta}\frac{P_Z^W}{\delta Q^2}\frac{\varepsilon_N}{\theta_{LT}}\left[\theta_{LN}\theta_{KZ}\theta_{MT}(\gamma_{SZ} - \gamma_{KZ}) - \theta_{IZ}|\theta|(\gamma_{IZ} - \gamma_{SZ})\right]\hat{\alpha} \tag{2.15}$$

Note that for cases I and II reported in Table 2.1, the change in the quality level following such equiproportionate across-the-board input trade liberalization is unambiguous. The effect is uncertain only in the other cases where the two types of tariff cuts have opposite effect on the quality of good Z. For example, suppose good Z is such that $\gamma_{IZ} > \gamma_{KZ} > \gamma_{SZ}$ or $\gamma_{KZ} > \gamma_{IZ} > \gamma_{SZ}$. Thus, by Proposition 2.1, $\hat{\tau} < 0$ upgrades quality of good Z, whereas by Proposition 2.2, $\hat{t} < 0$ downgrades it. From Eq. 2.15, we can derive the following condition for quality of Z to improve (see appendix):

$$\gamma_{SZ} > \overline{\gamma}_{KZ} = A\gamma_{KZ} - (1 - A)\gamma_{IZ} \tag{2.16}$$

where $A = \frac{\theta_{LN}\theta_{KZ}\theta_{MT}}{\theta_{LN}\theta_{KZ}\theta_{MT} - \theta_{IZ}(\theta_{LN} - \theta_{LT})}$.

Note, A can be positive or negative, given that $\theta_{LN} - \theta_{LT} > 0$. Hence,

Lemma 2.1 $\overline{\gamma}_{KZ} < 0$ *for A < 0, whereas* $\overline{\gamma}_{KZ} > \gamma_{KZ} > 0$ *for A > 0.*

Proof See appendix.

Using this we can write.

Proposition 2.3 *If good Z is such that* $\gamma_{IZ} > \gamma_{KZ} > \gamma_{SZ}$ *or* $\gamma_{KZ} > \gamma_{IZ} > \gamma_{SZ}$ *, then by Lemma 2.1 , across-the-board input trade liberalization will upgrade quality of it if A* < 0.

Proof If A is negative, then condition in Eq. 2.16 is satisfied for any positive value of γ_{SZ}. That is, across-the-board input trade liberalization will upgrade quality of good Z despite reduction of tariff on input M used by sector T having an adverse effect on the quality of Z under the stated conditions that $\gamma_{IZ} > \gamma_{KZ} > \gamma_{SZ}$ *or* $\gamma_{KZ} > \gamma_{IZ} > \gamma_{SZ}$. But, when $A > 0$, condition in Eq. 2.16 can never be satisfied if $\gamma_{KZ} > \gamma_{SZ}$.

2.5 Effect on Value of Exports

Since the primary objective of incentivizing quality upgrading through input trade liberalization is to raise export earnings, it is worthwhile to check whether consequent quality improvement (if at all) raises the value of export of good Z. From the full employment condition of skilled labour, there arises a trade-off between the quantity and quality dimensions of Z; i.e. export quality can be raised only at the cost of its level of output and correspondingly volume of exports: $\hat{Z} = -\gamma_{SZ}\hat{Q}$. So when input tariff reduction incentivizes quality upgrading, even though a higher quality will fetch a higher per unit foreign currency price of Z, $\hat{P}_Z^W(Q) = \gamma_Z\hat{Q}$, corresponding fall in the volume of exports makes the change in the value of exports (VE_Z) uncertain. To find the exact condition for export value to rise, note that by definition,

$$\text{VE}_Z = P_Z^W(Q)X_Z = P_Z^W(Q)\frac{\overline{S}}{a_{SZ}(Q)} \tag{2.17}$$

As explained above, a change in the quality of good Z changes the value of exports as

$$V\hat{E}_Z = (\gamma_Z - \gamma_{SZ})\hat{Q} \tag{2.18}$$

It follows from the zero-profit condition in sector Z (given by Eq. 2.5) that the quality elasticity of willingness-to-pay for Z, $\gamma_Z = \frac{P_Z^{W'}(Q)Q}{P_Z^W(Q)}$, is the sum of weighted average of quality elasticity of the per unit inputs (S, K and I) with weights being the share of each of the inputs in unit production cost of *Z:*

$$\gamma_Z = \gamma_{KZ}\theta_{KZ} + \gamma_{SZ}\theta_{SZ} + \gamma_{IZ}\theta_{IZ} \tag{2.19}$$

Using Eqs. 2.13 and 2.19, we can rewrite Eq. 2.18 when only the tariff on input I is lowered as follows (see appendix):

$$V\hat{E}_Z = -\frac{1}{\Delta}\frac{P_Z^W}{\delta Q^2}\frac{\varepsilon_N \theta_{IZ}|\theta|}{\theta_{LT}} \left[\theta_{KZ}(\gamma_{KZ} - \gamma_{SZ}) + \theta_{IZ}(\gamma_{IZ} - \gamma_{SZ})\right](\gamma_{IZ} - \gamma_{SZ})\rho\hat{\tau} \tag{2.20}$$

So, value of exports will rise along with export quality for input trade liberalization for Z sector itself under the following condition:

$$\gamma_{SZ} < \tilde{\gamma}_{SZ} = \frac{\theta_{KZ}}{\theta_{KZ} + \theta_{IZ}}\gamma_{KZ} + \frac{\theta_{IZ}}{\theta_{KZ} + \theta_{IZ}}\gamma_{IZ} \tag{2.21}$$

Lemma 2.2 will be helpful in defining the sign in Eq. 2.20:

Lemma 2.2

(a) $\gamma_{IZ} < \tilde{\gamma}_{SZ}$ *if* $\gamma_{KZ} > \gamma_{IZ}$.
(b) $\gamma_{IZ} > \tilde{\gamma}_{SZ}$ *if* $\gamma_{KZ} < \gamma_{IZ}$.

Proof See appendix.

Hence, we can write the following proposition:

Proposition 2.4 *If $\gamma_{KZ} > \gamma_{IZ} > \gamma_{SZ}$, then upgrading of quality induced by input trade liberalization in Z sector will also raise the value of exports.*

Proof Note that by Proposition 2.1, the quality of good Z improves under this condition. This lowers the volume of exports of Z. Yet, by Lemma 2.2a and condition in Eq. 2.21, the value of exports of Z rises.

Note that in other two cases where lowering tariff on imported input I raises export quality, such as $\gamma_{IZ} > \gamma_{SZ} > \gamma_{KZ}$ and $\gamma_{IZ} > \gamma_{KZ} > \gamma_{SZ}$, condition in Eq. 2.21 may hold by Lemma 2.2, so that value of exports may rise.

Similarly, for a ceteris paribus reduction in tariff on input M we obtain:

$$V\hat{E}_Z = \frac{1}{\Delta}\frac{P_Z^W}{\delta Q^2}\frac{\varepsilon_N \theta_{LN}\theta_{KZ}\theta_{MT}}{\theta_{LT}} \left[\theta_{KZ}(\gamma_{KZ} - \gamma_{SZ}) + \theta_{IZ}(\gamma_{IZ} - \gamma_{SZ})\right](\gamma_{SZ} - \gamma_{KZ})\beta\hat{t} \tag{2.20b}$$

The value of exports will once again rise under the same condition as in Eq. 2.21. Hence,

Proposition 2.5 *If $\gamma_{SZ} > \gamma_{IZ} > \gamma_{KZ}$, then upgrading of quality induced by input trade liberalization in T sector will not raise the value of exports. In other cases, i.e. $\gamma_{SZ} > \gamma_{KZ} > \gamma_{IZ}$ and $\gamma_{IZ} > \gamma_{SZ} > \gamma_{KZ}$, upgrading of quality may raise the value of exports.*

Proof First case, i.e. $\gamma_{SZ} > \gamma_{IZ} > \gamma_{KZ}$, itself rules out condition given by Eq. 2.21 by Lemma 2.2. Note that by Proposition 2.2, the other relevant cases under which quality of good Z improves when input tariff in sector T is lowered are $\gamma_{SZ} > \gamma_{KZ} > \gamma_{IZ}$ and $\gamma_{IZ} > \gamma_{SZ} > \gamma_{KZ}$. In the former, by Lemma 2.2 (a), condition (Eq. 2.21) is feasible, such as $\tilde{\gamma}_{SZ} > \gamma_{SZ} > \gamma_{KZ} > \gamma_{IZ}$. Similarly, in the latter, condition (Eq. 2.21) is again feasible by Lemma 2.2 (b), such as $\gamma_{IZ} > \tilde{\gamma}_{SZ} > \gamma_{SZ} > \gamma_{KZ}$.

2.6 Future Empirical Analysis

Empirical tests of our theory, while certainly plausible, require a detailed and exhaustive empirical strategy and arduous investigation into data sets which are beyond the scope of the present paper. Therefore, instead of a half-baked empirical analysis, we outline below the empirical strategy that may be adopted for future analysis based on the theoretical results obtained here.

Firstly, in view of the problem at hand and in order to overcome multiple biases like endogeneity, autocorrelation, etc., arising out of reverse causality and omitted variables, dynamic panel estimation, i.e. system GMM, may be an appropriate estimation procedure. Not only do they take care of the multiple challenges in the panel data but also free us from finding strictly exogenous instruments by generating their own instruments. Now coming to the data for such an analysis, our primary concerning variables are export quality and tariff on imported inputs.

Given that our theoretical concern is driven by the low-quality phenomenon and asymmetric quality variations experienced by the developing countries, we may focus on India for the empirical analysis. To examine the effect of input trade liberalization on the choice of export quality across different product groups, a panel across export product groups (SITC one digit or two digits) and across time may be considered. Since our theoretical results reveal that the asymmetric quality variations emerge across three specific groups based on relative factor intensities, so the sample of products/industries should be identified according to this criterion. Import intensity of the products may be highly relevant in choosing the sample for example. Second, we would require dis-aggregate product line-specific data on the imported inputs used to produce the quality-differentiated exports. Depending on the period of availability of such disaggregated information on India's product line-specific imported inputs and the tariffs imposed on them and that of the quality estimates, the overall period of analysis has to be determined. In addition to this, one has to consider other variables that can potentially influence the variation in export quality as controls in our regression analysis. Such controls may include the world demand for the product varieties, trade openness, R&D, infrastructure, within-country income inequality and the like.

2.7 Conclusion

In the context of a general equilibrium structure of a small open economy that has a diversified export basket and consumes a non-traded good, we have shown that reduction of tariffs on imported inputs may not necessarily upgrade quality of export goods when higher qualities require more intensive use of domestic factors as well. Under sector-specific or selective input trade liberalization, a reduction of tariff on the input that is directly used in producing the quality-differentiated export good will induce quality upgrading only when higher qualities are relatively more intensive in imported input than skilled labour. On the other hand, if tariff on the input that is used in producing homogenous composite traded goods is lowered, export quality would be upgraded for those exports whose higher qualities are more intensive in skilled labour than capital. These results provide a plausible theoretical explanation for the observed asymmetric quality variations across product groups for India since the mid-1980s in particular, which coincided with her trade liberalization period. For equiproportionate across-the-board input trade liberalization, quality of export good(s) may be upgraded although one type of input tariff reduction has an adverse effect. We also show that improvement in quality of the export good may also raise the value of exports, despite a fall in volume of exports, under reasonable conditions.

Appendix

Profit Maximizing Choice of Quality of Z Exports and the Π_Z Curve

From the zero-profit condition in the Z sector, we get:

$$P_Z^{W'}(Q)\mathrm{d}Q = ra'_{KZ}(Q)\mathrm{d}Q + a_{KZ}(Q)\mathrm{d}r + a_{SZ}(Q)\mathrm{d}w_S + w_S a'_{SZ}(Q)\mathrm{d}Q + (1+\tau)P_I^W a'_{IZ}(Q)\mathrm{d}Q + P_I^W a_{IZ}(Q)\mathrm{d}(1+\tau)$$

Using the marginal condition (2.6) in the text, the above expression boils down to:

$$\Rightarrow 0 = \theta_{KZ}\hat{r} + \theta_{SZ}\hat{w}_S + \theta_{IZ}\rho\hat{\tau} \tag{2.21}$$

The change in quality can be obtained from total differentiation of the marginal condition:

$$P_Z^{W''}(Q)\mathrm{d}Q = a''_{SZ}(Q)\mathrm{d}Qw_S + a'_{SZ}(Q)\mathrm{d}w_S + ra''_{KZ}(Q)\mathrm{d}Q + a'_{KZ}(Q)\mathrm{d}r + (1+\tau)P_I^W a''_{IZ}(Q)\mathrm{d}Q + a'_{IZ}(Q)P_I^W\mathrm{d}(1+\tau)$$

$$\Rightarrow \frac{Q^2}{P_Z^W}\delta\hat{Q} = \frac{a_{SZ}(Q)w_S}{P_Z^W}\left[\frac{Qa'_{SZ}(Q)}{a_{SZ}(Q)}\right]\hat{w}_S$$
$$+ \frac{a_{KZ}(Q)r}{P_Z^W}\left[\frac{Qa''_{KZ}(Q)}{a_{KZ}(Q)}\right]\hat{r} + \frac{a_{IZ}(Q)(1+\tau)P_I^W}{P_Z^W}\left[\frac{Qa'_{IZ}(Q)}{a_{IZ}(Q)}\right]\rho\hat{\tau}$$
$$\Rightarrow \hat{Q} = \frac{P_Z^W}{\delta Q^2}\left(\theta_{SZ}\gamma_{SZ}\hat{w}_S + \theta_{KZ}\gamma_{KZ}\hat{r} + \theta_{IZ}\gamma_{IZ}\rho\hat{\tau}\right) \tag{2.22}$$

where $\delta \equiv \left[P_Z^{W''}(Q) - w_S a''_{SZ}(Q) - r a''_{KZ}(Q) - (1+\tau)P_I^W a''_{IZ}(Q)\right]$ by the second-order condition for profit maximization.

Substitution of the value for $\hat{w}_S$ in terms of $\hat{r}$ and $\hat{\tau}$ From (2.21) in (2.22) yields:

$$\hat{Q} + \frac{P_Z^W}{\delta Q^2}\theta_{KZ}(\gamma_{SZ} - \gamma_{KZ})\hat{r} = \frac{P_Z^W}{\delta Q^2}\theta_{IZ}(\gamma_{IZ} - \gamma_{SZ})\rho\hat{\tau} \tag{2.23}$$

At $\hat{\tau} = 0$, (2.23) gives us a relationship between Q and the r consistent with the marginal condition for profit maximizing choice of export quality as captured by the Π_Z curve in the text:

$$\left.\frac{\mathrm{d}r}{\mathrm{d}Q}\right|_{\Pi_Z} = -\frac{1}{\frac{P_Z^W}{\delta Q^2}\theta_{KZ}(\gamma_{SZ} - \gamma_{KZ})}\frac{r}{Q} \tag{2.23a}$$

Determination of Slope of M_N Curve

From the zero-profit condition in sector T, we can obtain changes in w and r as the input tariff t is changed:

$$\hat{w} = -\frac{\theta_{MT}}{\theta_{LT}}\beta\hat{t} - \frac{\theta_{KT}}{\theta_{LT}}\hat{r} \tag{2.24}$$

where $\beta = \frac{t}{1+t}$.

From the zero-profit condition in sector N, we can trace out how factor prices change when P_N changes, $\hat{P}_N = \theta_{KN}\hat{r} + \theta_{LN}\hat{w}$

$$\Rightarrow \hat{r} = \frac{\hat{P}_N}{\theta_{KN}} - \frac{\theta_{LN}}{\theta_{KN}}\hat{w} \tag{2.25}$$

Using (2.24), we can rewrite (2.25) as

$$\Rightarrow \hat{r} = \frac{\theta_{LT}}{|\theta|}\hat{P}_N + \frac{\theta_{LN}\theta_{MT}}{|\theta|}\beta\hat{t} \tag{2.26}$$

where $|\theta|$ is the determinant of the cost share matrix in the (T, N) nugget.

Now to trace out output changes, the percentage change form of the capital constraint (2.10) will give:

$$-\frac{a'_{KZ}(Q)Q}{a'_{KZ}(Q)}\hat{Q}\frac{a_{KZ}X_Z}{\overline{K}} - \frac{a_{KZ}(Q)X_Z}{\overline{K}}\hat{X}_Z = \frac{a_{KT}X_T}{\overline{K}}\hat{X}_T + \frac{a_{KN}X_N}{\overline{K}}\hat{X}_N$$
$$\Rightarrow -\left(\gamma_{KZ}\hat{Q} - \hat{X}_Z\right)\lambda_{KZ} = \lambda_{KT}\hat{X}_T + \lambda_{KN}\hat{X}_N \tag{2.27}$$

Similarly, from the unskilled labour constraint (2.11) we get:

$$0 = \frac{a_{LT}X_T}{\overline{L}}\hat{X}_T + \frac{a_{LN}X_N}{\overline{L}}\hat{X}_N = \lambda_{LT}\hat{X}_T + \lambda_{LN}\hat{X}_N \tag{2.28}$$

On the other hand, the percentage change form of the skilled labour constraint (2.12) gives us how change in export quality affects the output of Z good:

$$\hat{S} = 0 = \frac{a'_{SZ}(Q)Q}{a_{SZ}(Q)}\frac{a_{SZ}(Q)X_Z}{\overline{S}}\hat{Q} + \frac{a_{SZ}(Q)X_Z}{\overline{S}}\hat{X}_Z$$
$$\Rightarrow \hat{X}_Z = -\gamma_{SZ}\hat{Q} \tag{2.29}$$

Substituting $\hat{X}_Z$ from (2.29) in (2.27), we get:

$$\Rightarrow \lambda_{KN}\hat{X}_N + \lambda_{KT}\hat{X}_T = \lambda_{KZ}(\gamma_{SZ} - \gamma_{KZ})\hat{Q} \tag{2.30}$$

where $\lambda_{Kj} \equiv \frac{a_{Kj}X_j}{K_Z(Q)}$, j = T, N, denote the share of sector j in net availability of capital for the (T, N) nugget.

Representing (2.28) and (2.30) in matrix notation,

$$\begin{bmatrix} \lambda_{LT} & \lambda_{LN} \\ \lambda_{KT} & \lambda_{KN} \end{bmatrix}\begin{bmatrix} \hat{X}_T \\ \hat{X}_N \end{bmatrix} = \begin{bmatrix} 0 \\ \lambda_{KZ}(\gamma_{SZ} - \gamma_{KZ})\hat{Q} \end{bmatrix}$$

we solve for the values of $\hat{X}_T$ and $\hat{X}_N$ by Cramer's rule:

$$\hat{X}_T = -\frac{\lambda_{KZ}\lambda_{LN}(\gamma_{SZ} - \gamma_{KZ})\hat{Q}}{|\lambda|}; \hat{X}_N = \frac{\lambda_{KZ}\lambda_{LT}(\gamma_{SZ} - \gamma_{KZ})\hat{Q}}{|\lambda|} \tag{2.31}$$

Now from the market-clearing condition in the non-traded sector under homothetic tastes, we obtain how the price of the non-traded good changes following output changes:

$$-\varepsilon_N\hat{P}_N = \hat{X}_N - \hat{X}_T \tag{2.32}$$

Substituting (2.28) in (2.29) yields:

$$\hat{P}_N = -\frac{\hat{X}_N - \hat{X}_T}{\varepsilon_N} = \frac{\lambda_{KZ}(\gamma_{SZ} - \gamma_{KZ})\hat{Q}}{|\lambda|\varepsilon_N} \tag{2.32a}$$

Hence, using (2.32a), from (2.26) we obtain the change in r following a change in Q as:

$$\frac{\lambda_{KZ}(\gamma_{SZ} - \gamma_{KZ})\hat{Q}}{|\lambda|} + \frac{\varepsilon_N|\theta|}{\theta_{LT}}\hat{r} = \frac{\varepsilon_N\theta_{LN}\theta_{MT}}{\theta_{LT}}\beta\hat{t} \tag{2.33}$$

At $\hat{t} = 0$, (2.23) gives us a relationship between Q and the r consistent with the market-clearing condition for the non-traded good as captured by the M_N curve in the text:

$$\left.\frac{\mathrm{d}r}{\mathrm{d}Q}\right|_{M_N} = -\frac{\theta_{LT}\lambda_{KZ}(\gamma_{SZ} - \gamma_{KZ})}{\varepsilon_N|\theta||\lambda|}\frac{r}{Q} \tag{2.33a}$$

Input Trade Liberalization and Change in Equilibrium Quality

Equations (2.23) and (2.33) together solve for changes in equilibrium Q and r when τ and t are changed. Writing these in matrix notation,

$$\begin{bmatrix} \frac{\lambda_{KZ}(\gamma_{SZ}-\gamma_{KZ})}{|\lambda|} & \frac{\varepsilon_N|\theta|}{\theta_{LT}} \\ 1 & \frac{P_Z^W}{\delta Q^2}\theta_{KZ}(\gamma_{SZ} - \gamma_{KZ}) \end{bmatrix}\begin{bmatrix} \hat{Q} \\ \hat{r} \end{bmatrix} = \begin{bmatrix} \frac{\varepsilon_N\theta_{LN}\theta_{MT}}{\theta_{LT}}\beta\hat{t} \\ \frac{P_Z^W}{\delta Q^2}\theta_{IZ}(\gamma_{IZ} - \gamma_{SZ})\rho\hat{\tau} \end{bmatrix}$$

we solve for $\hat{Q}$ and $\hat{r}$ in terms of the parameters as:

$$\hat{Q} = \frac{1}{\Delta}\frac{P_Z^W}{\delta Q^2}\left[(\gamma_{SZ} - \gamma_{KZ})\frac{\varepsilon_N\theta_{LN}\theta_{KZ}\theta_{MT}}{\theta_{LT}}\beta\hat{t} - \frac{\varepsilon_N\theta_{IZ}|\theta|}{\theta_{LT}}(\gamma_{IZ} - \gamma_{SZ})\rho\hat{\tau}\right] \tag{2.34}$$

$$\hat{r} = \frac{1}{\Delta}\left[\frac{\lambda_{KZ}(\gamma_{SZ} - \gamma_{KZ})\theta_{IZ}}{|\lambda|}\frac{P_Z^W}{\delta Q^2}(\gamma_{IZ} - \gamma_{SZ})\rho\hat{\tau} - \frac{\varepsilon_N\theta_{LN}\theta_{MT}}{\theta_{LT}}\beta\hat{t}\right] \tag{2.35}$$

where $\Delta = \left(\frac{\lambda_{KZ}\theta_{KZ}(\gamma_{SZ}-\gamma_{KZ})^2}{|\lambda|}\frac{P_Z^W}{\delta Q^2} - \frac{\varepsilon_N|\theta|}{\theta_{LT}}\right) > 0.$

Change in Quality Under Sector-Specific/Selective Input Trade Liberalization

Proof of Proposition 2.1

When tariff on input I is lowered only, i.e. $\hat{\tau} < 0, \hat{t} = 0$, then from (2.34):

$$\hat{Q} = -\frac{1}{\Delta}\frac{P_Z^W}{\delta Q^2}\frac{\varepsilon_N \theta_{IZ}|\theta|}{\theta_{LT}}(\gamma_{IZ} - \gamma_{SZ})\rho\hat{\tau} \tag{2.36a}$$

So given $\Delta > 0$, $\delta < 0$ and $|\theta| < 0$, $\hat{Q} > 0$ if $(\gamma_{IZ} - \gamma_{SZ}) > 0$ and $\hat{Q} < 0$ if $(\gamma_{IZ} - \gamma_{SZ}) < 0$.

Proof of Proposition 2.2

When tariff on input M is lowered only, i.e. $\hat{\tau} = 0, \hat{t} < 0a$, then from (2.34)

$$\hat{Q} = \frac{1}{\Delta}\frac{P_Z^W}{\delta Q^2}(\gamma_{SZ} - \gamma_{KZ})\frac{\varepsilon_N \theta_{LN}\theta_{KZ}\theta_{MT}}{\theta_{LT}}\beta\hat{t} \tag{2.36b}$$

So given $\Delta > 0$ and $\delta < 0$, $\hat{Q} > 0$ if $(\gamma_{SZ} - \gamma_{KZ}) > 0$ .and $\hat{Q} < 0$ if $(\gamma_{SZ} - \gamma_{KZ}) < 0$.

Equiproportionate Across-the-Board Input Trade Liberalization

Let the initial rate of tariff on input M and I be equal, and then, the initial tariff rates are both lowered by the same rate, such that $\rho\hat{\tau} = \beta\hat{t}$. Let us denote this equiproportionate fall in input tariff as $\hat{\alpha} < 0$. Using this, the change in quality can be rewritten from (2.34) as:

$$\hat{Q} = \frac{1}{\Delta}\frac{P_Z^W}{\delta Q^2}\frac{\varepsilon_N}{\theta_{LT}}\left[(\gamma_{SZ} - \gamma_{KZ})\theta_{LN}\theta_{KZ}\theta_{MT} - \theta_{IZ}|\theta|(\gamma_{IZ} - \gamma_{SZ})\right]\hat{\alpha} \tag{2.37}$$

Now given $\Delta > 0$ and $\delta < 0$, $\hat{Q} > 0$ if the expression in the parenthesis on the right-hand side is positive. That is,

$$\begin{aligned}
&\left[(\gamma_{SZ} - \gamma_{KZ})\theta_{LN}\theta_{KZ}\theta_{MT} - \theta_{IZ}|\theta|(\gamma_{IZ} - \gamma_{SZ})\right] > 0 \\
&\Rightarrow (\gamma_{SZ} - \gamma_{KZ})\theta_{LN}\theta_{KZ}\theta_{MT} > -\theta_{IZ}(\theta_{LN} - \theta_{LT})(\gamma_{IZ} - \gamma_{SZ}) \\
&\Rightarrow \gamma_{SZ}\{\theta_{LN}\theta_{KZ}\theta_{MT} - \theta_{IZ}(\theta_{LN} - \theta_{LT})\} > \gamma_{KZ}\theta_{LN}\theta_{KZ}\theta_{MT} - \theta_{IZ}(\theta_{LN} - \theta_{LT})\gamma_{IZ} \\
&\Rightarrow \gamma_{SZ} > \frac{\theta_{LN}\theta_{KZ}\theta_{MT}}{\{\theta_{LN}\theta_{KZ}\theta_{MT} - \theta_{IZ}(\theta_{LN} - \theta_{LT})\}}\gamma_{KZ} \\
&\quad - \frac{\theta_{IZ}(\theta_{LN} - \theta_{LT})}{\{\theta_{LN}\theta_{KZ}\theta_{MT} - \theta_{IZ}(\theta_{LN} - \theta_{LT})\}}\gamma_{IZ}
\end{aligned}$$

$$\Rightarrow \gamma_{SZ} > \overline{\gamma}_{KZ} = A\gamma_{KZ} - (1 - A)\gamma_{IZ} \tag{2.38}$$

where $A = \frac{\theta_{LN}\theta_{KZ}\theta_{MT}}{\{\theta_{LN}\theta_{KZ}\theta_{MT} - \theta_{IZ}(\theta_{LN} - \theta_{LT})\}}$.

Proof of Lemma 2.1

Note that $\theta_{LN} - \theta_{LT} > 0$ as $|\theta| < 0$. So, $\frac{\theta_{LN}\theta_{KZ}\theta_{MT}}{\theta_{LN}-\theta_{LT}} > \theta_{IZ}$ or $\frac{\theta_{LN}\theta_{KZ}\theta_{MT}}{\theta_{LN}-\theta_{LT}} < \theta_{IZ}$.

If $\frac{\theta_{LN}\theta_{KZ}\theta_{MT}}{\theta_{LN}-\theta_{LT}} > \theta_{IZ}$, then denominator of A and so $A > 0$. Also, $A > 1$. To check,

$$\begin{aligned} A - 1 &= \frac{\theta_{LN}\theta_{KZ}\theta_{MT}}{\{\theta_{LN}\theta_{KZ}\theta_{MT} - \theta_{IZ}(\theta_{LN} - \theta_{LT})\}} - 1 \\ &= \frac{\theta_{IZ}(\theta_{LN} - \theta_{LT})}{\{\theta_{LN}\theta_{KZ}\theta_{MT} - \theta_{IZ}(\theta_{LN} - \theta_{LT})\}} > 0 \end{aligned}.$$

So given $A > 1$, from (2.38), we must have $\overline{\gamma}_{KZ} > \gamma_{KZ} > 0$.

In the other alternative, i.e. if $\frac{\theta_{LN}\theta_{KZ}\theta_{MT}}{\theta_{LN}-\theta_{LT}} < \theta_{IZ}$, then denominator of A and so A < 0 and $(1 - A) > 0$. So RHS of (2.38), i.e. $(A\gamma_{KZ} - (1 - A)\gamma_{IZ}) < 0 \Rightarrow \overline{\gamma}_{KZ} < 0$. This completes proof of Lemma 2.1.

Effect on Value of Exports of Good Z

Total differentiation of Eq. 2.17 from text gives

$$\begin{aligned} V\hat{E}_Z &= \hat{P}_Z^W(Q) + \hat{X}_Z = \hat{P}_Z^W(Q) + \hat{\bar{S}} - \hat{a}_{SZ}(Q) = \frac{P_Z^{W'}(Q)Q}{P_Z^W(Q)}\hat{Q} \\ &- \frac{a'_{SZ}(Q)Q}{a_{SZ}(Q)}\hat{Q} = (\gamma_Z - \gamma_{SZ})\hat{Q} \end{aligned} \tag{2.39}$$

where $\gamma_Z \equiv \frac{QP_Z^{W'}(Q)}{P_Z^W}$ is the quality elasticity of the foreign currency price of good Z.

Recall the marginal condition for quality choice from the text: $P_Z^{W'}(Q) = a'_{SZ}(Q)w_S + a'_{KZ}(Q)r + a'_{IZ}(Q)(1+\tau)P_I^W$.

Dividing throughout by $\frac{P_Z^W(Q)}{Q}$, we will get:

$$\begin{aligned} &\Rightarrow \frac{P_Z^{W'}(Q)Q}{P_Z^W(Q)} = \frac{a_{SZ}(Q)w_S}{P_Z^W}\left[\frac{Qa'_{SZ}(Q)}{a_{SZ}(Q)}\right] + \frac{a_{KZ}(Q)r}{P_Z^W}\left[\frac{Qa'_{KZ}(Q)}{a_{KZ}(Q)}\right] \\ &+ \frac{a_{IZ}(Q)(1+\tau)P_I^W}{P_Z^W}\left[\frac{Qa'_{IZ}(Q)}{a_{IZ}(Q)}\right] \\ &\Rightarrow \gamma_Z = \theta_{SZ}\gamma_{SZ} + \theta_{KZ}\gamma_{KZ} + \theta_{IZ}\gamma_{IZ} \end{aligned} \tag{2.40}$$

where $\theta_{SZ} + \theta_{KZ} + \theta_{IZ} = 1$

Using (2.40), we can rewrite (2.39) as:

$$\begin{aligned} V\hat{E}_Z = (\gamma_Z - \gamma_{SZ})\hat{Q} = \{-\gamma_{SZ}(\theta_{KZ} + \theta_{IZ}) + \theta_{KZ}\gamma_{KZ} + \theta_{IZ}\gamma_{IZ}\} \\ \hat{Q} = \{\theta_{KZ}(\gamma_{KZ} - \gamma_{SZ}) + \theta_{IZ}(\gamma_{IZ} - \gamma_{SZ})\}\hat{Q} \end{aligned} \quad (2.41)$$

Proof of Lemma 2.2

Recall condition in Eq. 2.21 from the text,

$$\gamma_{SZ} < \tilde{\gamma}_{SZ} = \frac{\theta_{KZ}}{(\theta_{KZ} + \theta_{IZ})}\gamma_{KZ} + \frac{\theta_{IZ}}{(\theta_{KZ} + \theta_{IZ})}\gamma_{IZ}$$

Note that $\tilde{\gamma}_{SZ}$ is a weighted average of γ_{KZ} and γ_{IZ} where the weights are $\frac{\theta_{KZ}}{(\theta_{KZ}+\theta_{IZ})}$ and $\frac{\theta_{IZ}}{(\theta_{KZ}+\theta_{IZ})}$, respectively, and they add up to 1. So $\tilde{\gamma}_{SZ}$ must lie between γ_{KZ} and γ_{IZ}. Two rankings are thus possible. First, if $\gamma_{KZ} > \gamma_{IZ}$, then it must be that $\gamma_{KZ} > \tilde{\gamma}_{SZ} > \gamma_{IZ}$. This completes proof of Lemma 2.2 (a). Second, if $\gamma_{KZ} < \gamma_{IZ}$, then it must be that $\gamma_{KZ} < \tilde{\gamma}_{SZ} < \gamma_{IZ}$. This completes proof of Lemma 2.2 (b).

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Chapter 3
Informal Sector in India: A Critique of Inclusive Transition

Anirban Kundu and Saumya Chakrabarti

3.1 Introduction

During the last few decades, the discourse on development has been experiencing a shift away from the 'Lewisian transition' era (Lewis, 1954). Indeed, it is recognised that even high rates of capital accumulation and growth in the formal (industrial and service) sectors (henceforth *fs*) and sizeable expansion of the globalised market are unable to absorb/include the overwhelming majority of the Third-World population. Neither there is substantial progress for these outsiders, as large parts remain excluded even from the spillover effects of globalisation.

In fact, most of the (non-agricultural) workforce in the developing world is engaged in the petty informal sectors (henceforth *infs*), at best, having weak links with the globalisation process. Moreover, 'informality tends to become the over-arching structure (even) of the global labour market' (Breman, 2013, pp. 10). The *infs*, especially an overwhelming majority of the petty self-employed, is persisting painfully outside the growth poles, and thus, we experience a nagging continuance of misery and growing inequality between the *fs* and *infs*. This is one of the central paradoxes of contemporary development discourse.

Not only that the pre-capitalistic non-agricultural production systems still exist beyond the core circuits of capital, but more importantly, a vast non-agricultural economy of outsiders has been created in tandem with the very growth processes. These nomads (Breman, 2013) form the sea of surplus humanity (Davis, 2004), who find their refuge in the *infs*. Thus, the *infs* not only consists of the petty commodity

A. Kundu (✉)
School of Management, Presidency University, Bengaluru, Karnataka 560064, India
e-mail: anirbankundu@presidencyuniversity.in

S. Chakrabarti
Department of Economics and Politics, Visva Bharati (University), Santiniketan, West Bengal 731235, India
e-mail: saumya_chakrabarti@biari.brown.edu

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producers of the pre-capitalistic era, but more importantly, is a product of the growth development processes that we have witnessed in the contemporary Global South; it has been endogenous/integral to the so-called modernisation process that we have experienced in the recent past. Unfortunately, both these pre-capitalistic remnants and the non-capitalistic refugees are being unable to reap substantially the benefits of globalised capital-centric growth, and hence, the *infs* languishes as the devalued other of the *fs* (Chakrabarti et al., 2009). The mainstream argument that whatever be the source and locus of the *infs* in due course it should derive a variety of benefits from the growth of the *fs* is not being observed in reality. Only a small part of the *infs* is able to gain, while a much larger part continues to suffer.

Hence, a crucial question arises: why, despite high rates of growth of the globalised *fs* and ever-growing investible surplus, the curse of the informal sector goes on persisting (as outside of the capital), and there is a lack of adequate improvement at the firm level; why there is an absence of comprehensive transformation from petty-production-based *infs* towards nascent capitalism, especially for the self-employment segment; why there is no progressive universalisation of wealth—no 'inclusive growth' (Basile, 2013).

To deal with this question, we, first, take up a brief review of the relevant literature—both orthodox and heterodox. Based on and as a response to these writings, we explain, using the structuralist macro-framework, the lack of comprehensive transformation of the *infs* towards a capitalistic sector that is fully incorporated into the global market economy. Subsequently, we go for some empirical analyses, vindicating our fundamental proposition of coexistence of *fs* growth and *infs* misery in the contemporary developing world. We shall undertake basic statistical analysis utilising aggregate and state-level data for India over 2000–01 and 2005–06.

The informal sector, as seen by ILO as the 'dual' of the *fs*, is consisted of petty producers with a little surplus, but having considerable agility and dynamism of transforming itself under a variety of environments (ILO vision as encapsulated by Bangasser, 2000). Not only the ILO but also the institutionalists (North, 1990) and specifically the legalists (De Soto, 2000), neo-classicals (Ranis & Stewart, 1993 {the 'favourable archetypes'} and 1999; Marjit, 2003), the World Bank (Lanjouw & Lanjouw, 2001; Maloney, 2004) and the UNO (UN-Habitat, 2003) consider the *infs* in a positive light and explicitly or implicitly accept its dynamism. It is advocated as one of the most dynamic, active, innovative, adaptive and effective segments of the economy (Marjit & Kar, 2011) having significant positive linkages with the *fs* (Moreno-Monroy et al., 2012) and agriculture (Mellor, 1976). Moreover, it is argued that the *infs* is experiencing a transition in some of the developing countries like China and India: the firms are gradually becoming more dynamic transcending the petty commodity production mode through complex political–economic processes, and the sector is slowly becoming a part of global capitalism (Bardhan, 2009).

Contrarily, there is a sizeable literature that considers the *infs* as a zone of persistent misery and exploitation (Moser, 1978; Tokman, 1978 {subordination approach}; Benería, 1991; Pardo et al., 1991; Basile, 2013; Breman, 2013). Moser argues that the *fs* uses cheaper outputs of the petty-commodity-production-based *infs* and thereby induces the latter; however, through this process, the *infs* is essentially 'exploited' by the former. Thus, the *infs* is seen as a subordinate economic space that serves to reduce the input and labour costs of large capitalist firms of the *fs* (Tokman, 1978). Breman opines that the *fs* is able to acquire cheap labour from the *infs* and thereby enhance its profit; in fact, the *infs* is an outcome of the contemporary (neoliberal) capitalism itself that wants to create and maintain this *infs* to exploit the marginalised/cheap labour. It is argued by Basile in the Indian context that the rich and the poor—largely overlapping with the *fs* and the *infs,* respectively—are the twin products of the peculiar form of contemporary capitalism.

Contrary to these views, there has emerged recent literature that looks at the *infs* as a pool of 'surplus population'. It is visualised as the band of petty self-employed, having mainly the survival-objective, who remains outside (and non-functional vis-à-vis) the circuits of capital (Pardo et al., {case of garments in Bogota} 1991; Nun, 2000; Sanyal, 2007; Chatterjee, 2008). Further, Sanyal and Bhattacharya (2009) propose a 'non-transition' for the Indian economy and a complex political–economic framework with coexistence (not always peaceful) of dynamic 'capital' (*fs*) and subsistent 'non-capital' (*infs*). Here, the capitalistic *fs* maintains its hegemony over this devalued other with the help of complex social processes (also see: Chakrabarti et al., 2009). Pardo, Castaño and Soto (1991) show that informal garment units in Bogota, Columbia, survive without having a direct linkage with the formal industry; these activities facilitate the reproduction of urban informal working class (survival needs) by providing cheap goods and services.

While the first strand of writings cannot explain the persistence of misery within the *infs*—especially the self-employment and rural segments, the second group of authors ignores the relatively dynamic parts of the *infs* that are attached to the global market. On the other hand, the last thread of argument discounts these heterogeneities within the *infs* (for a detailed critical review, see Chakrabarti, 2016).

We, on the contrary, conceive of the *infs* as a heterogeneous sector—diverse segments behaving differently and having varied relations with the rest of the economy, especially the *fs*. In fact, we borrow from different discourses to build our structuralist framework. Based on such construction, we show why and how the *infs* continues to persist and comprehensive economic transition is markedly retarded, though some parts (of the *infs*) are able to enjoy the fruits of global capitalistic expansion. Finally, we support our theoretical proposition with the help of empirical exercise.

The rest of the paper is organised as follows. In the next section, we highlight the analytical framework of the macro-structuralist model and the following comparative static analysis. In Sect. 3.3, we have undertaken some empirical exercise vindicating the propositions derived from the model. Section 3.4 concludes with the political–economic implications of our theoretical and empirical analyses.

3.2 A Model of Formal–Informal–Agriculture Interactions

In view of the above discussions on the literature concerning the nature and dynamics/transformation of the *infs*, Chakrabarti (2016) constructs a macroeconomic framework along (broadly) structuralist lines, *a* la Kalecki (1954), Bhaduri (1986), and Chakrabarti (2013), to explain the possibilities of transformation or persistence of *infs*. We can summarise the framework below.

3.2.1 The Structure of Our Model Economy

The macro-structure of the economy comprises a capitalistic formal sector (*fs*), the non-capitalistic (non-agricultural) informal sector (*infs*), and agriculture (*agr*). Further, *infs* is divided into two sub-segments based on rural–urban or traditional–modern dichotomy, namely modern (*inmod*) and traditional (*intad*) *infs*. Similarly, we dichotomise the *agr* into modern (*magr*) and traditional segments (*tagr*).

fs operates with capital–labour dichotomy and accumulation dynamics. Workers do not save, but profit is fully saved in the current period. The *fs* product price is cost-determined, and output is demand-determined with excess capacity and unemployment of skilled labour. *intad* and *inmod* are characterised by a dominance of consumption-motive over accumulation and absence of fixed/limiting capital.[1]

There is surplus un-/semi-skilled labour in *intad* and *inmod*. Hence, outputs are demand-determined without any limiting factor of production. However, there is a structural difference between these two segments of *infs*. *Intad* consists of petty commodity producers producing mostly inferior goods. It is a subsistence sector where there is no net surplus over and above the requirements for basic food and non-food consumption and a simple commodity reproduction. Its price is determined accordingly by average costs (without any surplus). Nevertheless, in *inmod*, price is determined in the presence of a markup over the average cost of production. However, this markup is distinctly different from that imposed by a monopolist or oligopolist of the *fs*. *Inmod* tries to set this markup only to arrange for future consumption and not for accumulation. Even if the surplus is reinvested in production, it is done with the basic motive of improvements in livelihood. The *inmod* uses *intad* products, but not vice versa.

Agriculture is considered as a proxy for overall resource base (water–forest–land–mines–space) outside the circuits of *fs* and *infs*. Due to resource, technology and institutional constraints and due to the non-tradability of most of these resources,

[1] 'Informal sector may be broadly characterised as consisting of units engaged in the production of goods or services with the *primary objective of generating employment and incomes to the persons concerned*. These units typically operate at *a low level of organization*, with *little or no division between labour and capital* as factors of production and on a small scale. Labour relations, wherever to exist, are based mostly on casual employment, kinship, or personal or social relations *rather than contractual arrangements with formal guarantees'* (National Sample Survey Office, 2001, pp. 1; authors' emphasis).

we assume a resource-constrained state. Hence, we consider a supply constraint in agriculture. The *magr* produces high-value crops (HVCs), e.g. fruits, vegetables, flowers and agro-fuel feedstock for the *fs*. On the other hand, the whole chain of large-scale HVC cultivation–preservation–transportation–processing–packaging–trading is technology-intensive and uses *fs* goods and services. Further, the *fs* uses only *magr* products (and not the *tagr* output). In contrast, the marginal-farm-based, mainly, low-value food crop (LVC), e.g. basic cereals and pulses producing traditional agriculture (*tagr*), is more closely associated with the *infs*.

The *intad* and *inmod* are self-sufficient in terms of implements and non-food consumption, but they have to depend on *tagr* for food. The *intad* and *inmod* obtain food from *tagr* with the proceeds received through the sale of net outputs (net of requirements for self-consumption and reproduction) to *tagr* and *inmod* (for *intad*) and to the *fs* (for *inmod*). Aggregate *tagr* income is earned by selling the marketable surplus in the (undifferentiated) food market, which is purchased by the agents of both *intad* and *inmod*. This income, in turn, is fully spent on the products of *intad*. *fs* depends on *inmod*, not only for the supply of cheap inputs required in the production process of *fs*; but also the supply of cheap wage goods helps in keeping the overall cost of production in the *fs* low, and thereby, it could maintain a relatively higher level of profit. The presence of *inmod* is crucial for the *fs* in an intensely competitive globalised economic environment.

We assume a scenario where, although the *fs* and *infs* outputs and prices may vary and there could be intra-agriculture diversification across LVC and HVC, overall resource base, population and technology remain unchanged. We could think of it as a medium-run set-up, and only, in the long run, there could be an overall resource expansion along with population increase.

The structure of our economy can thus be presented in flow chart as shown in Fig. 3.1 which is used in Chakrabarti (2016).

If the *fs* has to expand, *magr* has to support this process by providing additional resources. However, growth of the *fs* also requires an expansion of *inmod*, which, in turn, needs an expansion of *tagr* (at the cost of *magr*, in a stagnant system). Thus, there arises a set of counteracting forces involving *magr* and *tagr*, given the overall capacity of the natural resource base. We show using comparative static how this inherent conflict is resolved and the reason for the non-transition of *infs*.

3.2.2 Comparative Static Analysis and the Phenomenon of Non-Transition

We consider a case of a rise in investment in the *fs* (ceteris paribus). Consequently, demand for HVC rises as well, raising the price of *magr,* i.e. HVC. This tilts the relative price away from LVC, and hence, there is a resource diversion towards HVC. Fall in LVC supply, on the one hand, and rise in LVC demand through expansionary

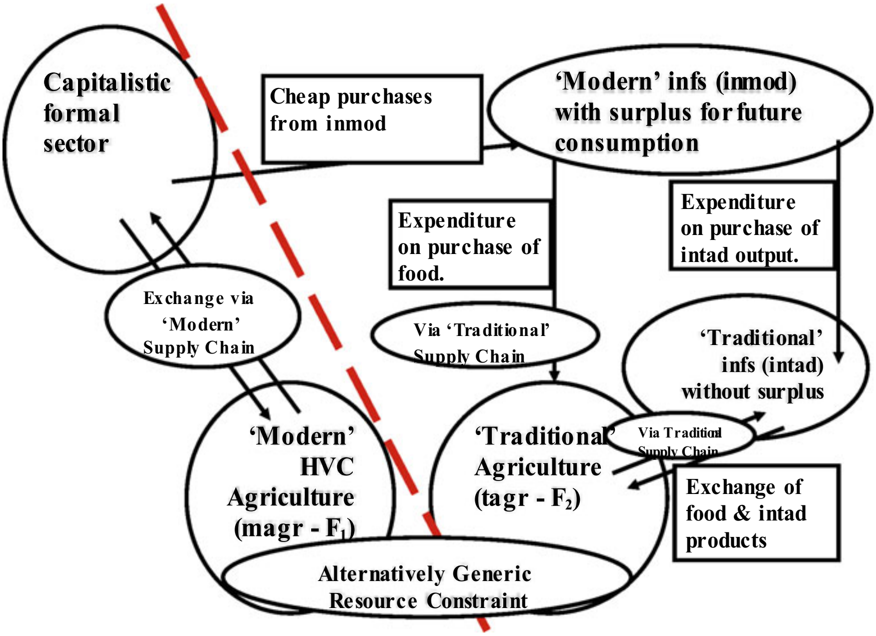

Fig. 3.1 Structure of the model economy. *Source* Reproduced from Chakrabarti (2016)

pressure on the *infs* (primarily, *inmod* and, hence, *intad* as well via linkages) due to the initial expansion in *fs*, on the other, disturb the initial equilibrium.

However, the corresponding price rise for LVC chokes off investment in the *fs*, as rise in LVC price, in turn, pushes up *inmod* price and, hence, squeezes the *fs* profit rate. This rise in LVC price continues until the rise in HVC demand is completely countered. This process, in turn, re-establishes the old set of equilibria. Thus, we get a fundamental result that the dependence of the *fs* on *infs* (*inmod*) and that of the *infs* on *tagr* restrict resource diversification towards the *fs* and, hence, choke off its zeal for accumulation. Consequently, the initial rate of investment is re-established.

However, this regeneration of macro-equilibrium is not at all cost less. In fact, due to increased investment in the *fs* beyond the optimum level—as there is a resource mobilisation away from LVC to HVC, there are contraction and immiserisation within the *infs*. This happens as the price of *inmod* does not rise instantaneously and contraction of LVC sector raises LVC price, which, in turn, reduces the rate of surplus generation even in *inmod*. Moreover, with the overall contraction of the LVC segment, the *intad* which is essentially a subsistence sector and highly dependent on basic resources should contract (despite a demand pull from the *inmod*). Thus, we have these costs of an expansion of *fs*, though finally the economy re-equilibrates.

On the other hand, the ever-increasing extent of accumulation in the *fs* could go on unhindered, only if there is a concomitant expansion of the resource base either through new explorations or via an increase in productivity or both. However, this balanced growth has to ensure an expansion of the LVC sector as well—in addition to the HVC sector—to guarantee the existence and expansion of *inmod* supplying cheap products to the *fs,* thereby ensuring the existence of the *infs* as a whole. Correspondingly, *intad* too survives and expands by using these expanding basic resources as well as acquiring additional demand from *inmod*. As the resource base in general expands, the *fs* can increase its volume of accumulation with the help of a growing *magr* and that of an increased supply of cheap inputs/wage goods from *inmod* which, in turn, can expand due to the expansion of its own resource base (i.e. *tagr*). This overall resource expansion (as well as increased demand from *inmod*) provides increased support to *intad* as well; *intad*, even with its disadvantaged/unequal position, swells.

Although the resource base expands and the *fs* accumulates and grows (in terms of skilled employment, output, productivity, etc.), the conditions of living may remain the same in *inmod* and *intad*: these segments of *infs* expand in terms of (un-/semi-skilled) employment and output, but productivities may remain the same and per capita resource availability as well should not change if population too expands concurrently. If, however, there is no change of population size and/or *infs* productivities rise too along with the expansion of resource base, the sectoral size, as well as the per capita income of *inmod* and *intad*, improves.

Thus, we have the crucial results:

(a) Along with the accumulation and growth of the *fs*, there is an expansion of the *infs* as well, with/without any change in its standard of living. But, more importantly, it happens without any significant economic transformation of the *fs–infs* complex, even if there is an overall expansion of the natural resource base. The economy fails to achieve an inclusive transition, despite the high rates of growth. Despite severe conflicts as also close complementarities between the *fs* and the different sub-segments of the *infs*, accumulation—growth—swelling of underemployment go hand in hand without substantial transformation within the economy. This outcome of our model clearly marks a departure from the orthodox literature that proposes a transformation of the *infs*, in particular, and *fs–infs* composite, in general.

(b) If, however, there is a lack of expansion of the resource base (which is quite possible, not only due to the limits of natural resources but also because of technological, economic, environmental, geopolitical, and various other political–economic factors), the dependence of *fs* on *inmod* and the latter's dependence on *tagr* restrict capital accumulation and growth, as resources cannot be transferred from *tagr* towards *magr*. Furthermore, unchanging *tagr* ensures perseverance of *intad* as well. Thus, frictions retarding the accumulation process restrict the growth of the *fs* and simultaneously ensure the persistence of vast *intad* (along with *inmod*).

(c) If capital on its own cannot restrict itself and manage these contradictions (which is quite likely in the contemporary neoliberal world), state has to intervene. Further, these binding impacts of the natural limits may, however, be toughened by the 'political limits' in a democracy where the *infs* has to be tolerated (for populist compulsions), despite alleged chaos associated with it.

Let us now move to the empirical exercises, keeping in view these fundamental results derived from the model.

3.3 Formal–Informal–Agriculture Interactions and Differentiation Within the Informal Sector

Our empirical regression-based analysis validates the stated outcome of the theoretical model to a greater extent by showing that complementary and conflicting relationships exist between *fs* and rural/urban *infs* in India. To this end, we have disaggregated the *infs* in India across its rural/traditional and urban/modern subsegments. However, *Infs* in India is highly heterogeneous in nature (Moreno-Monroy et al., 2012: 4); despite this heterogeneity, Indian Official Statistics made a clear demarcation across various segments of the *infs*. Although there are few studies in the Indian context that could demarcate the modern and traditional segments of the informal sector (Moreno-Monroy et al., 2012: 9), Moreno-Monroy et al. demarcated the informal manufacturing firms in India based on the degree of modernity using modernity index; this framework is defined broadly in the light of Ranis and Stewart (1999). Ranis and Stewart (1999) defined informal units are modern, which have the following characteristics: significantly high capital per labour; enterprises hire the workers; work premises are located outside the household premises. As an example, Ranis and Stewart cited metal working as the modern sector and textile handlooms as the traditional one. Moreno-Monroy et al. defined modernity index as the ratio of the number of enterprises having a fixed location outside the household's premises to the number of enterprises with/without the fixed location; since the index takes a continuous value, they did not define a specific industry as modern in their analysis. However, since agricultural resource allocation poses a central role in our entire analysis, we have divided the modernity of *infs* based on their location—rural enterprises are considered as traditional, and their urban counterpart is considered as modern in our analysis.

For our analytical purpose, we have divided the informal non-agricultural (non-farm) sector from the agriculture (farm), although the latter sector is also the part of the informal economy; we have focused only on the informal non-agricultural enterprise for our empirical analysis, which is termed as *infs* in our theoretical work. Moreover, we have confined our analysis to the informal manufacturing sector leaving the segment of informal services. Our empirical analysis is based on the unorganised enterprise survey conducted by National Sample Survey Office (NSSO, 2001, 2007), rather than the employment–unemployment household survey conducted by the same.

3.3.1 Empirical Exercise and Data Source

We have divided this section into three subsections—the proposed empirical models; data source and variable construction to support the empirical models; and finally, the results and discussion of the regression-based models.

3.3.1.1 Empirical Model

We have estimated three different models for our analysis. First, we have tested whether agricultural modernisation, captured through agricultural crop diversification index (CDI), and the growth of urban *infs* induce the growth of the *fs*, while controlling for other relevant macro-variables. Second, we have also analysed whether the growth of the urban *infs* is deteriorated due to the agricultural modernisation; but the growth of the urban *infs* is improved due to the growth of the *fs* as specified in our theoretical model. Finally, we have enquired whether the growth of the urban *infs* facilitates the growth of the rural *infs*, while agricultural modernisation and *fs* growth deteriorate the growth of the rural *infs*. These three independent models would help us to understand the stated dynamics of interdependence across sectors and the probable cause of the persistence of informality.

In order to address these phenomena, we have used the ordinary least square (OLS) estimates separately for two time spans 2000–01 and 2005–06. This is primarily due to the lack of panel data information for relevant variables, which made us perform cross-sectional analysis using OLS estimates. The followings are the specification of the three types of models:

$$\begin{aligned} FGVA_{ij} &= \beta_1 + \beta_2 CDI_j + \beta_3 ROI_j + \beta_4 (CDI_j X\ ROI_j) + \beta_5 Inv_{ij} \\ &\quad + \beta_6 UVA_{ij} + \beta_7 Road_j + \beta_8 PNSDP_j + u_{ij} \end{aligned} \tag{3.1}$$

$$\begin{aligned} UVA_{ij} &= \alpha_1 + \alpha_2 CDI_j + \alpha_3 ROI_j + \alpha_4 (CDI_j X\ ROI_j) + \alpha_5 (CDI_j X\ Inv_{ij}) \\ &\quad + \alpha_6 UInv_{ij} + \alpha_7 Inv_{ij} + \alpha_8 Srv_j + \alpha_9 Road_j + \alpha_{10} HH - Elc_j \\ &\quad + \alpha_{11} Tel_j + \alpha_{12} Power_j + v_{ij} \end{aligned} \tag{3.2}$$

$$\begin{aligned} RVA_{ij} &= \gamma_1 + \gamma_2 ROI_j + \gamma_3 (CDI_j X\ ROI_j) + \gamma_4 (CDI_j X\ FGVA_{ij}) \\ &\quad + \gamma_5 Road_j + \gamma_6 HH - Elc_j + \gamma_7 Power_j + \gamma_8 Tel_j + \gamma_9 RInv_{ij} \\ &\quad + \gamma_{10} UVA_{ij} + \gamma_{11} FGVA_{ij} + \gamma_{12} Srv_j + \gamma_{13} PNSDP_j + w_{ij} \end{aligned} \tag{3.3}$$

where i indexes 2-digit manufacturing industries and j indexes states; *FGVA* stands for formal manufacturing real GVA (2 digits), *CDI* stands for Simpson's crop diversification index, *ROI* is the regional openness index for the year 2002–03, *Inv* depicts the real investment in *fs* corresponding to (2-digit) manufacturing, *UVA* depicts real GVA in urban *infs*, *RVA* depicts real GVA in rural *infs*, *Road* represents the proportion of surface road across states in 2000–01 and the length of the road across states during 2005–06, *PNSDP* represents per capita net state domestic product at constant price (base 2004–05), *Srv* represents NSDP from services across states (base 2004–05), *RInv* and *UInv* represent, respectively, the real investment in rural and urban *infs*, *HH-Elc* depicts the percentage of households with access to electricity for the year 2000–01, *Power* stands for per capita power availability across states for the year 2005–06, *Tel* stands for teledensity across states for the year 2006, and finally, *u*, *v* and *w* represent disturbance terms.

Apart from the independent variables mentioned in our stated theoretical model, we have used the other relevant independent variables, as depicted in the above regression model, due to the following reasons. Real investment at the industry level is considered as one of the controlling variables that determine the growth of the industry in both formal and informal sectors, at the micro-level. There are various macro-variables pertaining to state-specific basic infrastructural indicators which explain the growth of the *fs* and *infs*. For instance, we have controlled for regional openness index (ROI) across states which indicates the region's link with the external sector as the growth of the *fs* also depends on the involvement of the states with the external sector. Among the other region-specific controlling variables across the regression models, we have considered the proportion of surface road, road length, the proportion of households having electrification, rural road length per 100 square kilometre, telephone density across states as the basic infrastructural indicators. These are the supply-side factors. However, as a demand-side factor, we have also considered the per capita net state domestic product and per capita net state domestic product from services for the respective years. Although we have not employed the two-stage least squares method (2-SLS) to avoid the potential simultaneity bias between *fs* and urban *infs* growth due to the paucity of information, we tried to minimise the simultaneity bias using real investment in *fs* as one of the independent variables that determines the growth of the urban *infs*. *fs* real investment growth at the firm level determines the output growth of *fs,* and hence, it is considered as the proxy (not as an instrument) for *fs* output.

3.3.1.2 Data Source and Variable Construction

Based on the data available from NSSO, Government of India, we have concentrated on Indian unorganised manufacturing as a proxy for non-agricultural *infs*, for the two periods 2000–01 and 2005–06 for our regression analysis. We have considered the corresponding organised manufacturing as a proxy for *fs* and obtain the data from the Annual Survey of Industries (ASI), Central Statistical Office, Government of India. Further, we have used the state-level information on gross cropped area (GCA) under cultivation across crops from the Ministry of Agriculture and Farmer's Welfare, Government of India, to compute Simpson's crop diversification index (CDI) across major states of India for the year 2000–01 and 2005–06. The CDI is computed based on the following formula: $\mathrm{CDI} = 1 - \sum \mathrm{p}_{\mathrm{i}}^{2}$, for all $i = 1,$

2,…n, where p_i denotes the GCA share of crop *i* to the aggregate GCA of a particular state. We have also obtained the information on state-wise per capita availability of power and state-wise length of the road (in KM) both for the year 2005–06 from the Reserve Bank of India (RBI) database (RBI, 2017). We have obtained the state-wise infrastructural variables such as the proportion of surface road to total for the year 2000–01, teledensity (number of telephone lines per 100 people) for the year 2006, percentage of households with access to electricity for the year 2001 and percentage of villages electrified during 1999 from Ghosh (2017). Regional openness index (ROI) across states consists of both export and import of the states with the rest of the world, and the index is computed by Maiti and Marjit (2010) and is used in our analysis. We have computed per capita net state domestic product for the corresponding years of 2000–01 and 2005–06 at a constant price with the base year of 2004–05 using the RBI database. We have considered the gross value added (GVA) of rural–urban *infs* and *fs* (combined) across 14 major states of India, viz. Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. Our unit of analysis is firm-level GVA per enterprise across twenty-two 2-digit industries spreading across 14 major states.[2] We have deflated the nominal gross value added of *fs* by the wholesale price index (WPI) for the respective years with 1993–94 as the base period. Real gross fixed capital formation (investment) in *fs* for the corresponding years is collected from ASI and deflated by the WPI for machinery and machine tools obtained from the Reserve Bank of India database with 1993–94 as the base period. We deflate the nominal GVA of *infs* by the consumer price index of industrial worker (CPI-IW) with 1993–94 as the base period. Real investment of *infs* is computed based on the information on net addition to fixed capital at industry level obtained from the NSSO unit record database, and subsequently, the values are deflated by the corresponding WPI for machinery and machine tools with the base period of 1993–94.

3.3.1.3 Results and Discussion

We can notice from models 1 and 2 in Table 3.1 that agricultural diversification towards high-value crops (HVCs) captured through CDI has a significant and positive influence on the *fs* growth.

Capital accumulation in *fs* (investment) supports the growth of this sector; finally, the supply of cheap raw materials from modern *infs* influences the growth of *fs*—we found, during 2005–06, urban/modern *infs* facilitates the growth of the latter sector. So far as urban *infs* is concerned, we can find the rising crop diversification has a significant adverse impact on the latter sector (models 3 to 7) during both the periods under study. Also, it is noteworthy from models 3 to 7 that accumulation in *fs* (growth in real investment in *fs*) induces the growth of the modern *infs* while controlling the process of crop diversification along with other relevant variables (models 3 and 5 for

[2] Description of the 2-digit-level industry is furnished in Appendix 1 Table 3.3.

Table 3.1 Regression results-1

Model no.	1	2	3	4	5	6	7	8
	OrgVA01	OrgVA06	UVA01	UVA01	UVA01	UVA06	UVA06	UVA06
Constant	−0.95 (0.94)	−1.92 (1.83)	570.12^{a} (146.15)	556.44^{a} (146.75)	437.19^{a} (165.87)	3988.19^{b} (1777.19)	4530.41^{b} (1792.61)	285.48 (486.04)
CDI06		1.92^{c} (1.10)				−4650.27^{c} (2112.27)	−5159.04^{a} (1963.86)	114.54 (443.36)
ROI03		0.06 (0.06)				−611.2^{b} (253.18)	−674.85^{b} (242.82)	
ROI.CDI06						819.76^{b} (324.31)	904.81^{a} (302.2)	
CDI.Inv06								324.41^{b} (164.44)
CDI01	2.16^{b} (1)		−492.72^{c} (259.29)	−662.84^{a} (246.96)	−416.63^{b} (198.37)			
CDI.OVA01					83.11 (58.01)			
PIDI01					906.71^{a} (257.9)			
Road01	−0.21^{b} (0.01)		0.1 (3.63)	−2.15 (3.9)				
ShareRd06							−1961.62 (4550.11)	2393.89 (5322.82)
HHElec-01			6.62^{a} (2.58)	8.01^{a} (2.73)				
Powr06						−0.12 (0.45)	−0.19 (0.46)	0.05 (0.37)
TelD-06						90.51 (61.05)	91.12 (61.34)	71.33 (62.02)
UVA06		0.0002^{c} (0.001)						
UVA01	0.000 (0.00)							
Inv06		0.65^{b} (0.28)				88.76^{b} (40.35)	90.47^{b} (41.43)	−87.08 (59.61)
Inv01	0.81 (0.62)		173.77^{a} (92.55)	148.32 (92.8)	0.18^{b} (0.08)			
UInv06						0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
UInv01				0.16^{b} (0.08)				
PNSDP-06		0.000 (0.000)						

(continued)

Table 3.1 (continued)

Model no.	1	2	3	4	5	6	7	8
PNSDP-01	0.00[c] (0.00)							
NSDPSrv-01				0.000[a] (0.000)	0.000[a] (0.000)			
NSDPSrv-06								−0.00 (0.00)
R^2	0.16	0.24	0.12	0.14	0.1	0.13	0.13	0.11
N	273	269	245	245	245	238	238	249

[a], [b] and [c] imply levels of significance at 1%, 5% and 10%, respectively. Robust standard errors are in parentheses
OrgVA01: real gross value added of organised manufacturing for the year 2000–01
OrgVA06: real gross value added of organised manufacturing for the year 2005–06
UVA01: real gross value added of urban unorganised manufacturing for the year 2000–01
UVA06: real gross value added of urban unorganised manufacturing for the year 2005–06.
CDI01: Simpson's crop diversification index for the year 2000–01
CDI06: Simpson's crop diversification index for the year 2005–06
ROI03: regional openness index for the year 2002–03
OVA01: real value gross output of organised manufacturing for the year 2000–01
Inv01: real investment of formal manufacturing for the year 2000–01
Inv06: real investment of formal manufacturing for the year 2005–06
UInv01: real investment of urban unorganised manufacturing for the year 2000–01
UInv06: real investment of urban unorganised manufacturing for the year 2005–06
PIDI: physical infrastructural development index
Road01: proportion of surface road across states in 2000–01
ShareRd06: share of state-wise road length (in KM) to total road length in 2005–06
HHElec-01: percentage of households with access to electricity across states for the year 2000–01
Powr06 per capita power availability across states for the year 2005–06
TelD-06: teledensity (number of telephone lines per 100 people) across states for the year 2006
PNSDP-01: real per capita net state domestic product for the year 2000–01
PNSDP-06: real per capita net state domestic product for the year 2005–06
NSDPSrv-01: real net state domestic product from service sector for the year 2000–01
NSDPSrv-06: real net state domestic product from service sector for the year 2005–06

the year 2000–01 and models 6 and 7 for the year 2005–06). Nonetheless, *fs* growth jointly with the rising crop diversification does not have any significant impact on the growth of the modern *infs* during 2000–01 (see model 5). This is perhaps due to the two contrasting forces that get nullified—the expansionary impact of *fs* and contractionary impact of CDI on the growth of modern *infs*—and hence, we found no significant impact on the urban *infs*.

One interesting observation to note modernisation of agriculture, captured through growth in CDI, jointly with an increasing association of states through export–import channels reflected by ROI, can positively influence the growth of urban *infs*, provided the capital accumulation in *fs* is maintained at a certain level, i.e. controlling the growth of real investment in *fs* (see model 6 and model 7). However, individual impacts of the above-mentioned two factors rather influence negatively the growth of the urban *infs* as one can observe from models 6 and 7. In the case of modern *infs* during 2005–06, we found that *fs* capital accumulation jointly with changing cropping pattern towards HVC cultivation enhances the growth of the modern/urban *infs* provided the capital accumulation in *fs* is kept at bay (model 8).

The crop diversification index negatively influences the growth of the rural *infs* during 2000–01 (models 9 and 10 in Table 3.2). Another interesting point reveals *fs* growth jointly with rising CDI does not influence the growth of the traditional (rural) *infs* during 2000–01 (model 10: Table 3.2). However, we found evidence that excessive growth in *fs* along with unbridled growth in HVC cultivation results in jeopardising the growth of the traditional *infs* in the latter stage during 2005–06 (see models 12 and 13). Hence, we can argue that *fs* needs to opt for a middle path by moderating its accumulation and simultaneously fostering the growth of the *infs*. We can also notice that the rising degree of openness of the economy has a negative influence on the growth of the rural *infs* (model 11). Hence, there is a trade-off between the growth of *fs* and rural *infs* with the modernisation of agriculture along with opening up of the economy; such growth conflict arises due to sharing of common agricultural resources.

Our empirical exercise supports the theoretical argument to a larger extent, which shows the reason for the inherent persistence of misery within segments of *infs*—especially the rural one. Expansion of *fs* needs appropriation of resources and the subsequent agricultural diversification towards HVCs. Such a process otherwise affects the growth of modern *infs* and traditional *infs* through different channels. Deteriorating growth in modern *infs* affects the growth of *the fs* sector as the latter sector depends on the former to maintain the competitive edge. Hence, we argue that *fs* needs to maintain a balanced path of fostering the modern sector for its own survival acknowledging the conflict that arises due to resource-sharing.

Table 3.2 Regression results-2

Estimation	9	10	11	12	13
	RVA01	RVA01	RVA06	RVA06	RVA06
Constant	642.35[b] (321.58)	367.3 (573.92)	287.24[a] (166.48)	−132.22 (126.52)	−53.16 (151.97)
CDI01	−1119.56[b] (449.72)	−1402.04[b] (697.23)			
CDI06			387.7[a] (217.39)	580.53[a] (222.13)	541.01[b] (251.96)
ROI03			−32.5[b] (15.03)		
CDI.OVA01		381.13 (754.43)			
CDI.OVA06				−133.21[a] (19.02)	−138.37[a] (19.38)
Road01	6.78[b] (3.39)	6.54[a] (3.63)			
VillElec99		5.38 (4.24)			
Road06					−0.000 (0.000)
HHElec-01	2.46 (1.79)				
Powr06					0.02 (0.13)
TelD-06					18.45 (13.32)
UVA06			0.22[b] (0.09)	0.2[b] (0.09)	0.19[b] (0.09)
UVA01		0.08 (0.07)			
OrgVA06				130.56[a] (17.23)	135.35[a] (17.71)
OrgVA01	132.57 (125.01)	−183.5 (554.85)			
RInv06			0.000 (0.00)	0.00(0.00)	0.00(0.00)
RInv01	0.1[b] (0.05)	0.11[b] (0.05)			
NSDPSrv-01		0.00 (0.00)			
NSDPSrv-06			−0.000 (0.00)	−0.000 (0.000)	−0.000 (0.000)
R^2	0.1	0.11	0.23	0.24	0.25

(continued)

Table 3.2 (continued)

Estimation	9	10	11	12	13
N	206	195	218	211	211

[a], [b] and [c] imply levels of significance at 1%, 5% and 10%, respectively. Robust standard errors are in parentheses
RVA01: real gross value added of rural unorganised manufacturing for the year 2000–01
RVA06: real gross value added of rural unorganised manufacturing for the year 2005–06
CDI01: Simpson's crop diversification index for the year 2000–01
CDI06: Simpson's crop diversification index for the year 2005–06
ROI03: regional openness index for the year 2002–03
OVA01: real value gross output of organised manufacturing for the year 2000–01
OVA06: real value gross output of organised manufacturing for the year 2005–06
Road01: proportion of surface road across states in 2000–01
Road06: proportion of surface road across states in 2005–06
VillElec99: percentage of villages electrified during 1999
HHElec-01: percentage of households with access to electricity across states for the year 2000–01
Powr06: per capita power availability across states for the year 2005–06
TelD-06: teledensity (number of telephone lines per 100 people) for the year 2006
UVA01: real gross value added of urban unorganised manufacturing for the year 2000–01
UVA06: real gross value added of urban unorganised manufacturing for the year 2005–06
OrgVA01: real gross value added of organised manufacturing for the year 2000–01
OrgVA06: real gross value added of organised manufacturing for the year 2005–06
RInv01: real investment of rural unorganised manufacturing for the year 2000–01
RInv06: real investment of rural unorganised manufacturing for the year 2005–06
NSDPSrv-01: real net state domestic product from service sector for the year 2000–01
NSDPSrv-06: real net state domestic product from service sector for the year 2005–06

3.4 Concluding Remarks

The prime objective of the paper is to analyse the puzzle of the non-transition of the vast informal sector in India—an absence of transformation towards comprehensive capitalistic dynamics. We propose that, essentially, such a non-transition of the informality and, hence, a lack of structural transformation of the overall economy itself develop the symptoms like the dual phenomena of high rates of growth in the formal sector along with persistence and even a spread of the informality. In explaining these intriguingly dichotomous phenomena, we have hypothesised that there are dualities within the informality across its traditional/petty/rural and modern/advanced/urban segments. Further, the relations of these varied segments with the rest of the economy, especially with the formal sector and agriculture, are diverse and structurally determined. These varieties of relations are, in fact, the fundamental reason for the observed phenomena of non-transition of the informality.

While the modern segment of informality bears a positive relationship with the formal sectors, the traditional counterpart is engaged in a bitter resource conflict with the former. Hence, even though this formality–petty informality contradiction remains hidden, there are inherent clashes. However, the formality itself and/or the state take up crucial measures to check these conflicts, for the sake of the overall political–economic system.

The formal sector, because of its own typically dispersed production organisation/network, has to depend on and, hence, has to have the modern segments of the informality growing. Now, as these modern informal segments, in its turn, have to depend on crucial basic resources, the formality cannot go on grabbing these resources and grow beyond an optimum rate. Our empirical exercise indicates this typical case with respect to *infs* in India. Consequently, the formal sector itself cannot or does not want to transform the formal–informal composite towards comprehensive capitalism. Conversely, it has to promote the informality for its own unhindered expansion. Thus, we have an economic explanation for the puzzle of coexistence and growth of modernity along with persistence and spread of the informality (as noted by Sanyal, 2007; Chatterjee, 2008; Bhattacharya, 2010; Basile, 2013; Breman, 2013; Chakrabarti, 2009, 2013, and specifically, detailed in Chakrabarti, 2016).

Further, we propose analytically: as the basic resource availability grows and relaxes the supply-side constraints for the economy as a whole and, hence, as the formal sector expands with the help of its accumulation process, both the modern and traditional informal activities swell. Though the economy as a whole grows, there is lack of transformation—the formality and informality simultaneously grow. We have 'a huge reserve army waiting to be incorporated in the (formalised) labour process becomes stigmatised as a redundant mass, an excessive burden that *cannot be included, now or in future,* in the economy and society' (Breman, 2013, pp. 142; emphasis added). Thus, based on the theoretical and empirical analyses it is proposed that the formal sector may be playing crucial roles (with the support from the state) in ensuring the existence and spread of informality and, simultaneously, threatening this very existence (of informality) because of an inherent resource conflict; this is a crucial dilemma of the modern capital.

Appendix 1

See Table 3.3.

Table 3.3 Description of 2-digit manufacturing industries in India

NIC Division 2004	Description of the manufacturing sector
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21	Manufacture of paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastics products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment n.e.c
30	Manufacture of office, accounting and computing machinery
31	Manufacture of electrical machinery and apparatus n.e.c
32	Manufacture of radio, television and communication equipment and apparatus
33	Manufacture of medical, precision and optical instruments, watches and clocks
34	Manufacture of motor vehicles, trailers and semi-trailers
35	Manufacture of other transport equipment
36	Manufacture of furniture; manufacturing n.e.c

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Chapter 4
An Analysis of the Medical Devices Sector in India—Domestic Manufacturing and International Trade

Saumaly Ghosh

4.1 Introduction

Medical technology can be interpreted as the collective of drugs, methods of diagnosis, treatment procedures, use of medical devices and the organization and availability of health services. It has the potential of significantly improving the population health and life conditions. This understanding has got even more engraved after the 60th World Health Assembly in 2007. It is now an accepted fact that health technology, especially medical devices, is necessary for equipping the healthcare systems with curative, diagnostic and preventive measures. The increasing burden of non-communicable diseases across the globe (the cure for which depends more on monitoring, diagnosis and management of symptoms than on post-illness treatment with drugs) has made medical devices even more indispensable in the present times. Technology diffusion, i.e. the scale, composition and speed with which medical technology reaches the target population, depends on an array of factors, of which domestic production capabilities and participation of the country in international trade are two very prominent. What also becomes important for consideration in countries like India where health care is mostly financed as an out-of-pocket expenditure is whether such diffusion happens with an inflation of the potential healthcare costs. The experience of the OECD countries suggests that enhanced access to health technologies has led to increased burden of healthcare costs (Sorenson et al., 2013). According to the WHO, developing countries are highly dependent on imports for their medical device needs (WHO, 2006; Datta & Selvaraj, 2019). India, together with other countries in similar stages like China, is experiencing both demand- and supply-side pressures for adopting medical technologies—while the former includes increased awareness, rising disposable incomes, reduced trade barriers, an ageing population and increased medical tourism, the latter includes medical institutions adopting new technologies and innovations to retain both customers as well as

S. Ghosh (✉)
CESP JNU, New Delhi, India

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medical professionals in the face of increased competition and the MNCs that are increasingly targeting markets like India and China to sell their products.

Increased dependence on imports, without sufficient development of the domestic production capabilities, for meeting the domestic needs of healthcare essentials, can have catastrophic consequences on the out-of-pocket health expenditures in a country like ours. India's experience with the pharmaceutical sector tells us how dependence on the MNCs can stifle access and inflate costs. There are three key industrial sectors of the modern healthcare technology system—drugs, devices and vaccines. The past few decades have focused on developing drugs and vaccines and making them accessible to the population in the global south. Many emerging economies have successfully developed national technological and industrial capabilities for manufacturing drugs and vaccines. India has been a global success story in this and has come to be known as the "pharmacy of the developing world". Such national capabilities have resulted in increased access to health care at reduced costs, both in developed as well as developing countries (Chaudhuri, 2005). The WHO suggests that the success in pharma and vaccines has not been emulated in the case of medical devices, and as a result, most developing countries are still dependent on imports (WHO, 2007). Such contrasting developments in related sectors of health care raise questions of industrial catch-ups and policy implementations and thus call for a detailed study for better analysis.

In complete contrast to the pharmaceutical and biotechnology sectors, the devices sector in India has remained neglected both in the academic sphere as well as in the policy domain. The negligible literature that exists mainly has had its focus on the diffusion and demand aspects of medical devices with not much focus on the supply-side dynamics. Mahal, Varshney and Taman (2006) and Mahal and Karan (2009) suggest in their papers that with increased imports and domestic production of devices, India has seen increased diffusion of medical technology. This on the demand side can be corroborated from data showing increased utilization of devices. Datta and Selvaraj (2019) have studied the market size and import dependence of the Indian medical devices sector. Very recently, Kale (2019) has analysed the role of regulation and correspondingly the lack of it in India that may potentially have been a reason for the underperformance of the local sector. None of these existing studies, however, has made any attempt to understand the technological and use-based heterogeneity of the devices sector in India. Given the wide variation of items that are classified as devices, we believe that, such a classification assumes significant importance, it is mainly high import dependence on technology-intensive devices (which are usually high value and low volume) that potentially can be inflationary for the healthcare costs. A use- and technology-based analysis also remains helpful for the governments to decide how to streamline their policies to promote this sector.

Taking the cue from here, this chapter makes an attempt to study and understand the medical devices industry in India, which has remained neglected not only in the policy domain but also in the academic sphere. Our attempt here is to understand how self-sufficient India is in meeting her requirements of devices. The focus of our study here is mainly on the structure, production profile and the export–import profile of the medical devices sector in India. Given the wide heterogeneity that characterizes the products in this sector, we make an attempt to understand which products are being produced domestically and for which we remain highly import dependent. Given the lack of space and scope, this chapter does not extend to the discussions of policy studies and theories of industrial catch-up, explicitly.

4.2 Methodology

The medical devices sector exhibits the wide heterogeneity among products (everything from the very simple tongue depressors to complex implants and artificial organs are all considered as medical devices). The focus primarily is to understand the type of products that are produced domestically and those for which we remain highly import dependent. The analysis is done using two main data sources—the ASI data for domestic manufacture and trade data based on HS codes for exports and imports. The chapter remains divided into three main parts—the first analyses the structure of devices industry in India using the data based on the NIC codes published by the ASI, and the second analyses the production profile of this sector in India, i.e. the type of products that are produced. For this, we use the NPCMS classification that is associated with NIC codes on which the ASI dataset is based.[1] The last part deals with the export–import profile of devices from and to India. The NPCMS classification is based on the international CPC code system which in turn has a very close link with the HS classification of the trade data. This helps us to concord the data for domestic manufacture with that of international trade. Tables 4.7, 4.8 and 4.9 in the appendix give the details of the NIC and NPCMS codes included in this study.

Following Bamber and Gereffi (2013), we follow a use-based classification for categorizing the finished products from the sector.[2]

(a) Disposables—This includes high-volume low-value products like syringes, surgical gloves, contraceptives, catheters, needles bandages, etc. These are mainly single use products that are cost-driven. These usually present the lowest health risks to patients and hence face the least approval burdens.
(b) Surgicals: These include products such as forceps, medical scissors and dental drills, as well as specialized surgical instruments used in cosmetic and endoscopic surgery. These are generally multi-use products that are sterilized between uses with different patients.
(c) Therapeutics: These are products that are especially used for treating patients and helping them in managing physical illness or discomfort. For example, hearing aids, contact lenses, artificial breathing apparatus.

[1] For the years when NPCMS codes were not in existence (before 2011), the ASICC codes were used for commodity classification. The ASICC can be concorded to the NPCMS, and this helps us in doing a continuous time period analysis.

[2] https://gvcc.duke.edu/wp-content/uploads/2013-08-20_Ch2_Medical_Devices.pdf.

(d) Implants: This is a specific component of the therapeutics and consists of products that are placed inside the human body like pacemakers, artificial joints, artificial body parts, etc. Due to their prolonged use inside the body, the production of implantable devices requires considerable expertise, particularly with respect to bio-compatibility, and obtaining regulatory approval for implantable devices is a costly process.
(e) Diagnostics: This product category covers equipment used in patient monitoring, diagnostics and imaging and ranges from infusion pumps and blood pressure monitors to considerably large investments such as MRI equipment or computed tomography. This category mainly consists of high-value, low-volume products that are a single time purchase and can be used for long periods.
(f) Furniture and others: This category consists of products like invalid carriages, hospital beds and other medical furniture.

Devices are commonly regulated according to a risk-based classification system; the stringency of a standard reflects its relative complexity and the potential harm posed to consumers. The regulatory system in the USA, which is the biggest market for devices, classifies class 1 devices as those that present the fewest health risks to patients and thus face the lowest approval barriers. Class 2 devices are those that pose a slightly greater health risk and are generally seen as similar to an existing product in the market. Class 3 devices are subject to the most rigorous regulatory procedures, such as clinical trials, which can require one to five years before a device is approved for sale. This risk-based classification system can be taken as a rough guide to the technological sophistication of each of the use-based category of devices. Disposables and surgicals consist mainly of class I devices and can be considered as low-technology group, while implants, therapeutics and diagnostics, consisting of class II and III products, are taken as the medium-to-high-technology group. The group furniture and others are kept outside of this technological classification given the wide heterogeneity of the constituent products. With a wide variation in most of the products, this technological classification is, however, only merely suggestive and cannot be taken to be sacrosanct. For example, a simple product like hearing aid can be of different types, having different specifications and different levels of technology embedded. Such intra-product heterogeneity of devices makes this technological classification to be merely suggestive.

4.3 Structure of the Manufacturing Sector for Medical Devices in India

Figures 4.1, 4.2, 4.3, 4.4 and 4.5 gives an idea about the structure of the devices manufacturing sector in India for the period 1999–2000 to 2017–18. The industry consisted of 787 units in 2017–18 and remains geographically concentrated with more than 60% of the units being located in the states of Haryana, Gujarat, Tamil Nadu, Maharashtra,

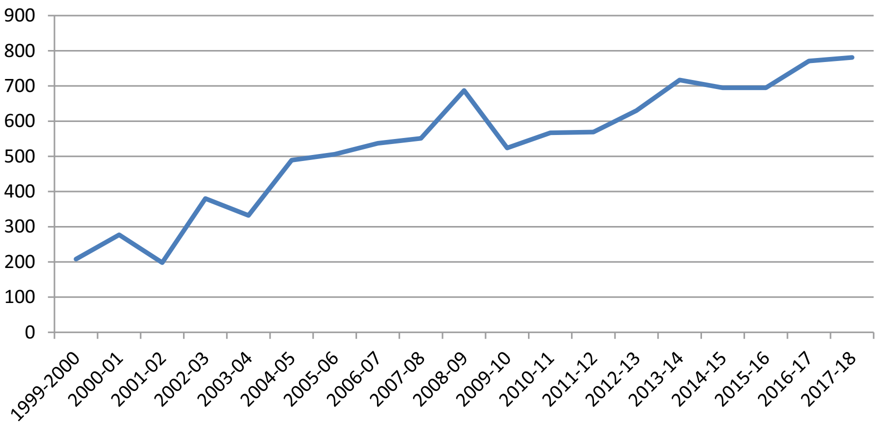

Fig. 4.1 Number of units manufacturing medical devices in India. *Source* Author's explanation based on secondary data

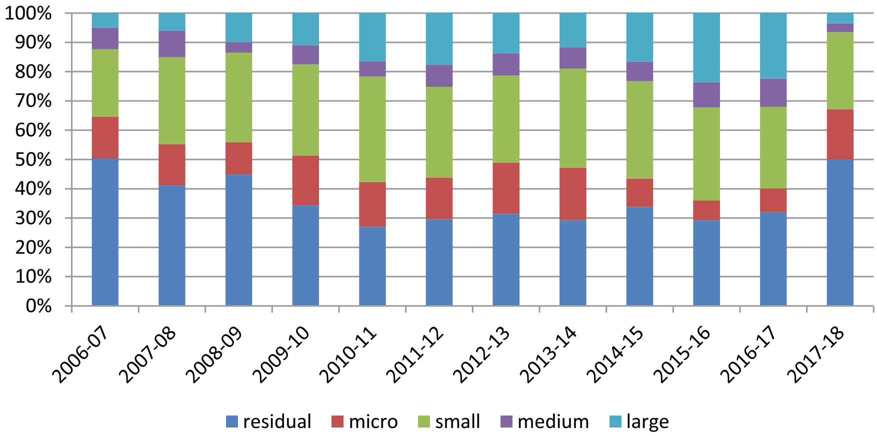

Fig. 4.2 Size composition of the units manufacturing medical devices in India. *Source* Author's explanation based on secondary data

UP and Karnataka. Using the standard size classification of the MSME act 2006[3] which is based on the values of investment in plant and machinery of an individual unit, we find that the industry remains highly dominated by small and micro-units

[3] The Act states in the case of the enterprises engaged in the manufacture or production of goods pertaining to any industry specified in the first schedule to the Industries Act 1951, as.

(a) a micro-enterprise, where the investment in plant and machinery does not exceed twenty-five lakh rupees;
(b) a small enterprise where the investment in plant and machinery is more than twenty-five lakh rupees but does not exceed five crore rupees;

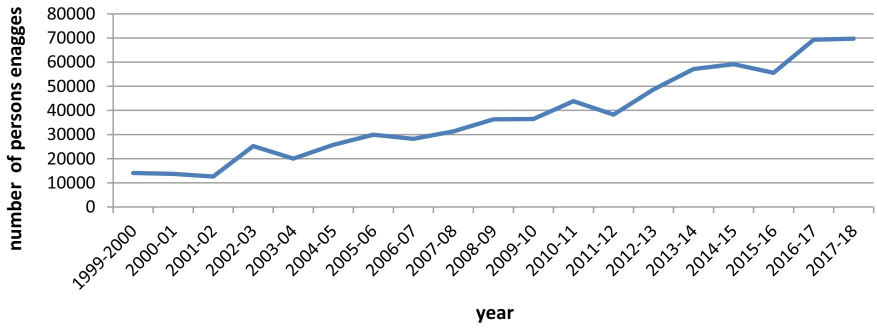

Fig. 4.3 Total number of persons engaged in the India medical devices industry. *Source* Author's explanation based on secondary data

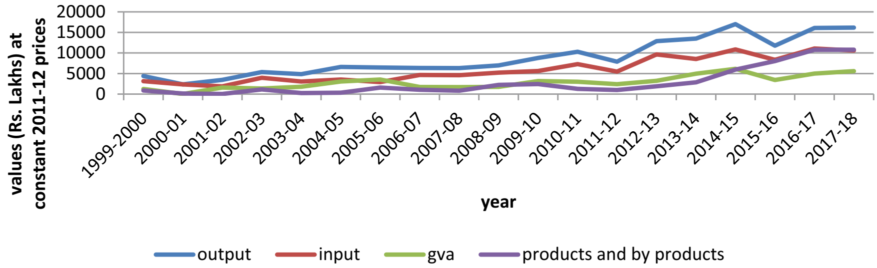

Fig. 4.4 Total output, GVA, total inputs used and the products and by-products produced by the medical devices sector in India 1999–2000 to 2017–18 (constant 2011–12 prices). *Source* Author's explanation based on secondary data

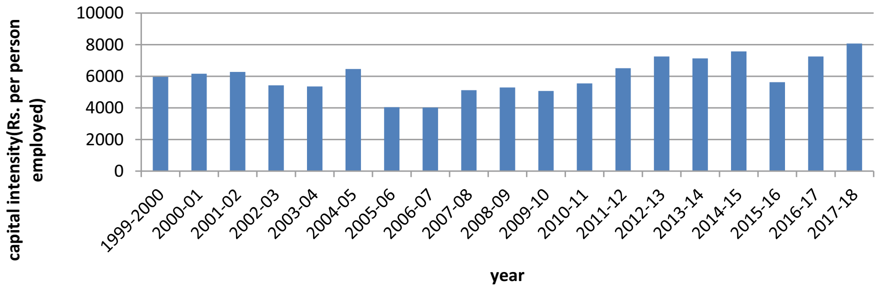

Fig. 4.5 Capital intensity of the Indian medical devices sector (Rs. Per person engaged). *Source* Author's explanation based on secondary data

(c) a medium enterprise where the investment in plant and machinery is more than 5 crore rupees but does not exceed 10 crore rupees.

Any enterprise that does not belong to any of the above groups is considered as large.

with their cumulative share being 43% in 2017–18, even though large units have increased their share from 5% in 2006–07 to 22% in 2016–17 (units for which data is not available are included in the residual group. It is very evident from the figure that data is not available for more than 30% of the total units.). The total count of people engaged in the manufacturing of devices in India increased from 14,000 in 1999–2000 to almost 70,000 in 2017–18. In 1999–2000, the sector produced output of Rs. 4393 lakhs and used up inputs worth Rs. 3149 lakhs, generating a gross value added of Rs. 1245 lakhs. In 2017–18, the values of output produced, inputs used and GVA generated were Rs. 16,173 lakhs, Rs. 10,599 lakhs and Rs. 5575 lakhs, respectively.[4] The capital intensity of (defined as the ratio of real fixed capital to that of total persons engaged) this sector has increased between 1999–2000 and 2017–18 in 1999–2000, the sector used fixed capital worth Rs. 5970 for every unit of labour which by 2017–18 rose to Rs. 8070, with the rise being significantly more prominent from 2009–10 onwards.

Figure 4.6 gives the share of medical devices in India's total organized industrial sector for total output produced, total number of persons engaged and the total number of units. In 1999–2000, device manufacturing units made up only 0.16% of the total which in 2017–18 rose to 0.33%. Similarly, in 1999–2000, the sector employed 0.25% of the total people and produced 0.30% of the total output produced by India's organized industrial sector. In 2017–18, these values correspondingly were 0.57% and 0.23%. In none of the three variables and for none of the years, has the share of this sector exceeded one—this makes it very evident that manufacturing medical devices in India is not very well developed an activity and occupies only a miniscule if not negligible position in the country's industrial sector.

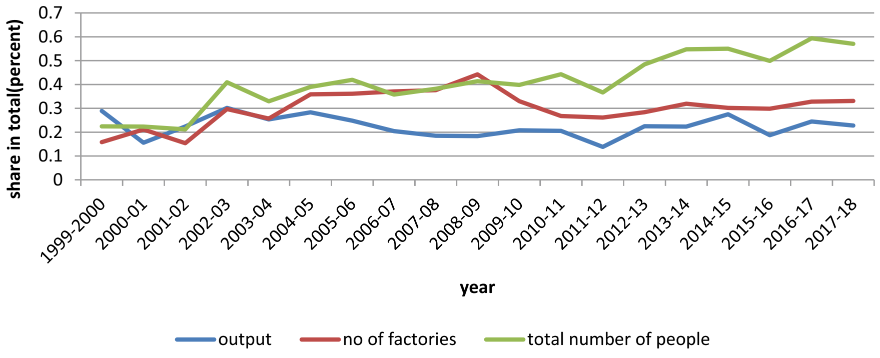

Fig. 4.6 Share of the medical devices sector in total organized industrial sector in India.[5] *Source* Author's explanation based on secondary data

[4] All values are at constant 2011–12 prices. Medical devices is a component of manufactured goods, and we have used the WPI for manufactured goods to deflate the values of output, inputs, GVA and products and by-products.

[5] Share of output is in nominal term.

Table 4.1 Share or medical devices in total products and by-products

Year	Value of total products and by products (Rs. Lakhs)	Value of medical devices (Rs. Lakhs)	Share of medical devices in the total products and by products
2011–12	696,489.5	492,756.8	70.7
2012–13	1,082,319	655,500.7	**60.5**
2013–14	1,081,406	796,619.3	73.7
2014–15	1,078,834	792,196.7	73.4
2015–16	883,398.7	657,383.7	**74.4**
2016–17	2,001,231	922,759.9	**46,1**
2017–18	1,244,067	885,888	**71.2**
Total	8,067,744	5,203,105	**64.5**

Source Figures from ASI unit-level data

Table 4.1 gives the share of medical devices in the value of total products and by-products produced by firms in this sector. Analysis at the product level using the NPCMS codes shows that of the total value of products and by-products that the industry manufactured between 2011–12 and 2017–18, only 64.5% can be classified as medical devices. The rest 35% are items that cannot be considered as medical devices. This suggests that units in this sector manufacture other products besides devices, i.e. to say, devices make up only a part of the total production basket for units in this sector. This, together with the fact that this sector in India remains mainly dominated by small and medium firms and occupies a miniscule if not negligible place in India's total organized industrial sector in terms of both output produced as well as employment generated, makes us conclude that manufacture of devices in India remains an activity that is underdeveloped and lacks coherent definition.

4.4 Domestic Production Profile of Medical Devices Sector in India

This section attempts to understand the production profile of the Indian medical devices sector, i.e. the type of devices that are being manufactured. This becomes important given the use based and technological heterogeneity that characterize the products of this sector.

Figure 4.7 gives the use-based classification, while Fig. 4.8 gives the technology-based classification of the products and by-products produced by the Indian medical devices sector.[6] As is evident from Fig. 4.7, production has fluctuated for most groups, especially till 2007–08. To start with, in 1999–2000, with a share of more

[6] The GVA or total output as tabulated by the ASI includes the incomes from services, value of electricity generated and sold and the sale value of goods sold in the same condition as purchased.

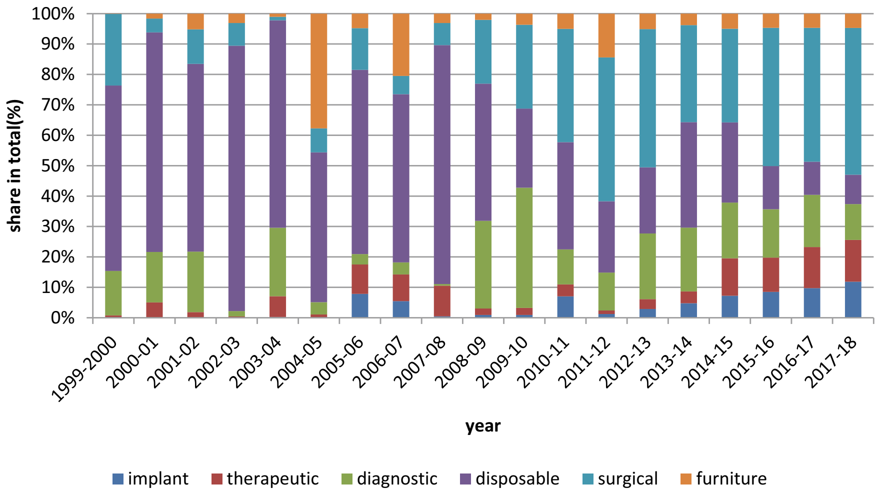

Fig. 4.7 Use-based composition of products and by-products. *Source* Author's explanation based on secondary data

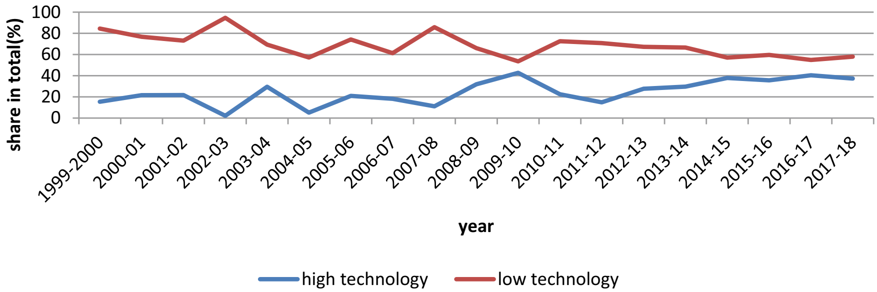

Fig. 4.8 Technological composition of products and by-products. *Source* Author's explanation based on secondary data

than 60%, disposables was the most dominant in the total products produced followed by surgicals with a share of 24% and diagnostics with a share of 15%. Therapeutics, implants and furniture had negligible presence. Disposables continued to remain the largest group of devices manufactured till 2008–09. In 2009–10, diagnostics held the highest share, while starting from 2010–11 till 2017–18, surgicals has remained the most dominant group. Its share in total products increased from 24% in 1999–2000 to 49% in 2017–18, while that of disposables fell from 61 to 10% during the same period. The production of therapeutics and implants has seen considerable increase

These, even though are relevant at the level of an industry, become irrelevant and difficult to determine at the product level. For this section, thus, we use the total value of products and by-products instead of the total output or the GVA.

between 1999–2000 and 2017–18, with therapeutics holding a share of 14% and implants 12% in the total products and by-products.

That the manufacturing for devices in India has always remained dominated by low technology products like disposables and surgicals is evident from Fig. 4.8. In 1999–2000, these made up close to 85% of total products, and with furniture having a negligible share, the remaining 15% consisted of medium-to-high-technology products like therapeutics, implants and diagnostics. Between 1999–2000 and 2017–18, the production of medium-to-high-technology goods has increased resulting in the share of this to reach 41% in 2016–17 followed by a slight decline, to 37% in 2017–18. The corresponding share of low-technology group has fallen to 58% in 2017–18, with the remaining 5% being held by furniture. Evident from Fig. 4.8 is the closing down of the gap between the shares of high- and low-technology groups even though till now, the latter far exceeds the former.

4.5 Import–Export Profile of Medical Devices to and from India

Cross-border movements can be a potential source of information regarding the pace at which technological innovations developed abroad are transferred to India and the appropriateness of such transfers. Analysis of international trade data also yields insights to understand domestic production which complements the analysis of the previous section, primarily for two reasons: first, the ASI data only incorporates factories that are covered by the Factories Act 1951, i.e. to say only firms in the organized sector. We do not get any information about firms that may be engaged in manufacturing activities in the informal sector. Further, for firms manufacturing devices, as seen from the previous section, a significant proportion of the total output cannot be classified as devices. This indicates that for products where there are significant overlaps in terms of manufacturing skills and resource requirements, firms that manufacture devices primarily, might also manufacture non-device items, i.e. the industry lacks coherent definition. With this happening in the organized sector firms, it might as well be the case that some firms in the informal sector manufacture products that can be classified as devices. This is even more plausible given that the sector is dominated by small and medium firms. Thus, incorporating the output of such firms from the unorganized sector in the analysis becomes imperative. In the absence of data for such unorganised sector firms, international trade data can act as a proxy. Secondly, the ASI is an activity classification, and with devices sector being very heterogeneous in its coverage, even at the most disaggregated level of analysis, the ASI data does not always give a very clear understanding of the underlying products. International trade data, which is available at product level, is much more robust and at the most disaggregated level, may provide insights, which when combined with that of domestic production can yield better conclusions.

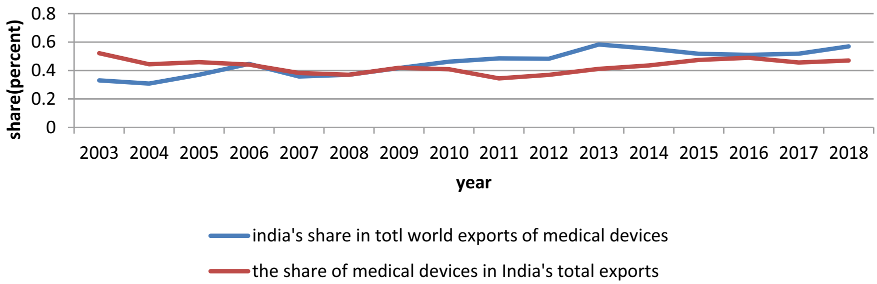

Fig. 4.9 India's share in total world exports of medical devices and the share of medical devices in India's total exports (in percent). *Source* Own calculations from UN Commodity trade

Fig. 4.10 Import, export and trade balance of medical devices industry India 2003–2018 at constant 1999–2000 prices. *Source* Own calculation from UN COMTRADE database

Figure 4.9 gives us India's share in total world exports of medical devices and the share of medical devices in India's total export basket during 2003 to 2018. India's share in global exports of devices has been negligible and has more or less remained constant, having increased marginally from 0.3% to around 0.6%. In India's total export basket, the share of medical devices was 0.5% in 2003. This declined between 2003 and 2017, to reach 0.48% in 2018. Evidently, medical devices represent a minuscule, if not negligible component of India's export basket, and India has marginal presence in total world export of devices.

Figure 4.10 gives the values of medical device imports to and exports from India during 2003–2018. The nominal values have been normalized using the import and export price indices (base 1999–2000) published by the RBI.[7] Very evident from the figure is the increase in imports and exports of devices to and from India. Between 2003 and 2018, total trade in medical devices (imports and exports together) increased by over 400% in nominal terms and close to 200% at constant 1999–2000 prices.

[7] For exports, there is no separate index that mentions medical devices/equipments specifically. So, we use that for electrical machinery, apparatus, appliances and electrical parts. For imports, we use the index for electro-diagnostic apparatus for medical and radiological apparatus which is a constituent component of electrical machinery, apparatus, appliances and parts.

With imports having exceeded exports for all years, India has seen a persistent trade deficit in medical devices.

To understand the regional pattern of trade in this sector, we calculate a regional intensity index

$$\text{EI} = \text{Sir}/\text{Siw}$$

where $\text{Sir} = \text{Xir}/\sum \text{Xir}$.

India's export/import of a product to/from a destination region *r* divided by India's total manufactured exports/imports to/from the region *r*.

And,

$$\text{Siw} = \text{Xiw}/\sum \text{Xiw}$$

India's export/import of the product to/from the world divided by India's total manufactured exports/imports to/from the world.

The index EI indicates whether or not India's export or import of the particular product is under represented or biased against a given region r relative to India's export/import of the same product to/from the world. A value exceeding one indicates that the share of the particular product in India's total manufacturing exports/imports to/from a given region exceeds its share in India's total manufactured exports/imports to/from the world; values less than 1 are suggestive of unexploited export/import potential for India.

EI for exports is calculated for two periods, 2016–17 and 2006–07, and is given in Table 4.2, while the EI for imports is only for 2016–17 and is given in Table 4.3.

The extensive margin reported in Tables 4.2 and 4.3, for each of the destination regions is defined as follows.

Extensive margin for destination region r = Number of HS 6 digit codes with EI > 1 for region r/Total number of HS 6 digit codes.

For example, for Europe in 2016–17, total number of HS codes with EI > 1 is 16. So, the extensive margin is calculated as 16/41 ~ 39%.

We see that between 2006–07 and 2016–17, the extensive margin for medical devices exports from India has reduced for Europe, Asia and Latin America and has increased significantly for Africa and North America. In 2016–17, Africa was the most over represented region in Indian exports of medical devices. This implies that exports of devices from India are increasingly shifting their markets towards North America (mainly the USA) and countries in Africa.

For imports in 2016–17, we find that the extensive margin is the highest for North America followed by that of Europe, suggesting that India's imports of medical devices are coming mostly from these two regions. This is expected given that USA together with the EU is responsible for close to two-third of the total exports for most of the device categories, globally. Further, most of the global majors in this sector are headquartered in the USA or in European nations like Germany and Netherlands.

Table 4.2 Extensive margin and number of products at HS 6 digit level where EI > 1 for Indian medical device exports

EI > 1 for exports 2016–17						EI > 1 for exports 2006–07					
Group	Europe	Asia	Africa	North America	Latin America	Group	Europe	Asia	Africa	N. America	Latin America
Disposable	5	1	8	2	5	Disposable	6	1	7	2	6
Surgical	4	3	6	3	2	Surgical	5	0	6	2	5
Diagnostic	3	0	4	3	1	Diagnostic	4	6	1	4	3
Implant	2	2	3	3	1	Implant	5	1	2	1	4
Therapeutic	2	2	6	4	2	Therapeutic	6	1	5	1	3
Total	16	8	29	15	11	Total	25	9	21	11	20
Extensive margin	39.2	19.5	70.7	36.6	26.8	Extensive margin	60.9	21.9	51.2	26.8	48.7

Source Author's own computation based on secondary data

Table 4.3 Product codes at HS 6 digit level where EI > 1 for India's import of medical devices 2016–17

Group	Europe	Asia	Africa	North America	Latin America
Disposable	6	2	0	6	3
Surgical	6	2	0	6	2
Diagnostic	5	3	0	9	0
Implant	6	0	0	6	1
Therapeutic	6	1	0	6	2
Total	29	8		33	8
Extensive margin	70.7	19.5	0	80.4	19.5

Source Author's own computation based on secondary data

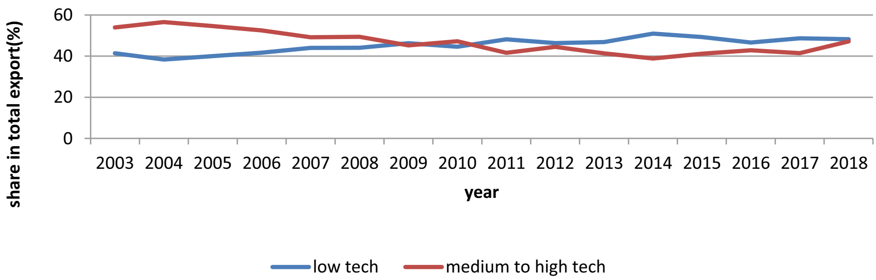

Fig. 4.11 Technological grouping of total exports 2003–2018. *Source* Own calculations from UN COmtrade

Figure 4.11 gives the technological composition of the total exports between 2003 and 2018. As is evident, between 2003 and 2010 (except 2008), the share of medium-to-high-technology group has been higher than that of low technology, while after 2010, it has been the opposite, with low-technology items dominating the total export basket. Figure 4.12 gives the technology grouping of devices imports to India. Medium-to-high-technology products have dominated Indian imports of devices in all years between 2003 and 2018, except, 2005–2008. 2008 onwards, with a fall in the share of low technology and a rise in the share of the high-technology group, the gap between the two is seen to be widening.

The RCA index developed by Balassa in 1965 can be used to understand the relative export performance of any country in the global market for any specific product. The country is said to have a RCA in that particular product's export when the share of that product in the country's total exports is larger than the share of that product in total world export, resulting in an RCA value that exceeds one. When a country has a RCA in any product, it is taken to be a competitive producer and exporter of that product relative to any other country that is producing that well at or below the world average.[8] A RCA in any product signals export strength of the

[8] https://unctadstat.unctad.org/EN/RcaRadar.html.

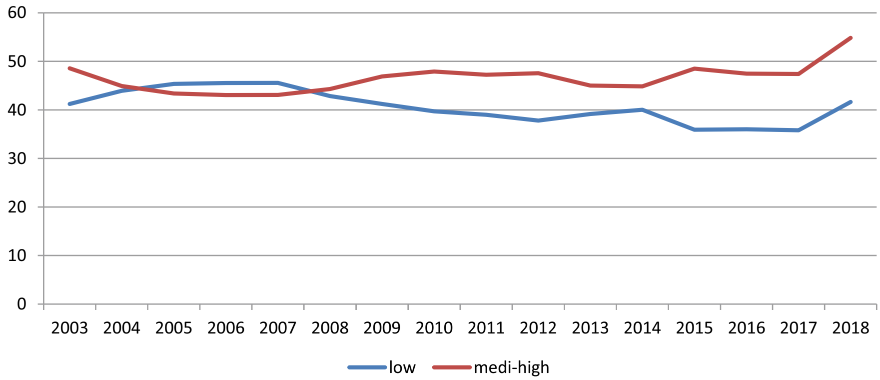

Fig. 4.12 Technology grouping of items in total imports.[9] *Source* Author's explanation based on secondary data

country in that particular product. In mathematical terms, RCA is calculated using the formula

$$\mathrm{RCA}_{ij} = \left(x_{ij}/X_{it}\right)/(x_{wi}/X_{wt})$$

where x_{ij} and x_{wj} are the values of country *i*'s exports of product *j* and world exports of product *j*, and where X_{it} and X_{wt} refer to the country's total exports and world total exports.

We here calculate the RCAs for India at three points of time—2003, 2016 and 2017. There was a revision of the HS codes in 2017. To ensure continuity, RCAs are also calculated for 2016, in addition to 2017. The calculations are done at the 6 digit HS level. Depending on the RCA values, we characterize the products in any of the following groups:

(i) Classic products—a product is a classic, if the country had a RCA in it in 2003 and also had a RCA in it in either 2016 or 2017
(ii) Disappearing products—a product in which the country had a RCA in 2003 but not in 2016 or 2017
(iii) Emerging products—a product in which the country had no RCA in 2003 but had a RCA in 2016 or 2017.

Table 4.4 gives the RCA analysis for medical devices. The highest RCA in 2003 as well as in 2017 has been in sheath contraceptives followed by X-ray tubes. While the former is clearly a labour-intensive product belonging to disposables, X-ray tubes even though high technology are intermediate goods and are based on technology that has been in existence for long. Disappearing products include apparatus based on UV and IR rays, X-ray-based apparatus, MRI apparatus and ultrasonic scanning apparatus, while the emerging ones include spectacle lenses of materials other than

[9] in excel sheet india new import total spectacle 28.4.20.

Table 4.4 Medical devices in which India had RCA in 2003, 2016 and 2017

Commodities in which India had RCA in 2003 and 2017/2016-classic	Technological classification	Products in which India had RCA only in 2003-disappearing	Technological classification	Products in which India had RCA in 2016/2017-emerging	Technological classification
Sheath contraceptives (401410)	Disposables	UV and IR apparatus, parts and accessories (901820)	Diagnostic	Carriages for disabled persons (871310)	Medical furniture
Surgical and medical gloves (401511)	Disposables	Apparatus based on X-ray (902214)	Diagnostic	Spectacle lenses of materials other than glass (900150)	Therapeutic
Parts and accessories of carriages for disabled persons (871420)	Medical furniture	Ultrasonic scanning apparatus (901812)	Diagnostic	Residual group of instruments used in dental science (901849)	Surgical
Spectacle lenses of glass (900140)	Therapeutic	Residual group (includes parts and accessories and x ray examination tables etc.-902290)	Diagnostics	Electro cardiographs (901811)	Diagnostic
X-ray tubes (902230)	Diagnostic	MRI imaging apparatus (901813)	Diagnostic		

Source Calculations done from UNCOMTRADE database

glass and carriages for disabled persons, electro-cardiograph and the residual group of of instruments used in dental sciences. In 2017, classic products made up 12.5% of total medical device exports from India, while disappearing and emerging products had shares of 13% and 11.5%, respectively. This is to say that products in which India has lost her advantage have a greater share in the total value of exports than those in which advantage has been gained or those in which advantage has been maintained during 2003–2018. The technological classification suggests that while all the disappearing products are mainly diagnostic devices, emerging ones are a mixed bag with medical furniture, therapeutics, surgical as well as diagnostic devices.

Table 4.5 Share of domestic production in the total market for medical devices in India

Year	High technology	Low technology	furniture	Total medical device sector
2011–12	26.8	87.3	49.2	60.4
2012–13	41.2	75.1	24.2	56.2
2013–14	42.7	78.3	19.7	57.6
2014–15	43.2	87.6	21.2	56.7
2015–16	37.6	80.4	16	50.5
2016–17	41.6	85.2	16.5	52.6
2017–18	40.5	80.2	66.5	58.2

Source Values of exports and imports taken from the Exim data bank of ministry of commerce; domestic production figures from ASI unit-level data

What is even more surprising is that the number of disappearing products is higher than that of emerging products, suggesting that between 2003 and 2017/2016, the medical devices sector in India has lost its competitive advantage in the export market.

Domestic production analysis in the previous section shows that in the last decade, medium-to-high-technology groups have increased their shares in total production, while the analysis above suggests that the contribution of this group in total exports has been falling while that in imports is on the rise. A rise in imports together with a rise in domestic production and a fall in exports may be attributed to a rise in the domestic demands for such high-value low-volume products in the recent past with increase in non-communicable diseases as well as increase in the coverage of the private healthcare facilities. The increase in imports in general, and that of the medium-to-high-technology products in particular, prima facie, suggests that there has been an increase in the scale at which internationally developed technology embedded in medical devices is being made available to the Indian patients. For example, the CT scanners and MRI scanners together accounted for 20% of total diagnostic imports in 2003, while in 2017, it rose to 35%. Similarly, artificial joints which had a share of less than 2% in total implants import in 2003, increased close to 30% in 2017. For pacemakers, the share in total implant imports rose from 15% in 2003 to around 20% in 2008, after which it fell to reach 5% in 2017. This may be due to increased domestic production of pacemakers in response to increased domestic demand in recent times as a response to a rise a in the numbers of coronary diseases.

Using data of domestic production together with that of international trade, one can generate an estimate of the supply as well as the size of the market. Likewise, the Indian market for devices can be calculated by adding net imports to domestic production.[10] Tables 4.5 and 4.6 show the share of domestic production in the total devices market in India, as well as in the markets for the different technological groups.[11] In 2011–12, domestic production covered 60% of the total market for

[10] Adding imports to domestic production and subtracting exports from it.

[11] The values for exports and imports have been taken from the export import data bank, maintained by the department of commerce under the Ministry of Commerce and Industry. The values of

Table 4.6 Shares of domestic production in the total market for devices in India for individual devices (in %)

	Pacemakers	MRI and CT scanners	Orthopaedic and fracture appliances
2011–12	14.5	–	4.8
2012–13	27.7	1.7	9.8
2013–14	67.3	0.3	22.7
2014–15	5	2.5	42.3
2015–16	5.5	1	27
2016–17	15.2	13.2	35.6
2017–18	42.2	2.5	45.6

Source Values of exports and imports taken from the Exim data bank of ministry of commerce; domestic production figures from ASI unit-level data

devices which slightly reduced to 58% in 2017–18. In 2011–12, domestic production only addressed 27% of the market for medium-to-high-technology devices, while in 2017–18, its coverage increased to 40.5%. On the other hand, in 2011–12, over 87% of the market for low-technology goods was met by domestic production, while in 2017–18, the corresponding figure was 80.2%. It becomes very evident that dependence on imports for the medium-to-high-technology products has been h higher than that for low-technology devices. What also emerges from the table is that between 2011–12 and 2017–18, the share of domestic production in the total market of technology-intensive devices has increased—this does suggest that manufacture of such devices has been picking up in the very recent past in India. For example, locally manufactured pacemakers have increased their share in the Indian market from 14.5% in 2011–12 to over 42% in 2017–18—correspondingly that share of share of pacemakers in the import of implants reduced from 15% in 2003 to 5% in 2017, while in orthopaedic and fracture appliances, the domestic manufactures made up almost half of the total market in 2017–18, as compared to less than 5% in 2011–12. On the other hand, for MRI and CT scanners, only a very small share of the market is served by local production, and we still remain highly import-dependent. CT and MRI scanners accounted for 20% of total diagnostic imports in 2003. In 2017, this rose to 35%. This can be interpreted to suggest that the domestic sector in India is making an attempt to move up the value and technology chain of manufacturing, which even though significant remains sporadic and incomplete.

domestic production available from the ASI are in rupees, and thus to ensure parity, values of exports and imports have been converted from US$ to Indian rupees using the average annual exchange rate published by the RBI. The harmonization of NPCMS codes on which domestic production is based and the HS codes which international trade adheres to has been done using the concordance between the CPC and HS codes provided by the UN statistics division.

The ratio of exports to imports can be an indicator of competitiveness in the international markets and consequently of the scale and sophistication of the domestic manufacturing sector. For example, data suggests that in 2003, the exports of electrocardiographs was only 40% of the imports for the same. In 2017, the value of exports stood at more than 170% of the imports. Similarly, domestic production capacity for exports of items like orthopaedic and fracture appliances, artificial teeth, X-ray tubes and some electro-diagnostic apparatuses, together with more traditional products like catheters, syringes and needles, has risen in recent years, and such exports now constitute more than 40% of the value of imports. It might very well be the fact that much of such exports are of inferior quality or that they are just second-hand refurbished products, the analysis of which is beyond the scope of this dissertation. However, substantial quantity and sustained growth of such exports (over respective imports) may be taken to imply a move towards technological upgrading and increasing technological competitiveness of the domestic manufacturing in India. In contrast, the ratio of exports to imports for more sophisticated products like MRI and CT scanners, echo cardiographs, etc., continue to remain below 20, suggesting that exports and presumably the domestic production capability for these are either stagnant or are growing at very slow pace.

4.6 Discussions and Conclusions

The coverage of health insurance has remained very low in India accounting for a mere 15% in 2014 (NSS 71st round). As a result, large part of total healthcare expenditure needs to be financed out of pocket.[12] Such high dependence on out of pocket for healthcare financing can have catastrophic effects on the population including pushing people below the official poverty line—for example, in 2015, 8% of the population slipped below the poverty line due to such OOP health spending. The proportion of households bearing such catastrophic health expenditures over the years has increased more for the poor than the rich. The odds of such high expenditures are higher among households with older people as well as female-headed households in the rural areas.[13] Such findings suggest that reducing OOP in health care remains an important policy concern. The burden of diagnostic expenditures in total costs has increased between 1993–94 and 2018—from 4.9% to 11.4% for inpatient cases and 1.6% to 12.6% for outpatient cases.[14] The increase for the latter has been steeper than that of the former. Between 2006 and 2015, charges for diagnostic services like X-ray and USG increased by 100% (Dutta & Selvaraj, 2019). Sorensen et al. (2013) show that increased use of medical technology has been a reason behind the rising healthcare costs in the developed world.[15]

[12] https://www.who.int/bulletin/volumes/96/1/17-191759/en/.

[13] https://www.who.int/bulletin/volumes/96/1/17-191759/en/.

[14] Mahal and Karan 2006, Dutta and Selvaraj 2019; NSSO Social consumption in India health 2018.

[15] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3686328/.

This chapter made an attempt to analyse the medical devices sector in India in the period 1999–2000 to 2017–18, with particular reference to domestic manufacture and international trade, with an aim of understanding India's position in self-sufficiency of meeting the demands for medical devices. Given the limitation of space and time, we limited ourselves to an analysis of primarily the supply-side dynamics. We find that manufacture of devices remains an underdeveloped activity occupying only a miniscule if not negligible part in total organized sector manufacturing in India. A further disaggregated analysis at the product level shows that domestic manufacture of devices has always remained biased towards low-technology products belonging to disposables and surgicals, although, it is evident that in the 18 years period between 1999–2000 and 2017–18, production of items belonging to medium-to-high-technology group like therapeutics, diagnostics and implants have picked up. On the trade part, we find that both exports and imports of devices have seen significant increase during the period of our study. In terms of technological ranking, however, imports coming to India remain primarily biased towards technology-intensive items, while Indian exports mainly comprise low-technology, low-value and high-volume products like surgicals and disposables. What also becomes evident from harmonization of the trade and domestic production data is that India remains much more biased towards imports for meeting her market needs of technology-intensive devices than for the needs of low-technology items—in fact for the latter, we almost are self-sufficient. That, a move towards manufacture of technology-intensive devices, has even though significant been incomplete, is evident from the variation in import dependence across technology-intensive products. For items like pacemakers and orthopaedic appliances, coverage of domestic manufacture has increased significantly between 2011–12 and 2017–18, while items like MRI and CT scanners continue to remain highly dependent on imports. This together with the fact that India has lost her RCA in medical devices during our period of analysis, especially on technology-intensive devices, seems to suggest that a lot more needs to be done to not only meet the domestic need of affordable devices, but also to establish the local industry in the global market.

Increased domestic production together with increased imports is suggestive of increased supply of devices in the local market. Corroborating evidence from the demand side, though incomplete and not device specific, available from the NSSO surveys shows that proportion of people getting benefits of specific services like X-ray or USG or ECG has increased in the last few decades and that the burden of expenditures on such diagnostic services has increased simultaneously for both hospitalization as well as outpatient cases. Such increased demand arising from better access to and greater diffusion of technology, balanced by matching supply, either from domestic manufacture or imports or a combination of both, is what is desirable for a well-functioning health system in a developing economy like India. What is of concern to India is the high dependence on imports for high-value technology-intensive products. Such dependence simultaneous with limited local manufacturing capacity can escalate the already increasing burden of diagnostic expenditures which in turn can impede accessibility of such technology to the masses. With the healthcare market, mostly that of devices being price sensitive in country like ours, increasing domestic manufacture and replacing imports by local goods is necessary not only for attaining self-sufficiency, but also for controlling inflation in the healthcare access. What the government needs to do is to guide the development of the devices sector through targeted policies, as was done to pharmaceuticals in the period 1970s onwards.

Appendix 1

See Tables 4.7, 4.8 and 4.9.

Table 4.7 The NIC code list according to the 2008 classification that we have considered as medical device

NIC code 2008	Definition
26600	Manufacture of irradiation, electro-medical and electro therapeutic equipment. This includes devices like MRI scanners, CT scanners, medical ultrasound equipments, pacemakers, hearing aids, etc
21006	Manufacture of medical impregnated wadding, gauze, bandages, dressings, surgical gut string, etc
30922	Manufacture of invalid carriages with or without motor
32501	Manufacture of dental fillings and cements (except denture adhesive or cement), dental wax and other dental plaster preparations; manufacture of dental laboratory furnaces, dental instruments, artificial teeth, bridges, etc., made in dental
32502	Manufacture of laboratory apparatus like laboratory ultrasonic cleaning machinery, laboratory sterilizers, laboratory type distilling apparatus, laboratory centrifuges, etc
32503	Manufacture of medical, surgical, dental or veterinary furniture such as operating tables, examination tables and dentists' chairs
32504	Manufacture of bone plates and screws, syringes, needles, catheters, cannulae, etc
32505	Manufacture of orthopaedic and prosthetic devices
32506	Manufacture of measuring instruments such as thermometers
32509	Manufacture of other medical and dental instruments n.e.c

*The NIC Code 32507 has not been included in the analysis. In NIC 2008, 32507 refers to the manufacture of ophthalmic goods, eyeglasses, sunglasses, lenses ground to prescription, contact lenses, safety goggles, etc. Of these, only contact lenses and prescription lenses come under the classification of medical devices, while the others do not. Since we do not have any way of knowing the contribution of only contact lenses and prescription lenses in total 32507, we neglect this subclass from our definition of medical devices sector in India

Table 4.8 Corresponding NIC 2004 codes

NIC code 2004	Definition
33111	Manufacture of apparatus based on the use of X-rays or alpha, beta or gamma radiations, whether or not for use in human or animal medicine. Included is the manufacture of X-ray tubes, high tension generators, control panels, desks, screens and the like
33112	Manufacture of instruments and appliances used in medical, surgical, dental or veterinary practice, including electro-diagnostic apparatus such as electrocardiographs, dental drill engines, ophthalmic instruments including sight testing sets, syringes, needles used in medicine and the like
33113	Manufacture of sterilizers
33114	Manufacture of mechano-therapy appliances; massage apparatus; artificial respiration or other therapeutic respiratory apparatus; other breathing appliances and gas masks other than simple protective masks
33115	Manufacture of orthopaedic appliances including crutches, surgical belts and trusses, orthopaedic corsets and shoes; splints and other fracture appliances; appliances worn, carried or implanted, e.g. hearing aids or pace makers, etc
33116	Manufacture of artificial teeth, artificial limbs and other artificial parts of the body
33119	Manufacture of other medical and surgical equipment and orthopaedic appliances, n.e.c
35922	Manufacture of invalid carriages, whether or not motorized or otherwise mechanically propelled
24236	Manufacture of surgical dressings, medicated wadding, fracture bandages, catgut and other prepared sutures

Table 4.9 List of NPCMS codes included in the analysis and their definitions

NPCMS codes	Definition
4814000	Medical, laboratory or surgical sterilizers
4815099	Other instruments and appliances used in medical, surgical or veterinary sciences (including syringes, needles, catheters, cannulae, ophthalmic instruments and appliances n.e.c. and electro-medical apparatus)
4813000	Other instruments and appliances (except syringes, needles and the like), used in dental sciences
3529007	Ceasure, forceps and other surgical tools
3529037	Shadowless lamps, c-arm and other o.t. apparatus
3529042	Stitching needles
3529043	Stitching threads (absorbable)
3529001	Adhesive tape medicinal
3529005	Bandage including adhesive tape bandage
3529008	Condoms
3529011	Copper-t (contraceptive)

(continued)

Table 4.9 (continued)

NPCMS codes	Definition
3529012	Cotton wool medicinal
3529004	Artificial limbs/orthopaedic supportives
3529005	Bandages including adhesive tape bandages
3529006	CT and MRI imaging machines and their parts
3529013	Dental cement and dental fillings
3529017	Drip stand table and other hospital furniture
3529018	ECG, EEG machines and their parts
3529028	Medicated tapes, band aids, etc
3529030	Metal beds/o.t. tables for hospitals
3529031	Other appliances for hospital use
3529032	Pacemaker
3529048	X-ray machines and parts
3529049	Stents
4992201	Invalid carriages non-motorized
4992203	Wheel chair with paddle
4992204	Wheel chair without paddle
4992299	Other invalid carriages
4811000	Apparatus based on the use of X-rays or of alpha, beta or gamma radiations
4812100	Electro-diagnostic apparatus, used in medical, surgical, dental or veterinary sciences
4812299	Ultraviolet or infra-red ray apparatus, used in medical, surgical, dental or veterinary sciences n.e.c
4813000	Other instruments and appliances (except syringes, needles and the like), used in dental sciences
4815015	X-ray tube
4816000	Mechano-therapy appliances; massage apparatus; psychological aptitude-testing apparatus; ozone therapy, oxygen therapy, aerosol therapy, artificial respiration or other therapeutic respiration apparatus; other breathing appliances and gas masks
4817100	Orthopaedic appliances; splints and other fracture appliances; artificial parts of the body
4817200	Hearing aids and other appliances which are worn or carried, or implanted in the body, to compensate for a defect or disability
4818000	Medical, surgical, dental or veterinary furniture; barbers' chairs and similar chairs, having rotating as well as both reclining and elevating movements
3544004	Artificial tooth

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Chapter 5
Impact of Climate Change on Agriculture: Empirical Evidence from South Asian Countries

Bipradas Rit

5.1 Introduction

Long-term changes in the average weather conditions which are unique combinations of factors like temperature, precipitation, and wind denote climate change. Since time immemorial, climate variability, and change have triggered natural disasters and climate extremes causing heavy losses of life and property (Salinger, 2005). Climate change due to human activities, higher variability of climate, and pollution of air and water will threaten our survival needs. The historical records show that our climate has changed in the past and will continue to vary and change during the coming decades (Jarraud, 2005). According to the National Oceanic and Atmospheric Administration (NOAA, 2009), there are ten main indicators of climate change. Seven of these indicators (tropospheric temperature, temperature over oceans, sea surface temperature, oceanic heat content, temperature over land, sea level, and humidity) are expected to increase, and three indicators (glaciers, snow cover, and sea ice) should show a declining trend. Intergovernmental Panel on Climate Change (IPCC) reports indicate that our climate is undergoing significant change as a result of day-to-day increasing greenhouse gas emissions. Global warming and climate change are results of continuously rising global average temperatures. Over the last millennium, the climate has varied by as much as 1 °C globally (IPCC, 2001). The current rate of global warming is 2 °C per century (Salinger, 2005). The IPCC (2001) projection shows that by the end of the twenty-first century the global temperature increase may be in the range of 1.4–5.8 °C with events like an increase in heavy rainfall. The Fifth Assessment Report of IPCC (2013) revealed that the atmospheric concentration of greenhouse gases like carbon dioxide (CO_2), methane, nitrous oxide has increased by about 40%, 150%, and 20%, respectively, since 1850. IPCC is producing the Sixth Assessment Report (AR6) which is expected to be released in 2022.

B. Rit (✉)
Economics, Jogesh Chandra Chaudhuri College, Kolkata, India

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Among the greenhouse gases, CO_2 accounts for about 76% of total greenhouse gas emissions according to the Centre for Climate and Energy Solutions report. Burning fossil fuels generates the largest share of greenhouse gas emissions. When CO_2 is released into the atmosphere from burning fossil fuels, approximately 50% remains in the atmosphere, 25% is absorbed by land plants and 25% is absorbed into certain areas of the ocean (NOAA, 2017 data). As agriculture and forestry directly depend on climate and weather, these two sectors are widely studied in the context of climate change. Climate change can affect agriculture in two ways; firstly, it can have an adverse effect due to changes in precipitation, temperature, and soil fertility, and secondly, increased level of CO_2 in the atmosphere may have a direct positive effect on agriculture due to the carbon fertilization effect. Earth's vegetable lands have shown significant greening since the early 1980s largely due to rising levels of atmospheric CO_2 (Hille, 2016). But CO_2 fertilization is unlikely to reduce human-made CO_2 concentration over the next century (Krischbaum, 2011). Agricultural productions in lower-latitude and lower-income countries are more likely to be negatively affected by climate change, whereas mid- and high-latitudes will experience increases in crop yield (IPCC, 2001). Climate change can produce positive or negative effects on agriculture depending on the region and the ways the climate changes; for example, Northern Europe is likely to benefit from warming and the direct effect of increasing CO_2, whereas southern Europe may see lower yield and higher yield variability (Mohta & Wolfgang, 2005). Chogyel and Kumar (2018) observed that global warming-induced climate change impacts have already been felt and may intensify in future in agriculture of Bhutan. Praveen and Sharma (2019) examined the climate sensitivity of Indian agriculture using panel data for the period 1967–2016 and found that climate variables have differential impacts on the growth rate of yield of different crops.

Different studies have attempted to evaluate the impact of climate change on agriculture. Two types of crop weather models are generally used to relate crop variables to meteorological variables. First, empirical statistical models which relate similar crop yield data to a sample weather data for the same area and time period, using statistical techniques such as regression analysis. The second is crop simulation models, which express the dynamical relationship of crop growth such as photosynthesis, respiration, and environmental and management factors such as climate, soils, and cultivation practices (Das et al. 2019). Sivakumar et al. (2005) observed that anticipated climate change and the associated impacts on water resources and agriculture in some regions of Asia, Africa, and Latin America would increase uncertainty to the agricultural system. Modeling studies suggest that any warming above current temperatures will diminish crop yields in the tropics, while up to 2–3 °C of warming in the mid-latitudes may be tolerated by crops, especially if accompanied by increasing precipitation (Easterling and APPS 2005). In their review, Olesen and Bindi (2002) commented that the effects of climate change likely increase the productivity of European agricultural systems, because increasing CO_2 concentration will directly increase resource use efficiency of crops and because warming will give more favorable conditions for crop production in Northern Europe. Chaves et al. (2009) did not find any significant vulnerability of crop productivity and food security to changes in climate in their simulation study. Their study indicates crop productivity in eastern China is expected to increase with spatial variation linked to regional precipitation patterns. They found that yields of winter wheat would increase substantially, canola yields would remain constant, potato yields would decrease substantially and rice yields would decrease in inland and increase toward the coast. Mendelsohn (2014) used the Ricardian method to estimate farm climate sensitivity where each farmer wishes to maximize income subject to the exogenous conditions of their farm. The results of his study revealed that warming would cause damages to Asian agriculture; a 1.5 °C warming would reduce crop net revenues by 13% or US$93 billion per year. But due to the beneficial effect of carbon dioxide fertilization, an increase in temperature by 1.5 °C would lead to a gain of 3% (US$18 billion per year). India is expected to suffer two-thirds of Asia's total losses. He acknowledged 'there remains uncertainty around all estimates of what might happen in 2100.' In another study (Mendelsohn, 2009) for developing countries, he found that marginal warming would cause damages to crop production in Africa and Latin America. Low-altitude countries will be adversely affected if climate scenarios turn out to be relatively hot and dry. But these countries may suffer minor damage or may get the beneficial effect if climate scenarios turn out to be relatively mild and wet. Kumar et al. (2004) estimated the functional relationship between farm-level net revenue and climate variables. They found that the temperature increase had a significant negative impact while higher precipitation had a positive impact on net revenue, but the negative impact was much more than the small positive impact. By applying the Ricardian method, Shakoor et al. (2011) found that increase in temperature has significantly reduced net revenues and a net loss of revenue is also expected in the future in the arid region of Punjab.

Though the researchers use advanced statistical tools to predict what would happen in the future, there remains uncertainty around all estimates. The agricultural sector may or may not grow as expected. The carbon fertilization effect may not be the same as predicted in the laboratory experiments. Farmers may respond in different ways than the models predicted (Mendelsohn, 2014). Changes in precipitation and changes in irrigational facilities may change the predictions of the studies. Lobell and Gourdji (2012) observed that it will never be possible to unambiguously measure the effect of change in climate and CO_2 given the scale of food production and the fact that agriculture is always changing in multiple ways. According to them, climate change represents a valid threat to sustaining global productivity growth.

The above discussion shows that the effect of climate change on agriculture will vary from one region to another and within a country; it will vary from one area to another. The effects of climate change will be different on different crops. Moreover, there is uncertainty in all these estimates.

We shall now consider the studies made to find the evidence of the effect of climate change (increase in CO_2 emissions, a temperature rise) on agricultural production using the time series data. These studies are more relevant in the context of this study. Liu et al. (2017) attempted to explore the impact of per capita renewable energy consumption and agricultural value-added on CO_2 emissions on four countries, Indonesia, Malaysia, the Philippines, and Thailand for the period from 1970 to 2013. Their study showed increasing usage of renewable energy and agricultural value-added decreased CO_2 emissions, while nonrenewable energy was positively correlated with emissions. Asumadu-Sarkodie and Owusu (2016) studied the relationship among CO_2 emissions, GDP, energy use, and population growth in Ghana from 1971 to 2013 with the help of vector error correction and autoregressive distributed lag models. They found a two-way causality between energy use and GDP. Zhang et al. (2019) found agricultural energy consumption has both short-run and long-run negative impacts on agricultural carbon emissions in China for the period 1996 to 2015. They also found a two-way causality between agricultural carbon emissions and agricultural economic growth in both the short run and long run. A two-way causal relationship among GDP, energy use, agriculture, and CO_2 emissions was found by Gokmenoglu and Taspinar (2018) while investigating the long-run equilibrium relationship among CO_2 emissions, income growth, energy consumption, and agriculture in Pakistan for the period of 1971 to 2014. Ayinde et al. (2011) found temperature change had a negative effect while rainfall had a positive effect on agricultural productivity in Nigeria. An insignificant association between CO_2 emissions, land under cereal crops, and agricultural value added in Pakistan for the period of 1961 to 2014 was reported by Ali et al. (2019). Amponsah et al. (2015) found a significant negative link between CO_2 and cereal yield and a significant positive long-run and a short-run link between cereal yield and income in Ghana for the period 1960 to 2010. Dumrul and Kilicaslan (2017) found a positive effect of precipitation on agricultural GDP but a negative effect of temperature on agricultural GDP, while the increase vin temperature had affected agricultural GDP negatively in Turkey for the studied period 1961 to 2013.

From the previous discussion we are getting mixed results. In some cases, we have causal relation between the increase in CO_2 emissions or increase in temperature with GDP and agricultural output (or growth of agricultural output), and in some cases, we do not find any such relation. In some cases, CO_2 (or temperature) appeared to be a significant factor in explaining agricultural output, and in some cases, CO_2 is insignificant.

It is projected that climate change may adversely affect global food security in this century. Climate change is likely to impact the poor people of the world because they are more exposed to the weather. Income distribution will be much skewed due to the impacts of climate change in the near future and will deteriorate for more than a century (Tol et al., 2004). South Asia accommodated nearly half (48%) of the World's multidimensional poverty in 2017, and any adverse impact on agriculture will hurt South Asian countries very badly. If we see the average annual growth rate of per capita emission of carbon dioxide (CO_2) computed from the database World Bank, we can realize the grim situation. Per capita emission of CO_2 in the South Asian region is indeed very less compared to developed zones, but the average annual rate of growth of per capita CO_2 in our planet for the period 1960–2016 was 0.55%, but in the South Asian region, this rate is 2.06%. Before the year 2000, this rate of growth 0.54% which increased to 1.33% in the first 16 years of this millennium. South Asia performed very poorly compared to the world average. In South Asia, the annual average rate of growth of per capita CO_2 for the period 1960 to 2016 was 3.10%. In the period 1960 to 1999, this rate was 2.81% and increased to 4.30% from 2000 to 2016. Several countries in this region have reported increasing surface temperature trends in the recent decade. The warming trends over India and Sri Lanka have been reported to be about 0.57 and 0.30 °C per hundred years. Pakistan has a consistent rising trend of surface temperature since the beginning of the twentieth century (Sivakumar et al., 2005). IPCC (2013) report shows that the mean value of temperature rise by the end of the century in South Asia is 3 °C with a max–min range of 2.7–4.7 °C, which is higher than the global average.

Let us now look at some of the interesting facts of South Asian agriculture. South Asia is the most populous and most densely populated geographical area accommodating nearly 25% of the world's population with 3.5% of the world's land surface area (FAO). South Asia has the highest rate of agricultural land in total land area (nearly 50%) and the highest rate of irrigated land in total agricultural land (nearly 48%). It has the highest rate of irrigated land in all regions; 46% of total agricultural has irrigational facilities (UNFPA). Bangladesh and Pakistan have a larger proportion of irrigated land compared to the South Asian average. The value of agricultural production per hectare of agricultural land is highest in South Asia. But agricultural GDP per agricultural worker is second lowest in South Asia (higher than Sub Saharan Africa). In South Asia, agricultural area per agricultural worker is nearly one-fifth of the world average.

Among eight South Asian countries, agriculture contributed nearly 17% of total GDP, and accommodating 39% of the global poor in 2018, the adverse impact on agriculture is not very hard to realize. (World Bank, 2020a; b). We have selected five major economies of South Asia, Bangladesh, India, Nepal, Pakistan, and Sri Lanka, for inter-country comparison in this region. These countries together have a share of 99.24% of the total GDP of South Asia (at current year prices) and 97.4% of the total population (World Bank, 2020a; b). This study may provide an inter-country comparison in the region regarding the impact of climate change on agriculture.

5.2 Data

5.2.1 Data Sources

Data on real value added by agriculture, forestry, and fishing (AVA) measured in terms of US$ in fixed 2010 prices, per capita carbon dioxide emission (CO_2) in metric tons, land under the production of cereals (LC) in hectares are collected from World Bank central database (2020a; b). We have computed the per capita value of AVA (PAV) and per capita LC (PLC) by dividing AVA and LC by population of the corresponding years, respectively. Data on monthly average temperature (in °C) and monthly average rainfall (in mm) have been collected from the Climate Change Knowledge Portal of the World Bank (2020a; b). We have computed annual average temperature (TEM) and annual average rainfall (RN). All the variables are measured in natural log units. For data on rainfall and temperature of South Asia the average rainfall and temperature of five selected countries have been computed. We have used the first letter of the name of the country before the abbreviation of the series name to denote the series for the concerned country. For example, BPAV denotes the per capita value added by agriculture, forestry, and fishing. For Sri Lanka, we use L before the name of the variable to avoid the mix-up with South Asia (S).

5.2.2 Stationarity of Data

The time plots of the studied variables measured in the natural log are shown in Fig. 5.1. We have used the augmented Dickey–Fuller (ADF) test (Dickey & Fuller, 1979), Phillips–Perron (PP) test (Phillips &Perron, 1988), and KPSS test (Kwiatkowski et al., 1992) to detect the stationarity of a variable. The optimum lag length is determined on the basis of the Akaike information criterion (AIC) (Akaike, 1974) for the ADF test, based on Newey–West (Newey & West, 1994) for PP and KPSS tests. Generally, ADF and PP tests have very low power against I(0) alternatives that are close to being I(1). These tests cannot distinguish highly persistent stationary processes from non-stationary processes (Schwert, 1989). In the ADF and PP tests, the null hypothesis is that the time series is I(1), but in the stationarity test, the null hypothesis should be that the series is I(0). The most used unit root test is the KPSS test. But one major limitation of the KPSS test is that it tends to reject the null hypothesis too often. In our study, if all the tests show the same result, we shall accept that, but if the outcomes of the tests are ambiguous, we shall not conclude regarding the order of integration of the series. We shall look carefully at whether any series is I(2) from any of the three tests because methodology to be adopted in this study will depend on the order of integration of the variables. ARDL model cannot be applied if any variable is I(2). The results of unit root tests are shown in Table 5.1.

From Table 5.1, we see that some series are unambiguously I(0) like BRN, and I(1) like BPAV, but for some series, we are not sure like BCO_2. These series are either I(0) or I(1), but none of the series are I(2). In this type of situation, ARDL modeling and bounds testing are applied to know the long-run relationship among the variables. Among the variables, we shall give primary importance to the relationship between CO_2 and PAV, since CO_2 is the primary greenhouse gas emitted through human activities and it is primarily responsible for global warming and climate change. We shall look into the bidirectional causality between PAVA and CO_2 to see the direction of causality using the Granger causality test (Granger, 1969). If we reject the null hypothesis that 'CO_2 does not Granger-cause PAV,' we shall express PAV as a function of CO_2 and other control variables PLC and RN. If the direction of causality runs in another way, from PAV to CO_2 (when we reject the null hypothesis PAV does not Granger-cause CO_2), we shall express CO_2 as a function of PAV with other control variable PLC. If we see the direction of causality in both directions, we shall estimate both the functions to determine the relationship. If we do not

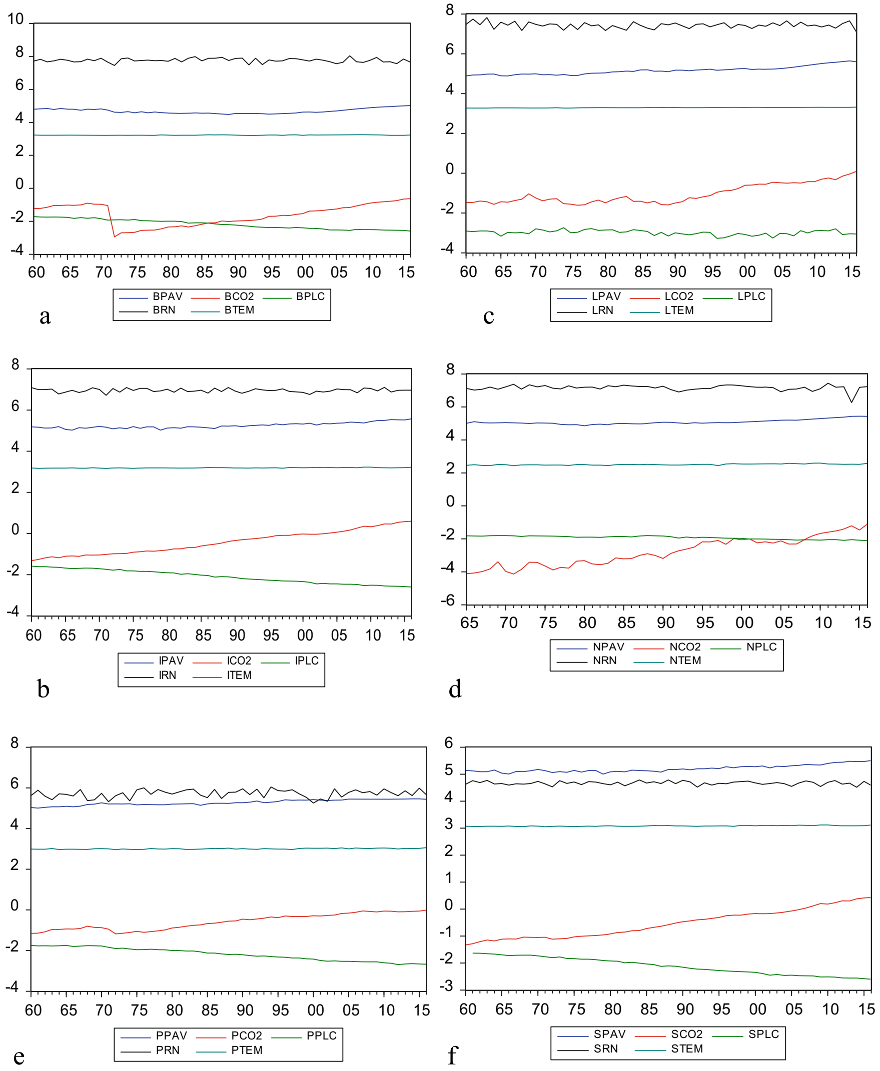

Fig. 5.1 Time plot of the study variables in South Asia and selected countries (in natural log). **a** Bangladesh, **b** India, **c** Sri Lanka, **d** Nepal, **e** Pakistan, **f** South Asia. *Source* World Bank Central Database

find causality in any direction between PAV and CO_2, we may again try to find out whether there is any significant statistical relationship among the variables. For the control variables, we do not check the bidirectional causality. We check the direction of causality from RN, PLC, and TEM to PAV and from PLC to CO_2. We shall not use TEM in our primary model since CO_2 is primarily responsible for the increase

Table 5.1 Results of unit root test (ADF, PP, and KPSS tests)

	ADF (level)	P value	ADF (first difference)	*P* value	PP (level)	*P* value	PP (first differnce)	*P* value	KPSS test statistic (level)	KPSS test statistic (1st difference)	Conclusion
BPAV	0.53	0.99	−3.79	0.03	0.46	0.99	−10.14	0.00	0.231	0.121	I(1)
B CO_2	−1.65	0.76	−7.91	0.00	−1.62	0.77	−7.92	0.00	0.215		I(1) or I(0)
BPLC	−2.41	0.37	−8.87	0.00	−2.31	0.42	−9.31	0.00	0.144		I(1) or I(0)
BRN	−8.18	0.00			−8.18	0.00			0.271		I(0)
BTEM	−4.59	0.00			−4.57	0.00			0.056		I(0)
IPAV	−2.73	0.23	−5.90	0.00	−3.68	0.051	−11.34	0.00	0.253	0.075	I(1)
ICO2	−1.52	0.81	−8.08	0.00	−1.61	0.77	−8.06	0.00	0.161		I(1) or I(0)
IPLC	−2.03	0.57	−10.61	0.00	−2.70	0.24	−11.38	0.00	0.133		I(1) or I(0)
IRN	−8.58	0.00			−8.58	0.00			0.061		I(0)
ITEM	−5.71	0.00			−5.67	0.00			0.053		I(0)
NPAV	−0.97	0.94	−9.56	0.00	−0.97	0.94	−9.71	0.00	0.229	0.502	I(1)
NCO_2	−3.55	0.04			−3.50	0.051	−12.89	0.00	0.087		I(1) or I(0)
NPLC	−2.67	0.25	−8.97	0.00	−2.60	0.28	−8.98	0.00	0.167		I(1) or I(0)
NRN	−3.54	0.01			−6.43	0.00					I(1)
NTEM	−5.58	0.00			−5.54	0.00				0.105	I(0)
LPAV	−2.12	0.52	−1.92	0.05	−1.65	0.76	−6.75	0.00	0.150		I(1) or I(0)
LCO_2	−3.55	0.04			−3.50	0.051	−12.89	0.00	0.087		I(1) or I(0)
LPLC	−4.52	0.00			−4.54	0.00			0.111		I(0)
LRN	−3.54	0.01			−6.43	0.00			0.220		I(0)
LTEM	−6.30	0.00			−6.25	0.00			0.065		I(0)

(continued)

Table 5.1 (continued)

	ADF (level)	P value	ADF (first difference)	*P* value	PP (level)	*P* value	PP (first differnce)	*P* value	KPSS test statistic (level)	KPSS test statistic (1st difference)	Conclusion
PPAV	−3.19	0.10	−9.09	0.00	−3.06	0.13	−9.07	0.00	0.068		I(1) or I(0)
PCO_2	−1.67	0.75	−5.76	0.00	−1.96	0.61	−5.84	0.00	0.111		I(1) or I(0)
PPLC	−3.09	0.12	−7.57	0.00	−3.11	0.12	−7.60	0.00	0.226	0.064	I(1)
PRN	−7.24	0.00			−7.34	0.00			0.164		I(0)
PTEM	−6.16	0.00			−6.14	0.00			0.081		I(0)
SPAV	−2.38	0.38	−5.87	0.00	−3.13	0.11	−23.31	0.00	0.256	0.074	I(1)
SCO_2	−1.19	0.90	−7.42	0.00	−1.35	0.86	−7.44	0.00	0.182		I(1) or I(0)
SPLC	−1.74	0.72	−9.99	0.00	−2.41	0.37	−10.48	0.00	0.135		I(1) or I(0)
SRN	−8.69	0.00			−8.76	0.00			0.153		I(0)
STEM	−5.31	0.00			−5.37	0.00			0.065		I(0)

Source World Bank central database. Author's analysis. *Notes* The number of observations (n) is 57. For all series, intercept and trend are included in the test equation except Rainfall (RN) where only intercept is included. The optimum lag length is determined based on the Akaike Information Criteria (AIC) for the ADF test, for the PP and KPSS tests, the lag is selected based on the recommendation of Newey–West (1994). For KPSS test, the critical value at 1% level is 0.216, for all series (with intercept and trend) and for rainfall (RN), it is 0.739 (with intercept only) in surface temperature. To check the robustness of our findings, we shall use TEM data.

The results of Granger causality tests are shown in Table 5.2. We can see unidirectional causality running from CO_2 to PAV for South Asia, India, Nepal, and Pakistan and from PAV to CO_2 in the case of Sri Lanka. For Bangladesh, we do not see any causal relation between PAV and CO_2. We see the direction of causality from PLC to PAV for South Asia, and all the countries we consider except Sri Lanka. We see the evidence of Granger causality from TEM to PAV for South Asia, Bangladesh, India, and Nepal, and from RN to PAV for India only.

5.3 Methodology

In this study, we assume PAV as a function of CO_2, PLC, and RN.

$$\mathrm{PAV}_t = f(\mathrm{CO}_{2t}, \mathrm{PLC}_t, \mathrm{RN}_t) \tag{5.1}$$

Since we do not have the data on fertilizer use for the entire period, we are unable to use fertilizer as an explanatory variable. This is valid for India, Nepal, Pakistan, and South Asia. The basic form of the ARDL (p, q, r, s) model is:

$$\mathrm{PAV}_t = \beta_0 + \sum_{i=1}^{p} \beta_i \mathrm{PAV}_{t-i} + \sum_{j=0}^{q} \alpha_j \mathrm{CO}_{2t-j} + \sum_{k=0}^{r} \gamma_k \mathrm{PLC}_{t-k} + \sum_{l=0}^{s} \delta_l \mathrm{RN}_{t-l} + \varepsilon_t \tag{5.2}$$

Here, the errors (ε_t) must be serially independent; otherwise, the estimated parameters will not be consistent. We shall check the serial correlation of the residuals by Breusch–Godfrey (Breusch, 1978; Godfrey, 1978) test for serial correlation in the residuals. In the Breusch–Godfrey test LM test statistic is calculated for the null hypothesis of no serial correlation. If we cannot reject the null hypothesis, we conclude that residuals are not serially correlated. We shall use Schwarz (Bayes) criterion to select the lag in the ARDL model (Eq. 5.2) for keeping our model simple but consistent. In the AIC criterion, there is always a chance of selecting an overfitted model. We shall now perform the 'bounds testing' (Pesaran et al., 2001) to see if there is any long-run relationship using the following unrestricted error correction model. From the above-estimated equation, we shall have lower and upper bounds on the critical values of the F statistic. The lower bound is based on the assumption that all the variables are I(0), and the upper bound is based on the assumption that all the variables are I(1). If the computed F statistic falls below the lower bound, we conclude that the variables are I (0), so cointegration is not possible. If F statistic is higher than the upper bound, we conclude that we have cointegration among the variables. If F-statistic falls between the bounds, we have an inconclusive result (Giles, 2013). If the bounds test rejects the null hypothesis of no level relationship among

Table 5.2 Results of bidirectional causality (Granger causality test)

Null hypothesis	F statistic	Lag (AIC criterion)	Conclusion
BCO_2 does not Granger-cause BPAV	1.574 (0.208)	3	H_0 not rejected
BPAV does not Granger-cause BCO_2	1.578(0.207)	3	H_0 not rejected
BPLC does not Granger-cause BPAV	18.172^{*} (0.00)	2	H_0 rejected
BRN does not Granger-cause BPAV	0.329 (0.568)	1	H_0 not rejected
BTEM does not Granger-cause BPAV	5.19^{**} (0.03)	1	H_0 rejected
ICO_2 does not Granger-cause IPAV	23.47^{*} (0.00)	1	H_0 rejected
IPAV does not Granger-cause ICO_2	1.626 (0.210)	1	H_0 not rejected
IPLC does not Granger-cause IPAV	4.198^{*} (0.01)	3	H_0 not rejected
IRN does not Granger-cause IPAV	12.241^{*} (0.00)	3	H_0 rejected
ITEM does not Granger-cause IPAV	5.39^{*} (0.01)	2	H_0 rejected
LCO_2 does not Granger-cause LPAV	1.576 (0.215)	1	H_0 not rejected
LPAV does not Granger-cause LCO_2	5.685^{**} (0.018)	1	H_0 rejected
LPLC does not Granger-cause LPAV	0.397(0.531)	1	H_0 not rejected
LPLC does not Granger-cause LCO_2	0.030 (0.863)	1	H_0 not rejected
LRN does not Granger-cause LPAV	0.508 (0.479)	1	H_0 not rejected
LTEM does not Granger-cause LPAV	0.04 (0.84)	1	H_0 not rejected
NCO_2 does not Granger-cause NPAV	5.570^{**} (0.022)	1	H_0 rejected
NPAV does not Granger-cause NCO_2	1.416 (0.240)	1	H_0 not rejected
NPLC does not Granger-cause NPAV	16.364^{*} (0.00)	2	H_0 rejected
NRN does not Granger-cause NPAV	2.432 (0.125)	1	H_0 not rejected
NTEM does not Granger-cause NPAV	7.31^{*} (0.00)	2	H_0 rejected
PCO_2 does not Granger-cause PPAV	11.260^{*} (0.00)	1	H_0 rejected
PPAV does not Granger-cause PCO_2	2.039 (0.160)	1	H_0 not rejected
PPLC does not Granger-cause PPAV	7.247^{**} (0.01)	1	H_0 rejected
PRN does not Granger-cause PPAV	0.023 (0.99)	1	H_0 not rejected
PTEM does not Granger-cause PPAV	1.21 (0.28)	1	H_0 not rejected
SCO_2 does not Granger-cause SPAV	22.748^{*} (0.00)	1	H_0 rejected
SPAV does not Granger-cause SCO_2	0.085 (0.780)	1	H_0 not rejected
SPLC does not Granger-cause SPAV	3.77^{**} (0.017)	3	H_0 rejected
SRN does not Granger-cause SPAV	1.810 (0.174)	2	H_0 not rejected
STEM does not Granger-cause SPAV	3.24^{**} (0.047)	2	H_0 rejected

Source World Bank central database. Author's analysis. ** and * denote significance at 0.05 and 0.01 levels, respectively. The numbers in parentheses are the p values the variables, we shall estimate the long-run equilibrium relationship among the variables in level to see whether CO_2 or other variables are significant in explaining PAV. We shall estimate the long-run level equation as:

$$\mathrm{PAV}_t = c + a\mathrm{CO}_{2t} + b\mathrm{PLC}_t + d\mathrm{RN}_t + \in_t \tag{5.3}$$

Finally, we shall estimate the error correction model to estimate the speed of adjustment to equilibrium in a cointegrating relationship by the following equation:

$$\begin{aligned}\Delta\mathrm{PAV}_t &= \mu + \sum_{i=1}^{p-1} \eta_i \Delta\, \mathrm{PAV}_{t-i} + \sum_{i=1}^{q-1} \lambda_i \Delta\, \mathrm{CO}_{2t-i} \\ &\quad + \sum_{i=1}^{r-1} \xi_i \Delta\, \mathrm{PLC}_{t-i} + \sum_{i=1}^{s-1} \rho_i \Delta\, \mathrm{RN}_{t-1} + \varphi z_{t-1} + \upsilon_t \end{aligned} \tag{5.4}$$

Here, z_{t-1} is the error correction term that is required to be negative and significant for cointegration.

To check the robustness of our study, we shall replace CO_2 by temperature (TEM) and estimate the following ARDL (p, q, r, s) model:

$$\mathrm{PAV}_t = \beta_0 + \sum_{i=1}^{p} \beta_i \mathrm{PAV}_{t-i} + \sum_{j=0}^{q} \mathrm{TEM}_{t-j} + \sum_{k=0}^{r} \gamma_k \mathrm{PLC}_{t-k} + \sum_{l=0}^{s} \delta_l \mathrm{RN}_{t-l} + \varepsilon_t \tag{5.5}$$

If there is no serial correlation of residuals, we shall perform the bounds test, and if the null hypothesis of ‘no level relationship’ is rejected, we shall estimate long-run level equation

$$\mathrm{PAV}_t = c + a\mathrm{TEM}_t + b\mathrm{PLC}_t + d\mathrm{RN}_t + \in_t \tag{5.6}$$

We shall estimate the error correction model:

$$\begin{aligned}\Delta\mathrm{PAV}_t &= \mu + \sum_{i=1}^{p-1} \eta_i \Delta\, \mathrm{PAV}_{t-i} + \sum_{i=1}^{q-1} \lambda_i \Delta\, \mathrm{TEM}_{t-i} \\ &\quad + \sum_{i=1}^{r-1} \xi_i \Delta\, \mathrm{PLC}_{t-i} + \sum_{i=1}^{s-1} \rho_i \Delta\, \mathrm{RN}_{t-1} + \varphi z_{t-1} + \upsilon_t \end{aligned} \tag{5.7}$$

Finally, we shall see the relationship between PAV and CO_2 only, and we shall estimate the ARDL (p, q) model:

$$\mathrm{PAV}_t = \beta_0 + \sum_{i=1}^{p} \beta_i \mathrm{PAV}_{t-i} + \sum_{j=0}^{q} \alpha_j \mathrm{CO}_{2t-j} + \varepsilon_t \tag{5.8}$$

And, the long-run equation:

$$\mathrm{PAV}_t = c + a\mathrm{CO}_{2t} + \in_t \tag{5.9}$$

The error correction model:

$$\Delta\mathrm{PAV}_t = \mu + \sum_{i=1}^{p-1} \eta_i \Delta\,\mathrm{PAV}_{t-i} + \sum_{i=1}^{q-1} \lambda_i \Delta\,\mathrm{CO}_{2t-i} + \varphi z_{t-1} + \upsilon_t \tag{5.10}$$

For Sri Lanka, where the causality runs from PAV to CO_2, we estimate CO_2 as a function of PAV and PLC:

$$\mathrm{CO}_{2t} = f(\mathrm{PAV}_t, \mathrm{PLC}_t) \tag{5.11}$$

We shall proceed to estimate the ARDL (p, q, r) model

$$\mathrm{CO}_{2t} = \beta_0 + \sum_{i=1}^{p} \beta_i \mathrm{CO}_{2t-i} + \sum_{j=0}^{q} \alpha_j \mathrm{PAV}_{t-j} + \sum_{k=0}^{r} \gamma_k \mathrm{PLC}_{t-k} + \varepsilon_t \tag{5.12}$$

performs bound test to know the long-run equilibrium and estimate long-run relationship as

$$\mathrm{CO}_{2t} = c + a\mathrm{PAV}_t + b\mathrm{PLC}_t + \in_t \tag{5.13}$$

The error correction model is:

$$\Delta\mathrm{CO}_{2t} = \mu + \sum_{i=1}^{p-1} \eta_i \Delta\,\mathrm{CO}_{2t-i} + \sum_{i=1}^{q-1} \lambda_i \Delta\,\mathrm{PAV}_{t-i} + \sum_{i=1}^{r-1} \xi_i \Delta\,\mathrm{PLC}_{t-i} + \varphi z_{t-1} + \upsilon_t \tag{5.14}$$

To check robustness of findings, we shall replace CO_2 by TEM and estimate the ARDL (p, q, r) model

$$\mathrm{TEM}_t = \beta_0 + \sum_{i=1}^{p} \beta_i \mathrm{TEM}_{t-i} + \sum_{j=0}^{q} \alpha_j \mathrm{PAV}_{t-j} + \sum_{k=0}^{r} \gamma_k \mathrm{PLC}_{t-k} + \varepsilon_t \tag{5.15}$$

to perform bounds test and the long-run relationship

$$\mathrm{TEM}_t = c + a\mathrm{PAV}_t + b\mathrm{PLC}_t + \in_t \tag{5.16}$$

The error correction model of the above equation is

$$\Delta\,\mathrm{TEM}_t = \mu + \sum_{i=1}^{p-1} \eta_i \Delta\,\mathrm{TEM}_{t-i} + \sum_{i=1}^{q-1} \lambda_i \Delta\,\mathrm{PAV}_{t-i} + \sum_{i=1}^{r-1} \xi_i \Delta\,\mathrm{PLC}_{t-i} + \varphi z_{t-1} + \upsilon_t \tag{5.17}$$

Finally, we shall find the relationship between CO_2 and PAV by estimating ARDL (p, q) model as follows

$$\mathrm{CO}_{2t} = \beta_0 + \sum_{i=1}^{p} \beta_i \mathrm{CO}_{2t-i} + \sum_{j=0}^{q} \alpha_j \mathrm{PAV}_{t-j} + \varepsilon_t \tag{5.18}$$

and long-run relationship if bound test shows as follows.

$$\mathrm{CO}_{2t} = c + a\mathrm{PAV}_t + \in_t \tag{5.19}$$

The error correction model is

$$\Delta\mathrm{CO}_{2t} = \mu + \sum_{i=1}^{p-1} \eta_i \Delta\,\mathrm{CO}_{2t-i} + \sum_{i=1}^{q-1} \lambda_i \Delta\,\mathrm{PAV}_{t-i} + \varphi z_{t-1} + \upsilon_t \tag{5.20}$$

For Bangladesh, we shall estimate both models. To test the stability of parameters estimated above, we have performed the CUSUM test and CUSUM of squares test. The CUSUM test is based on the cumulative sum of recursive residuals. In the plot, we shall have a cumulative sum together with 5% critical lines. If the cumulative sum goes outside the 5% critical lines, then there will be parameter instability. In the CUSUM of squares test, if the cumulative sum of squares is within 5% significance lines, we conclude that residual variance is stable.

5.4 Results

In our study, we have divided South Asia and five selected countries into three groups. In the first group, we have South Asia, India, Nepal, and Pakistan where we have the evidence of causality running from CO_2 emissions to PAV from the Granger causality test. We have shown the estimated results of Eqs. (5.2), (5.3), and (5.4) for these countries and the region. To check the robustness of the findings, we have estimated Eqs. (5.5)–(5.10), but estimated results of Eqs. (5.6) and (5.9) are shown in the tables. Equations (5.6) and (5.9) are estimated when we have found the residuals are not serially correlated, and bound tests have shown the long-run relationships from Eqs. (5.5) and (5.8), respectively. The results of the Breusch–Godfrey test and bound test are reported in the tables. Results of estimated equations of these countries and the region are shown in Tables 5.3, 5.4, 5.5 and 5.6. In the second group, we have Sri Lanka, where causality runs from PAV to CO_2. We have estimated the equations from (5.12) to (5.20), and as stated for the first group, we have reported the estimated results of the Eqs. (5.12), (5.13), (5.14), (5.16), and (5.19). Table 5.7 shows the estimated results. Lastly, for Bangladesh, we do not find any causal relation either from CO_2 to PAV or PAV to CO_2. We have estimated both models. Here, we have reported the results of the Breusch–Godfrey test and bound test of the Eqs. (5.2), (5.8), (5.12), and (5.17) and the estimated results of Eqs. (5.3) and (5.9).The estimated results are shown in Table 5.8.

There is a long-run equilibrium relationship among the variables in our basic model expressed by Eq. (5.1). Both CO_2 and PLC are found to be positive significant factors in explaining PAV. When we replace CO_2 with TEM, we again have the equilibrium long-run relationship, but we find that temperature is not a significant factor. Conducting CUSUM and CUSUM of squares tests, we find that parameters and variance of residuals are stable for our estimated equations, except for a short time period in Eq. (5.5) for the variance of residuals. A long-run equilibrium relationship can be observed among PAV, CO_2, PLC, and RN for India, Nepal, and Pakistan. In India, CO_2, PLC, and RN are all positive significant factors in explaining PAV. In Pakistan, only CO_2 has a positive significant effect on PAV. In Nepal, CO_2 is not significant but PLC and RN are significant at 10% level. Like South Asia, TEM is not significant in explaining PAV in India, Nepal, and Pakistan. The robustness check from Eq. (5.8) also confirms that CO_2 is positively significant in explaining PAV in India and Pakistan and insignificant in Nepal. Parameters are stable for these countries for our basic model (Eq. 5.2). In India, in Eq. (5.5), parameters related to temperature are not stable in the last 15 years. In South Asia and India, PLC is a positive significant factor in explaining PAV, negative significance (at 10%) in Nepal, and insignificant in Pakistan. In the first group of countries rainfall (RN) is the positive significant factor only in India and Nepal (at 10% level).

In Sri Lanka, we have a long-run equilibrium relationship among CO_2, PAV, and PLC; but PAV and PLC are insignificant. PAV has a positive significant relation with TEM in Sri Lanka. In the bound test of Eq. (5.18), the value of F-statistics is lower than the lower bound at a 5% significance level. CO_2 and PAV in Sri Lanka appeared to be I(0), and no long-run equilibrium relationship is possible between them. The parameters and variance of residuals are stable for the estimated Eqs. (5.12), (5.15), and (5.18) are stable in accordance with the findings of CUSUM and CUSUM squares test.

In Bangladesh, though we have a long-run equilibrium relationship among the variables in Eq. (5.2), CO_2, PAV, and RN are not statistically significant. CO_2 remains insignificant in Eq. (5.9) also. In our second model where CO_2 is explained by PAV and PLC, we do not have any equilibrium relation. The robustness checks of the

Table 5.3 Estimates of regression equations for South Asia

The estimates of Eq. 5.2, ARDL (1, 1, 1, 0) model, (dependent variable: SPAV)						
C	SPAV(−1)	SCO_2	$SCO_2(-1)$	SPLC	SPLC(−1)	SRN
4.124*	0.318*	−0.032	0.373**	1.166*	−0.885*	0.049
(0.081)	(0.112)	(0.140)	(0.141)	(0.214)	(0.237)	(0.064)
Residual diagnostic of Eq. 5.2. Breusch–Godfrey Test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	2.804	0.246	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.2. (H_0: no long-run relationship among variables)						
Test statistic	Value	k	Significance	I(0) bound	I(1) bound	Conclusion
F statistic	13.090	3	1%	3.65	4.66	H_0: rejected
The long-run equilibrium relationship, Eq. 5.3 (dependent variable SPAV)						
C		SCO_2		SPLC		SRN
6.049*		0.499*		0.412*		0.072
(0.501)		(0.070)		(0.115)		(0.094)
Error correction model, Eq. 5.4 (dependent variable: ΔSPAV)						
φ		ΔSCO_2			ΔSPLC	
−0.682*		−0.032			1.166*	
(0.081)		(0.105)			(0.166)	
Residual diagnostic of Eq. 5.5 (ARDL (3,0,3,0) model) Breusch–Godfrey Test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	0.201	0.904	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.5 (H_0: no long-run relationship) $\varphi = -0.289^*$ (0.049)						
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion
F statistic	6.394	3	1%	3.65	4.66	H_0: rejected
The long-run equilibrium relationship, Eq. 5.6 (dependent variable SPAV)						
C		STEM		SPLC		SRN
10.038*		−2.038		−0.562*		0.099
(1.980)		(1.770)		(0.115)		(0.270)
Residual diagnostic of Eq. 5.8.(ARDL (3,0) model) Breusch–Godfrey test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	2.562	0.283	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.8 (H_0: no long-run relationship)$\varphi = -0.468^*$ (0.144)						
Test statistic	Value	k	Significance	I(0) bound	I(1) bound	Conclusion
F statistic	5.830	1	1%	4.94	5.58	H_0: rejected
The long-run equilibrium relationship, Eq. 5.9 (dependent variable SPAV)						
C				SCO_2		
5.373*				0.282*		
(0.031)				(0.036)		

Source World Bank central database. Author's analysis.
Notes Terms in parentheses are standard errors. *, ** indicate statistical significance at 1 and 5%, respectively.

Table 5.4 Estimates of regression equations for India

The estimates of Eq. 5.2, ARDL (1,2,1,1) model, (dependent variable: IPAV)						
C	SPAV(−1)	SCO_2	$SCO_2(-1)$	SPLC	SPLC(−1)	SRN
4.124*	0.318*	−0.032	0.373**	1.166*	−0.885*	0.049
(0.081)	(0.112)	(0.140)	(0.141)	(0.214)	(0.237)	(0.064)
Residual diagnostic of Eq. 5.2. Breusch–Godfrey Test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	2.804	0.246	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.2 (H_0: no long-run relationship among variables)						
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion
F statistic	13.090	3	1%	3.65	4.66	H_0: rejected
The long-run equilibrium relationship, Eq. 5.3. (dependent variable SPAV)						
C	SCO_2		SPLC		SRN	
6.049*	0.499*		0.412*		0.072	
(0.501)	(0.070)		(0.115)		(0.094)	
Error correction model, Eq. 5.4 (dependent variable: ΔSPAV)						
φ	ΔSCO_2			ΔSPLC		
−0.682*	−0.032			1.166*		
(0.081)	(0.105)			(0.166)		
Residual diagnostic of Eq. 5.5 (ARDL (3,0,3,0) model) Breusch–Godfrey Test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	0.201	0.904	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.5 (H_0: no long-run relationship)$\varphi = -0.289^*$ (0.049)						
Test statistic	Value	k	significance	I(0) Bound	I(1) Bound	Conclusion
F statistic	6.394	3	1%	3.65	4.66	H_0: rejected
The long-run equilibrium relationship, Eq. 5.6 (dependent variable SPAV)						
C	STEM		SPLC		SRN	
10.038*	−2.038		−0.562*		0.099	
(1.980)	(1.770)		(0.115)		(0.270)	
Residual diagnostic of Eq. 5.8 (ARDL (3,0) model) Breusch–Godfrey test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	2.562	0.283	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.8. (H_0: no long-run relationship)$\varphi = -0.468^*$ (0.144)						
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion
F statistic	5.830	1	1%	4.94	5.58	H_0: rejected
The long-run equilibrium relationship, Eq. 5.9 (dependent variable SPAV)						
C				SCO_2		
5.373*				0.282*		
(0.031)				(0.036)		

Source World Bank central database. Author's analysis
Notes Terms in parentheses are standard errors. *, ** indicate statistical significance at 1 and 5%, respectively

Table 5.5 The estimates of regression equations for Nepal

The estimates of Eq. 5.2, ARDL (1,1,2,1) model, (dependent variable: NPAV)								
C	NPAV(−1)	NCO_2	$NCO_2(-1)$	NPLC	NPLC(−1)	NPLC(−1)	NRN	NRN(−1)
−0.115	0.936*	0.013	0.030	0.178	0.432*	−0.708*	−0.021	0.052*
(0.364)	(0.042)	(0.009)	(0.016)	(0.128)	(0.154)	(0.131)	(0.017)	(0.126)
Residual diagnostic of Eq. 5.2 Breusch–Godfrey test								
Test statistic	Lags	Value	P value	Conclusion				
LM test statistic	2	4.269	0.118	H_0: no serial correlation is not rejected				
Result of bounds test from Eq. 5.2. (H_0: no long-run relationship among variables)								
Test statistic	Value	k	Significance	I(0) bound	I(1) bound	Conclusion		
F statistic	6.669	3	1%	3.65	4.66	H_0: rejected		
The long-run equilibrium relationship, Eq. 5.3 (dependent variable NPAV)								
C	NCO_2			NPLC		NRN		
−1.783	0.254			−1.410***		0.455***		
(0.171)	(0.173)			(0.784)		(0.265)		
Error correction model, Eq. 5.4 (dependent variable: ΔNPAV)								
φ	ΔNCO_2		ΔNPLC		ΔNPLC(−1)		ΔNRN	
−0.070*	−0.012		0.178		0.709*		−0.021	
(0.011)	(0.015)		(0.112)		(0.116)		(0.014)	
Residual diagnostic of Eq. 5.5 (ARDL (1,0,2,1) model), Breusch–Godfrey Test								
Test statistic	Lags	Value	P value	Conclusion				
LM test statistic	2	2.188	0.335	H_0: no serial correlation is not rejected				
Result of bounds test from Eq. 5.5. (H_0: no long-run relationship)$\varphi = -0.051^*$ (0.009)								
Test statistic	Value	k	Significance	I(0) bound	I(1) bound	Conclusion		
F statistic	5.999	3	1%	3.65	4.66	H_0: rejected		
The long-run equilibrium relationship, Eq. 5.6 (dependent variable NPAV)								
C	NTEM		NPLC			NRN		
−6.884	−0.873		−4.585			0.778		
(11.263)	(2.749)		(3.153)			(0.992)		
Residual diagnostic of Eq. 5.8 (ARDL (1,1) model), Breusch–Godfrey Test								
Test statistic	Lags	Value	P value		Conclusion			
LM test statistic	2	1.718	0.164		H_0: no serial correlation is not rejected			
Result of bounds test from Eq. 5.8 (H_0: no long-run relationship)								
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion		
F statistic	3.13	1	5%	3.62	4.16	H_0: not rejected		
The long-run equilibrium relationship, Eq. 5.9 (dependent variable NPAV)								
C				NCO_2				

Source World Bank central database. Author's analysis
Notes Terms in parentheses are standard errors. *, ** indicate statistical significance at 1 and 5%, respectively

Table 5.6 The estimates of regression equations for Pakistan

The estimates of Eq. 5.2, ARDL (1,2,0,0) model, (dependent variable: PPAV)						
C	PPAV(−1)	PCO_2	$PCO_2(-1)$	$PCO_2(-2)$	PPLC	PRN
1.997^{*}	0.622^{*}	0.062	−0.117	0.165^{**}	−0.009	0.010
(0.549)	(0.111)	(0.086)	(0.116)	(0.083)	(0.059)	(0.021)
Residual diagnostic of Eq. 5.2. Breusch–Godfrey test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	2.194	0.334	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.2 (H_0: no long-run relationship among variables)						
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion
F statistic	4.08	3	5%	2.79	3.67	H_0: rejected
The long-run equilibrium relationship, Eq. 5.3 (dependent variable PPAV)						
C	PCO_2		PPLC		PRN	
5.281^{*}	0.292^{**}		−0.024		0.025	
(0.438)	(0.121)		(0.151)		(0.056)	
Error correction model, Eq. 5.4. (dependent variable: ΔPPAV)						
φ	ΔPCO_2			$\Delta PCO_2(-1)$		
-0.378^{*}	0.062			-0.165^{**}		
(0.080)	(0.073)			(0.078)		
Residual diagnostic of Eq. 5.5. ARDL (1,0,1,0) model, Breusch–Godfrey Test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	2.008	0.366	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.5 (H_0: no long-run relationship)$\varphi = -0.255^{*}$ (0.064)						
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion
F statistic	2.91	3	5%	2.79	3.67	H_0: not rejected
The long-run equilibrium relationship, Eq. 5.6 (dependent variable PPAV)						
C	PTEM		PPLC		PRN	
Residual diagnostic of Eq. 5.8 ARDL (2, 0) model, Breusch–Godfrey Test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	1.351	0.508	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.8 (H_0: no long-run relationship)$\varphi = -0.077^{*}$ (0.058)						
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion
F statistic	7.463	1	1%	4.94	5.58	H_0: rejected
The long-run equilibrium relationship, Eq. 5.9 (dependent variable PPAV)						
C			PCO_2			
5.489^{*}			0.308^{*}			
(0.027)			(0.038)			

Source World Bank central database. Author's analysis
Notes Terms in parentheses are standard errors. *, ** indicate statistical significance at 1 and 5%, respectively

Table 5.7 The estimates of regression equations for Sri Lanka

The estimates of Eq. 5.12, ARDL (1,4,0,) model, (dependent variable: LCO_2)							
C	$LCO_2(-1)$	LPAV	LPAV(−1)	LPAV(−2)	LPAV(−3)	LPAV(−4)	LPLC
−2.227*	0.924*	0.761***	0.302	−0.248	−1.222**	0.532	−0.522**
(0.549)	(0.111)	(0.397)	(0.467)	(0.462)	(0.458)	(0.376)	(0.128)
Residual diagnostic of Eq. 5.12, ARDL (1,4,0,) model, Breusch–Godfrey Test							
Test statistic	Lags	Value	P value	Conclusion			
LM test statistic	2	0.748	0.688	H_0: no serial correlation is not rejected			
Result of bounds test from Eq. 5.12 (H_0: no long-run relationship among variables)							
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion	
F statistic	6.578	2	1%	4.13	5.00	H_0: rejected	
The long-run equilibrium relationship, Eq. 5.13 (dependent variable LCO_2)							
C	LPAV			LPLC			
−30.281**	1.653			−6.904			
(13.290)	(1.243)			(4.945)			
Error correction model, Eq. 5.14.(dependent variable: $\Delta LCO2$)							
φ	ΔLPAV	ΔLPAV(−1)		ΔLPAV(−2)		ΔLPAV(−3)	
−0.076*	0.761**	0.939*		0.690**		−0.532***	
(0.014)	(0.322)	(0.298)		(0.300)		(0.299)	
– Residual diagnostic of Eq. 5.15. ARDL (1,0,0) model, Breusch–Godfrey test							
Test statistic	Lags	Value	P value	Conclusion			
LM test statistic	2	3.865	0.145	H_0: no serial correlation is not rejected			
Result of bounds test from Eq. 5.5 (H_0: no long-run relationship) $\varphi = -\ 0.751^*$ (0.115)							
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion	
F statistic	10.025	2	1%	4.13	5.00	H_0: rejected	
The long-run equilibrium relationship, Eq. 5.16 (dependent variable LTEM)							
C	LPAV				LPLC		
2.949*	0.050*				−0.029**		
(0.043)	(0.007)				(0.011)		
Residual diagnostic of Eq. 5.18. ARDL (1,4) model, Breusch–Godfrey Test							
Test statistic	Lags	Value	P value	Conclusion			
LM test statistic	2	0.768	0.681	H_0: no serial correlation is not rejected			
Result of bounds test from Eq. 5.18. (H_0: no long-run relationship among variables)							
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion	
F statistic	2.386	1	5%	4.94	5.58	H_0: not rejected	
The long-run equilibrium relationship, Eq. 5.9 (dependent variable LCO_2)							
C			LPAV				

Source World Bank central database. Author's analysis
Notes Terms in parentheses are standard errors. *, ** indicate statistical significance at 1 and 5%, respectively

Table 5.8 Estimates of regression equations for Bangladesh

Residual diagnostic of Eq. 5.2, ARDL (2,3,2,0,) model, Breusch–Godfrey test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	0.393	0.821	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.2 (H_0: no long-run relationship among variables)						
Test statistic	Value	k	significance	I(0) Bound	I(1) Bound	Conclusion
F statistic	6.233	3	1%	3.65	4.66	H_0: rejected
The long-run equilibrium relationship, Eq. 5.3 (dependent variable BPAV)						
C	BCO_2		BPLC		BRN	
25.338	0.772		−2.996		3.244	
(72.437)	(1.369)		(7.008)		(7.779)	
Error correction model, Eq. 5.4. (dependent variable: $\Delta BPAV$) $\varphi = -0.020^{*}$ (0.003)						
Residual diagnostic of Eq. 5.8. ARDL (6, 4) model, Breusch–Godfrey Test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	3.818	0.148	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.8 (H_0: no long-run relationship among variables)						
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion
F statistic	5.470	1	1%	4.94	5.58	H_0:not rejected
			5%	3.62	4.66	H_0: rejected
The long-run equilibrium relationship, Eq. 5.9 (dependent variable BPAV)						
C			BCO_2			
389.082			2.667			
(2292.38)			(14.41)			
Residual diagnostic of Eq. 5.12 ARDL (2,2,0) model, Breusch–Godfrey Test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	0.399	0.819	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.8 (H_0: no long-run relationship among variables)						
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion
F statistic	2.78	2	5%	2.72	3.83	H_0: not rejected
Residual diagnostic of Eq. 5.17 ARDL (2,2) model, Breusch–Godfrey Test						
Test statistic	Lags	Value	P value	Conclusion		
LM test statistic	2	0.550	0.759	H_0: no serial correlation is not rejected		
Result of bounds test from Eq. 5.18 (H_0: no long-run relationship among variables)						
Test statistic	Value	k	Significance	I(0) Bound	I(1) Bound	Conclusion
F statistic	3.66	1	5%	3.15	4.66	H_0: not rejected
The long-run equilibrium relationship, Eq. 5.19 (dependent variable BCO_2)						
C				BPAV		

Source World Bank central database. Author's analysis
Notes Terms in parentheses are standard errors. *, ** indicate statistical significance at 1 and 5%, respectively

second model do not any meaningful results in Bangladesh. The parameters of the estimated Eqs. (5.2), (5.8), and (5.18) are stable as shown by the CUSUM tests. The variance of residuals of Eqs. (5.2) and (5.8) are stable but not stable for Eq. (5.18).

5.5 Conclusion

We do not find any evidence of the adverse impact of climate change on agriculture in South Asia and selected five countries. In our study, we find that carbon dioxide has a positive significant effect on per capita value added in agriculture in South Asia, India, and Pakistan. In the introductory section, we have mentioned that CO_2 has both positive and negative effects on agriculture. But it is premature to say that what we find is due to the carbon fertilization effect on agriculture. Moreover, the impact of climate change on agriculture is a long-run phenomenon. The rate of growth of surface temperature has increased in the last thirty years. We may not observe that effect soon. We have also mentioned that the impact on agriculture due to climate change depends on the crops produced, regions, meteorological variables, and other factors. If we take agricultural value-added as a whole for a region or a country, we may not get the real picture. Crop specific, area-specific studies may be made to get a better insight.

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Part II
Health and Standard of Living

Chapter 6
Hurdles in Fuel Choice and Consumption in Rural India

Sanchita Daripa and Soumyananda Dinda

6.1 Introduction

Decisions of household regarding fuel choice and its actual consumption are important research issue focusing on sustainable development goals for year 2030. Least attention has been given on the hurdles in fuel choice and quantity decision of fuel consumption at household levels in developing countries like India. Fuel is required mostly for cooking purpose in rural India. The research is needed to focus on hurdles in fuel choice decision of households on the basis of available fuel sources in rural area. There is a great difference between fuel choice and actual consumption. Due to unavailability or supply constraints, rural rich household does not consume LPG; however, (s) he may select LPG as per choice. This chapter investigates hurdles in selection of fuel and identifies stage-based determinants of fuel choice and its consumption decision of households in rural India focusing on accessibility of different fuel sources. Applying double hurdle model (Cragg, 1971), this chapter attempts to identify the non-price determining factors at each stage of fuel consumption decision of household in rural India.

Traditional fuels like coal, charcoal, firewood, dung cakes, crop residues, etc. are termed as *dirty fuels* and create pollution during their combustion which leads to several health hazards. Modern fuels like petroleum, LPG, biogas, electricity, etc. are termed as *clean fuels* which are more efficient than traditional fuels. Firewood, which is often considered as a renewable source of energy (Couture et al., 2012), is considered as dirty fuel since it adds to CO_2 emissions upon combustion. Large part of supply of firewood comes from deforestation, which acts as a threat to environment. Till today, the dirty fuels are the major source of cooking fuels for households of developing economy like India. So, developing economies are

S. Daripa · S. Dinda (✉)
Department of Economics, University of Burdwan, Golapbag Campus, Burdwan, West Bengal 713104, India
e-mail: sdinda@eco.buruniv.ac.in

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ushered into a world of uncertainty with unsustainable development. Hence, it is required to understand the determinants of cooking fuel choice at household level under different constraints. Household fuel consumption decision depends on their socio-economic backgrounds. Various studies (Couture et al., 2012; Gundimeda & Kohlin, 2008; Gupta & Kohlin, 2006; Jingchao & Kotani, 2012) have pointed out several determining factors of fuel consumption at household level like income, fuel price, religion, caste, sex of household head, age of household head, educational level, etc. Other studies have pointed out availability, accessibility, ease of use of fuels as important factors determining fuel consumption. The methodologies used in earlier studies are based on certain restrictive assumptions regarding choice and actual consumption. Truly, choice and actual consumption may differ due to certain non-price factors. To overcome such limitation, the double hurdle model (Cragg, 1971) is used in the current paper to estimate the stage-based fuel demand and its determinants at the household level in rural India.

This chapter is organized as follows: Sect. 6.2 reviews literature focusing recent state of the art. Section 6.3 describes data and discusses double hurdle methodology of Cragg (1971) model. Section 6.4 provides results and discusses these findings with appropriate interpretations. Finally, Sect. 6.5 concludes with remarks.

6.2 Literature Review

The choice of cooking fuel of households depends on their socio-economic backgrounds. Literature (Couture et al., 2012; Gundimeda & Kohlin, 2008; Gupta & Kohlin, 2006; Jingchao & Kotani, 2012) suggests that income is the most important economic factor affecting fuel choice decision of household. At lower level of economic development, households tend to consume more traditional fuels like dung cake, coal, firewood, etc., which are possibly cheaper. With economic development, households have a tendency to discard traditional dirty fuels and move to modern clean fuels like LPG, electricity, etc. Households rank their fuel preference based on physical characteristics of fuel such as cleanliness, ease of use, cooking time, etc. and switch over from the least preferred to the most preferred fuel with an increase in income. This fuel switching pattern is called *energy ladder*[1] *hypothesis* (Leach, 1992) that highlights importance of non-income or social factors like age of household head, family size, caste, religion, education, etc. in fuel choice decision. Educated people have a higher tendency to consume clean fuels than uneducated peoples and people of backward classes tend to consume more dirty fuels than other (Gupta & Kohlin, 2006; Heltberg, 2005; Hosier, 1987). Working women have a tendency to accept more clean fuels (Gupta & Kohlin, 2006) while it contradicts, possibly in man dominated decision (Kroon et al., 2014). Socio-political culture and limited technological access may affect transition to clean cooking fuels (Goswami et al., 2017). Asset transfer (Hanna & Olive, 2015) or pooling community-based

[1] This is similar to the idea of climbing a ladder.

financial resources (Nayak et al., 2015) encourage to take up clean fuels. Geographical factors also determine fuel choice decision of household (Jingchao & Kotani, 2012; Jumbe & Angelsen, 2011).

The energy ladder hypothesis assumes complete substitution of dirty fuels by clean fuels. Truly, households tend to accept cleaner fuels; however, it cannot completely discard the traditional dirty fuels. This is called *fuel stacking model* (Masera et al., 2000). Couture et al. (2012), Arnold et al. (2006), Brouwer and Falcao (2004) and Campbell et al. (2003) referred to multiple fuel uses. Firewood displays characteristics of normal good when used as back up fuel; however, it reveals characteristics of inferior good when used as a main fuel. Consumption of firewood as main fuel decreases with rising income, thereby supporting *energy ladder hypothesis*; however, it is not completely substituted by cleaner fuels and continues to be used as back up fuel with household's rising income which supports the *fuel stacking model* (Couture et al., 2012).

It might be possible that having huge endowments of energy sources, countries might lag behind in energy production as well as energy consumption like Sub-Saharan Africa (Kebede et al., 2010). Literature focuses on household's fuel demand and little on its supply. Source of fuel might play an important role in taking several policy decisions regarding fuel choice at household level; for example, source of firewood might be purchase from the market, home grown, or/and free collection.

Fuel choice decision also depends on cooking technology which changes over time. Literature helps to understand selection of fuel and cooking technology choice (Van der Kroon et al., 2014; Raman et al. 2014; Takama et al., 2012). Internal household characteristics like traditional practices and household external characteristics like abundance, lack of resources, etc. also affect household's fuel choice decision. Abundance biomass restricts to adopt improved cooking stoves (Van der Kroon et al., 2014). Results in real situation may differ, and adopters may switch to more firewood intensive meals using new technology or differences in education, preference, wealth, etc. Further on the field study compares the firewood consumption of users and non-users of improved cook stoves and these two groups may differ in terms of ability and preferences amongst them which is called the *self-selection issue* (Adrianzén, 2013).

Literature provides some methodologies like multinomial logit model for fuel choice decision (Couture et al., 2012; Takama et al., 2012), multinomial probit model (Gupta & Kohlin, 2006; Jumbe et al., 2011) and tobit model (Jingchao & Kotani, 2012). These methodologies are based on restrictive assumption that if desired consumption is negative, then actual consumption is zero, whereas if desired consumption is positive, then actual consumption is equal to desired consumption. This assumption is always not true. It may be possible that desired consumption is positive; however, actual consumption is not so because other factors inhibit carrying out the change for actual consumption to be positive. To overcome this limitation, the double hurdle (Cragg, 1971) model is required to estimate household fuel demand and its determinants.

6.3 Data and Methodology

6.3.1 Data

The 68th round NSSO data (2011–2012) is used in this paper to study the fuel choice decision of households in India. Briefly, this study describes nature of data and overviews sector-wise and state-wise data in India. NSSO data reveals that individuals have options of ten major alternatives for cooking purposes, namely coke or coal, firewood, LPG, gobar gas, dung cakes, charcoal, kerosene, electricity, others and no cooking arrangements. The NSSO 68th round data suggests that firewood (62.68%) is the most preferred fuel in rural India while LPG (68.9%) in urban India.

The most important determinant of fuel choice of households is income, which is not available. Following literature, we consider monthly per capita consumption expenditure (MPCE) as a proxy variable for income. Table 6.1 describes the distribution of cooking fuels types in rural India and corresponding mean MPCE and its standard deviation (SD). Table 6.1 displays 62.68% of rural households using firewood as cooking fuel having mean MPCE Rs. 1520.48.

Table 6.2 describes the distribution of major sources of firewood in rural India and corresponding mean MPCE and its standard deviation (SD). Table 6.2 shows that main source of firewood in rural India is free collection (34.32%) followed by purchase (30.05%) and home grown (27.54%), and corresponding average MPCE are Rs. 1465.7, Rs. 1669.24 and Rs. 2009.01. It is noted that average MPCE of free collection of firewood group is lower than that of only purchase and/or home-grown firewood consumers.

There are several other socio-economic factors that possibly govern the fuel choice of individuals like social groups, religion, gender, education level and land holding.

Table 6.1 Cooking fuel-type-wise income distribution of households in rural India

Cooking code	Frequency	Percentage	Mean MPCE	SD MPCE
Coke, coal	657	1.1	1358.733	645.822
Firewood and chips	37,410	**62.68**	1520.479	1132.267
LPG	14,562	24.4	2679.4	2649.242
Gobar gas	141	0.24	3130.399	2985.305
Dung cake	4203	7.04	1513.863	1035.254
Charcoal	25	0.04	2053.878	956.2597
Kerosene	619	1.04	2237.197	1340.257
Electricity	77	0.13	2815.011	2003.494
Others	1669	2.8	1312.268	751.6156
No cooking arrangement	320	0.54	3399.33	2525.16
Total	59,683	100		

Source NSSO 68th Round

Table 6.2 Firewood source-wise income distribution of households in rural India

Sources of firewood	Frequency	Percentage	Mean MPCE	SD MPCE
Only purchase	14,562	30.05	1669.243	1165.856
Only home-grown stock	13,347	27.54	2009.011	2328.285
Both purchase and home-grown stock	1580	3.26	1711.407	2292.636
Only free collection	16,631	34.32	1465.706	946.3091
Only exchange of goods and services	93	0.19	1342.986	731.3561
Only gifts/ charities	89	0.18	1785.55	992.7264
Others	2160	4.46	1429.139	862.549
Total	48,462	100		

Source NSSO 68th Round

Table 6.3 provides descriptive statistics of the socio-economic variables. The data on social groups represents four major social groups in India, namely ST, SC, OBC and others. Perhaps this, others category represents the general category. The data on religion represents eight major religions, namely Hinduism, Islam, Christianity, Sikhism, Jainism, Buddhism, Zoroastrianism and others. The sex of household head plays a major role in determining fuel choice of households also. In the data, majority are male headed households and very few female headed households. The data on education level reflects the educational attainment of the respondents and their members.

Table 6.3 shows that majority of households belong to category of OBC (39.46%) followed by others (26.82%), SC (17.08%) and ST (16.64%), respectively. Majority belongs to Hindu category (76.39%) followed by Islam (11.88%) and Christianity (7.16%), and all the other religions consist of a very small proportion of total population. For our analysis purpose, we club all other religions into a single group named others. It is noted that major household head are male (89.31%) while 10.69% are female. It is observed that educational levels of household head are illiterate (29.08%), educated below primary (11.77%), primary (13.71%), middle (16.43%), secondary (12.97%) and highly educated, i.e. graduate and above (7.41%). We have also considered other variables like age of household head, household size, composite average age and educational level of household. We have also considered the land holding pattern of households focusing on land owned by households. It is seen that we have data on land holdings only 25,794 households out of total 59,683 rural households, and their average land holding size is 0.0101902 hectares. This implies that 33,889 households are landless.

6.3.2 Methodology

Household faces difficulties to make decision on selection of fuel and its use. Decision of fuel choice of household has two stages—first stage is decision of participation, and

Table 6.3 Descriptive statistics of socio-economic variables

Name of the variable	Category	Frequency	Percentage
Social groups	Others	16,005	26.82
	ST	9930	16.64
	SC	10,193	17.08
	OBC	23,546	39.46
Religion	Hinduism	45,545	76.32
	Islam	7092	11.88
	Christianity	4273	7.16
	Sikhism	1344	2.25
	Jainism	66	0.11
	Buddhism	696	1.17
	Zoroastrianism	1	0.00
	Others	661	1.11
Sex of head of household	Male	53,304	89.31
	Female	6379	10.69
Educational level of head of household	Illiterate	17,354	29.08
	Through EGS/NFEC/AEC	192	0.32
	Through TLC	43	0.07
	Others	171	0.29
	Below primary	7022	11.77
	Primary	8181	13.71
	Middle	9804	16.43
	Secondary	7737	12.97
	Higher secondary	4230	7.09
	Graduate	3437	5.76
	Postgraduate and above	984	1.65

Source NSSO 68th Round

second stage is decision of quantity or amount of selected fuel consumption. Now, double hurdle model[2] of Cragg (1971) is appropriate for identifying stage-based determinants. Actually, Cragg model (1971) is an extension of Tobin's model for limited dependent variable (Wooldridge 2008). Tobit model (1958) was developed by Tobin to analyse censored dependent variables. Tobin's model is written as follows:

$$\begin{aligned} y_i &= y_i^* \text{ if } y_i^* > 0 \\ &= 0 \text{ otherwise} \end{aligned} \tag{6.1}$$

where y_i^* is the latent dependent variable.

[2] Cragg's double hurdle model was initially used to estimate the demand of durable goods.

The latent dependent variable y_i^* is described by the regression equation.

$$y_i^* = x_i\beta + u_i, \text{ where } u \sim N(0, \sigma_u^2) \tag{6.2}$$

Cragg (1971) put forward a two part extension to Tobin's model in his research paper. He addressed the presence of two latent variables through two regression equations, i.e. participation decision and actual consumption or expenditure decision. The occurrence of these two latent variables explains the double hurdles in Cragg model.

The latent variables are represented by two regression equations as follows:

$$y_{i1}^* = w_i\alpha + \in_1 \tag{6.3a}$$

$$y_{i2}^* = x_i\beta + \in_2 \tag{6.3b}$$

The Cragg model is represented as:

$$\begin{aligned} y_i^* &= x_i\beta + \varepsilon \quad if\ y_{i1}^* > 0 \text{ and } y_{i2}^* > 0 \\ &= 0, otherwise \end{aligned} \tag{6.4}$$

where y_{i1}^* is a latent endogenous variable representing an individual or household participation decision; y_{i2}^* is a latent endogenous variable representing an individual or household consumption or expenditure decision; y_i is the observed dependent variable; c is the set of individual characteristics explaining participation decision; x_i is the set of variables explaining the expenditure or consumption decision of the household; $\in_1$ and $\in_2$, and ε are the independent, homoscedastic, normally distributed error terms.

Tobit model assumes that participation and consumption decision can be modelled as a single equation, whereas Cragg (1971) relaxed this assumption and models both of these as separate regression equations introducing the double hurdle model.

6.4 Results and Discussions

6.4.1 Results

Table 6.4 provides the results of double hurdle model for firewood consumption decision in rural India. The estimated participation and quantity equations are reported here. The participation equation identifies determining factors for selection of firewood at household level in rural India. The quantity equation points out determining factors of actual firewood consumption. The results of the estimated participation equation indicate that independent variables like land owned (LO), household size,

Table 6.4 Estimated determinants of cooking fuel choice (participation equation) and actual consumption (quantity equation) in double hurdle model

	Participation equation			Quantity equation		
Variable name	Coefficient	t statistic	P-value	Coefficient	t statistic	P-value
Constant	0.6484544	0.63	0.527	1.518397*	1.94	0.053
Log_mpce	0.1011213	0.37	0.709	0.6491616***	3.08	0.002
Logmpce_sq	−0.0295916	−1.65	0.098	−0.0329401**	−2.32	0.021
LO	36.26633***	12.09	0.000	−23.15759***	−9.32	0.000
Hhsize	0.0208619***	3.03	0.002	0.061351***	12.85	0.000
Age	0.0127629***	3.22	0.001	0.0086669***	3.07	0.002
Age_sq	−0.0001421***	−2.97	0.003	– 0.0002112***	−6.19	0.000
Edu	-0.060983***	−9.04	0.000	0.0195901***	3.90	0.000
Age_head	0.019635***	4.40	0.000	−0.0011896	−0.35	0.728
Age_head_sq	−0.000199***	−4.57	0.000	0.0000543	1.64	0.100
Sex_head						
Female	0.1384057***	4.95	0.000	−0.0569522***	−2.90	0.004
Edu_head						
Through EGS/NFEC/AEC	−0.0794113	−0.48	0.633	0.0078658	0.07	0.944
Through TLC	−0.1462562	−0.42	0.674	– 0.2043849	−0.82	0.411
Others	−0.1668782	−1.07	0.287	0.0429797	0.37	0.713
Below primary	0.1410681***	4.15	0.000	0.030924	1.37	0.170
Primary	0.0870626**	2.58	0.010	0.0473543**	2.03	0.043
Middle	0.0957951***	2.75	0.006	0.0071174	0.29	0.772
Secondary	−0.2175211***	−5.66	0.000	−0.0549816*	−1.89	0.059
Higher secondary	−0.3092786***	−6.43	0.000	0.0642225*	1.68	0.092
Diploma/certificate course	−0.5478164***	−5.85	0.000	−0.0315409	−0.35	0.723
Graduate	−0.5860785***	−10.58	0.000	0.1987605***	4.21	0.000
Postgraduate and above	−0.6761837***	−8.42	0.000	0.1818265**	2.39	0.017
Social group						
ST	0.351624***	9.72	0.000	0.1203031***	4.76	0.000
SC	0.2879265***	10.54	0.000	−0.1942414***	−9.51	0.000
OBC	0.2508335***	11.10	0.000	−0.233179***	−13.23	0.000
Religion						
Islam	−0.0362976	−1.33	0.184	0.0766157***	3.83	0.000
Christianity	0.0356707	0.84	0.402	0.155413***	5.08	0.000

(continued)

Table 6.4 (continued)

	Participation equation			Quantity equation		
Variable name	Coefficient	t statistic	P-value	Coefficient	t statistic	P-value
Others	−0.4864342***	−11.74	0.000	0.1888761***	5.21	0.000

Note '***', '**' and '*' denotes 1%, 5% and 10% level of significance, respectively

age, age-square, education level of household, age of household head and its square, sex of the household head being female, all social groups like ST, SC, OBC and 'others' religion group, and educational level of household head at below primary level and above secondary level all are significant at 1% level, and the primary level of education of the household head is significant at 5% level.

The estimated results of quantity equation in double hurdle model show that log MPCE, land owned, household size, average educational level of the household, average age of the household, square of the average age of the household, sex of the household head being female, all social groups, all religious groups and the education of the household head at graduate level are significant at 1% level while square of log MPCE, education level of household head at primary level and above postgraduate level is significant at 5% level and education of household head at secondary and higher secondary level is significant at 10% level of significance.

These findings also suggest examining source-wise hurdles in fuel choice considering the two stages of firewood selection in rural India. We consider three major sources of firewood, namely only purchase, home grown and free collection. Tables 6.5 and 6.6 report source-wise estimated results of firewood consumption in rural India. Table 6.5 shows the results of determinants of firewood selection for each source, and Table 6.6 represents source-wise results of amount determinants of actual firewood consumption.

6.4.2 Discussion on Results

Coefficients of MPCE in Table 6.4 are statistically insignificant in participation equation and highly significant in quantity equation. Result of participation equation suggests that income is probably not a significant determining factor for selecting firewood as cooking fuel in rural India. Statistically significant positive sign of the coefficient of log MPCE and negative sign of its square in quantity equation suggest that amount of firewood consumption rises with increasing income at a diminishing rate. These findings indicate that income has no significant role in firewood selection; however, income crucially determines its quantity.

Land ownership (LO) may provide insightful probable information regarding choice of fuel consumption, particularly firewood, at household level in rural area. The positive coefficient of land holding (LO) in participation equation indicates that

Table 6.5 Source-wise estimated determinants of participation choice of firewood selection

	Only purchase		Home grown		Free collection	
Variable name	Coefficient	t statistic	Coefficient	t statistic	Coefficient	t statistic
Constant	4.515955***	2.64	7.027716***	5.16	4.30695***	2.58
Log_mpce	−0.2462218	−0.54	−0.936314***	−2.67	−0.1687442	−0.37
Logmpce_sq	−0.028842	−0.95	0.0281244	1.24	−0.0275296	−0.90
LO	−1.193607	−0.54	−9.8549***	−3.21	−16.1183***	−6.93
Hhsize	−0.065775***	−9.09	−0.057733***	−9.28	−0.053627***	−6.69
Age	0.0042322	0.75	0.020404***	3.42	0.0036537	0.66
Age_sq	−0.0000102	−0.15	−0.000245***	−3.38	−0.0000296	−0.44
Edu	−0.02728***	−2.99	−0.07197***	−7.72	−0.045973***	−4.87
Age_head	−0.0044858	−0.70	−0.017283***	−2.64	−0.0049534	−0.74
Age_head_sq	0.0000222	0.37	0.0001063*	1.79	3.39e−06	0.05
Sex_head						
Female	0.0602524	1.46	−0.0835594*	−1.90	0.0642659	1.53
Edu_head						
Through EGS/NFEC/AEC	0.2747202	1.06	−0.0930644	−0.41	0.0520439	0.23
Through TLC	−0.73678**	−2.04	0	0	−0.3333392	−0.73
Others	−0.015163	−0.07	−0.1811741	−0.54	0.1315506	0.63
Below primary	0.164328***	3.68	0.0304415	0.65	0.153243***	3.53
Primary	0.11238**	2.54	−0.041303	−0.91	0.0704416	1.60
Middle	−0.0199478	−0.46	−0.208637***	−4.68	−0.07762*	−1.71
Secondary	−0.183507***	−3.79	−0.272124***	−5.53	−0.180305***	−3.48
Higher secondary	−0.237219***	−3.94	−0.36476***	−6.09	−0.15448**	−2.24
Diploma/certificate course	−0.610282***	−4.28	−0.706546***	−5.21	−0.413265***	−2.64
Graduate	−0.251584***	−3.59	−0.46067***	−6.74	−0.368069***	−4.35
Postgraduate and above	−0.492648***	−4.35	−0.38014***	−3.59	−0.451476***	−3.22
Social group						
ST	0.490398***	9.45	0.328161***	7.49	0.523909***	11.19
SC	0.0204635	0.54	0.0270334	0.61	−0.0470484	−1.20
OBC	−0.071553***	−2.41	−0.0378502	−1.32	−0.150757***	−4.53
Religion						
Islam	0.190814***	5.19	0.0594547	1.57	−0.0263985	−0.56
Christianity	−0.154984**	−2.56	−0.37864***	−7.52	−0.0204818	−0.35
Others	−0.280032***	−4.78	−0.284232***	−4.73	−0.468303***	−7.21

Note '***', '**' and '*' denotes 1%, 5% and 10% level of significance, respectively

Table 6.6 Source-wise determinants of quantity decision of firewood consumption

	Only purchase		Home grown		Free collection	
Variable name	Coefficient	t statistic	Coefficient	t statistic	Coefficient	t statistic
Constant	−1.5892*	−1.65	1.083653	1.40	−1.328513	−1.55
Log_mpce	1.36775***	5.32	0.810964***	4.05	1.47518***	6.30
Logmpce_sq	−0.089026***	−5.17	−0.049437***	−3.81	−0.098631***	−6.13
LO	−6.0509***	−4.54	−9.71889***	−5.34	−19.4711***	−16.25
Hhsize	0.05759***	12.79	0.0445526***	11.62	0.074505***	17.64
Age	0.008326**	2.54	0.0103832***	2.96	0.00968***	3.51
Age_sq	−0.000172***	−4.23	−0.000221***	−5.16	−0.00023***	−6.84
Edu	0.0011695	0.21	−0.009976*	−1.79	−0.013296***	−2.70
Age_head	0.011769***	3.05	−0.00642*	−1.65	0.0059867*	1.75
Age_head_sq	−0.000091**	−2.49	0.0000822**	2.31	−0.0000295	−0.89
Sex_head						
Female	−0.070253***	−2.88	−0.0122745	−0.47	−0.0096887	−0.46
Edu_head						
Through EGS/NFEC/AEC	−0.0234716	−0.17	−0.004311	−0.03	−0.0043792	−0.04
Through TLC	−0.622984**	−2.54	0.5074196	1.62	−0.1111616	−0.46
Others	0.0106138	0.08	−0.2607042	−1.33	0.0892082	0.91
Below primary	0.114734***	4.46	0.0552587**	2.05	0.067281***	3.15
Primary	0.114124***	4.37	0.0143429	0.54	0.058844***	2.64
Middle	0.027436	1.03	−0.068619**	−2.57	0.0140341	0.59
Secondary	−0.108094***	−3.60	−0.133949***	−4.48	−0.077565***	−2.77
Higher secondary	−0.0552085	−1.46	−0.238156***	−6.45	−0.0686334*	−1.82
Diploma/certificate course	−0.268465***	−2.89	−0.43240***	−5.19	−0.379368***	−4.06
Graduate	−0.083988*	−1.91	−0.25950***	−6.13	−0.140475***	−2.93
Postgraduate and above	−0.281668***	−3.87	−0.31279***	−4.71	−0.22003***	−2.66
Social group						
ST	0.3298879***	11.72	0.229017***	9.22	0.159307***	7.33
SC	−0.0111159	−0.48	0.006496	0.25	−12,991***	−6.20
OBC	−0.09633***	−5.30	−0.0347766**	−1.99	−0.202021***	−11.13
Religion						
Islam	0.10126***	4.65	0.1337264***	5.95	−0.0332582	−1.32
Christianity	0.1655426***	4.75	0.3472593***	11.48	0.240614***	8.99
Others	0.0240311	0.65	−0.095248**	−2.55	0.1081484***	3.06

Note '***', '**' and '*' denotes 1%, 5% and 10% level of significance, respectively an increase in average size of land holding of households increases its probability to choose firewood as cooking fuel in rural India. This result possibly suggests that increased LO leads to increase production of firewood and thereby rising probability of its consumption choice. Negative coefficient of LO in quantity equation indicates that amount of firewood consumption declines with increasing land holding, which suggests possibility to switch over to alternative fuels available in rural India.

Positive coefficients of household size in participation and quantity equations indicate that an increase in household size increases probability of choosing firewood and amount of firewood consumption also rises. It suggests that increased manpower probably helps to collect firewood nearly free of cost in rural India.

Positive coefficient of 'age' and negative coefficient of its square in participation equation represent that an increase in average age of household raises probability of firewood selection at a decreasing rate. The quantity equation suggests that if the household chooses to consume firewood, its consumption amount increases with decreasing rate as average age of household rises. Positive coefficient of 'age_head' and negative coefficient of its square in the participation equation suggest probability of firewood choice increases with diminishing rate along age of household head.

This study has considered two variables on educational attainment: one representing average educational level of household and other representing educational attainment of household head. Negative coefficient of 'edu' in participation equation represents a decreasing probability to choose firewood with rising average years of schooling of household, while its positive coefficient in quantity equation indicates that if households consume firewood, they make positive amount of consumption with an increase in average educational level of household. These results might be due to lack of access to cleaner or alternative fuels; truly, it is difficult to comment anything on it without further study. In this context, role of education of household head plays crucial role for selection of firewood and its consumption amount. Negative coefficients of secondary, higher secondary, certificate, graduate and postgraduate education of household head in participation equation indicate that probability of firewood selection declines with secondary and higher level of education of household head. Positive coefficient of educational level of household head at below primary, primary and middle school level indicates that probability of firewood selection rises at lower levels of education of household head. Quantity equation reflects slightly different picture. Negative coefficient of secondary education in quantity equation further indicates that if household head achieves secondary level of education, then firewood consumption decreases. Compared to this positive coefficient of graduate, postgraduate and above educational level of household head is quite surprising which indicates a positive consumption of firewood with rising educational level of household head. It should be mentioned that graduate and above educated household heads reduce probable choice of firewood however its amount of consumption raises due to unavailability of alternative clear fuels. This indicates that achieving a secondary level of education of household head is desirable for reducing firewood consumption. Policy should be designed to raise educational level of household head beyond secondary and ensure availability of clean fuels matching with demand associated higher educations.

Positive coefficient of female headed household in participation equation indicates that probability of selecting firewood rises compared to male headed household. Negative coefficients in quantity equation indicate that if firewood is chosen as a cooking fuel, amount of firewood consumption decreases compared to male headed household. These results possibly suggest that female headed households might be financially worse off than male headed households, and female headed households have positive probability to select cheap firewood compared to male headed households. Since cooking is in women's domain, they are more aware of the ill effects of using firewood, and this might be possible reason of lesser firewood consumption compared to male headed households as indicated in quantity equation.

The double hurdle model represents effect of different social groups, namely ST, SC and OBC compared to general caste on fuel selection behaviour of household. Positive coefficients of three social groups in participation equation represent that probability of firewood choice rises for ST, SC and OBC compared to general caste. Positive coefficient of ST and negative coefficients of SC and OBC in quantity equation reflect that compared to general caste, ST households make more consumption of firewood, while SC and OBC households consume lesser amount of firewood.

For religious, it is observed in participation equation that only others religion group have chance to decline probability to choose firewood. Positive coefficients of religious group Islam, Christianity and others in quantity equation represent that they increase firewood consumption compared to Hindu households.

Results of Tables 6.5 and 6.6 suggest that source-wise firewood choice is independent of income except home grown; however, firewood quantity of all sources depends on income. Probability of selecting free firewood collection decreases with landholding which also reduces free firewood collection amount. At each source, probability of firewood selection reduces with education and its quantity declines in case of free collection. Educations of household heads at secondary and above certainly reduce probability of firewood consumption and quantity too. Female headed household reduces purchase of firewood quantity and might switch over to cleaner fuels. Quantity of free collected firewood consumption declines across social group while it rises across religions except Islam.

6.5 Conclusion

This paper addresses both fuel choice and its quantity demand at household level. Focusing on hurdles in fuel choice decision, this study attempts to identify stage-based determining factors of fuel selection and actual amount of fuel consumption of households in rural India. Applying Cragg (1971), this paper observes that average education level of household, land owned, family size, average age of household, its square, age of household head and its square, social groups like ST, SC and OBC, others religion group, female headed household, secondary and above education of household head are significant in first hurdle of fuel selection. Secondary and graduation education level of household head, female headed household, Islam, Christianity, and others religion, social group of ST, SC, OBC, family size, land holding, average education and average age composition of household and income are significant determining factors in second hurdle of quantity consumption decision.

The results reflect significant socio-economic variables in first hurdle of fuel selection are different from second hurdle or quantity choice of selected fuel. Participation equation further reveals that average age composition of household, age of household head, land owned, family size, social groups of ST, SC and OBC, and female headed household and education of household head at below primary, primary and middle levels have positive effect to raise probability of firewood selection. Average education level of household, others religious group, secondary and above education level of household head reflect negative impact on choice of firewood as cooking fuel. The results of quantity equation state that income, household size, average age of household, average education of household, ST social group, Islam, Christianity and others religious group and education of household head at primary level indicate positive amount of firewood consumption, while land holding, female headed household, secondary education level of household head, SC and OBC reflect a decline in amount of firewood consumption in rural India. Results of double hurdle model are significantly better than other models (Tobit, 1958; or Heckman, 1979).

Firewood, being a dirty fuel, has several ill effects, and such fuel consumption should be discouraged. Our results indicate that an increase in education of household head at least up to secondary level lowers the probability of choosing firewood and amount of firewood consumption, which also declines in case of female headed household. Hence, policy makers should focus on policy design for improving female education beyond secondary education level. Empirical findings suggest shifting some of firewood consumers to other clean fuels through educational attainment of household head or raising awareness regarding dirty fuel consumption. Female participation should be encouraged at household level decision making that may help shifting household from consumption of dirty to clean fuels. It is true that women suffer directly from ill effects of dirty fuel consumption, and so their voice in decision making of households might bring about some positive change in fuel consumption patterns of rural household in India. This study has certain limitations. Constant or intercept term in the participation equation is still highly significant which might be for omission of some variables from this study. Education, in this paper, is considered as a categorical variable; however, the results could have been different if we could have used it as a continuous year of schooling. We have also not considered the interaction effects of some variables like education and sex of household head which might help in further analysis of firewood consumption pattern in rural India. The effect of such interaction terms could give us important insight for effective policy design and further research in this arena.

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Chapter 7
Explaining Cross-Region Disparities in Childhood Stunting in India

Saswata Ghosh, Santosh Kumar Sharma, and Dripta Roy Choudhury

7.1 Introduction

Stunting is an indicator of long-term nutrient deprivation (WHO, 2010). The persistent high prevalence of childhood stunting (low height-for-age) in India is a major public health concern (Ansuya et al., 2018). Children in the poorest wealth quantile are more stunted (49%) compared to the richest (19%) (CNNS, 2019). Fifth round of NFHS showed a rise in childhood stunting in 11 out of 17 states compared to its previous round. Populous states like Maharashtra, Gujarat, West Bengal are of high concern. Rise of stunting by 4–5% in affluent states like Kerala and Goa is also worrisome.

Childhood undernutrition is significantly influenced by household (size, assets, sanitation facility), individual (mother's age, educational attainment, breastfeeding practices, nutritional status and anaemia, child's diet quality) and contextual (seeking antenatal care services by mothers) (Khan & Mohanty, 2018; Menon et al., 2018; Subramanyam et al., 2010) factors. Thus, the effects of endowments (covariate) are found as a significant component to influence childhood stunting in India. Differences in the endowments may modestly explain the large cross-state disparities in child nutritional outcomes. Moreover, returns to the endowments or the effect of implementation of nutrition-relevant policies and programmes is found to play the central role in explaining such disparity (Cavatorta et al., 2015). Issues like influence of institutions in implementing public policies and programmes, availability and accessibility of public services, community's participation and health-seeking behaviour, quality of the governance, and macro-level politico-economic context are also contributory

S. Ghosh (✉)
Institute of Development Studies Kolkata (IDSK), Kolkata, India

S. K. Sharma
International Institute for Population Sciences, Mumbai, India

D. R. Choudhury
Centre for Technology Alternatives for Rural Areas (CTARA), IIT-Bombay, Mumbai, India

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factors (Bajpai, 2014; Barik & Thorat, 2015; Harriss & Kohli, 2009). But limited attempts are made to define the contribution of covariates operating at individual, household and at the aggregate level (*covariate effects*) as well as the contribution of the strength of relationship (*coefficient effects*) on child anthropometric outcomes in order to understand the cross-region disparities in India.

The present study proposes to investigate cross-region disparity in childhood stunting in India. Primary hypothesis is that the cross-region disparity of childhood stunting is arising out of varying endowments of the regions. Secondary hypothesis considers that even if a covariate or a coefficient dominates, there are important differences across the stunting distribution in the relative contributions of covariate and coefficient effects.

The objective of the present study is to assess the relative contribution of different endowments (or covariates) and returns to those endowments (effects of implementation of various policies and programmes) contributing in disparities of childhood stunting with respect to the southern states as benchmark by employing unconditional quantile regression-based counterfactual decomposition (QR-CD). We also enquired whether contribution of covariate and coefficient effects are different at the lower quantile of the HAZ distribution or not, where severe stunting is likely to be prevalent. Such insights are very much important for policy designing where focused intervention is required.

7.2 Materials and Methods

7.2.1 Data and Variables

This study used unit-level data from the NFHS 4 (2015–16). NFHS collects data on various socio-demographic and population health indicators including nutritional status of women, men and children based on a nationally representative sample. The dataset is accessible after obtaining requisite permission and approval from MEASURE-DHS archive. In all the states and union territories of India, information was collected from 601,509 households, 527,889 ever-married women (15–49 years) and 259,627 under-five children. In the state module, the sample sizes were 91,933 for women and 45,231 for children (complete information available from 38,696) born during five-years preceding the survey.

Covariate set for stunting was identified from literature and then further refined before using in the regression models. The final regression models included covariates like representing child, maternal and household characteristics. We included present age of the child (months) and its square, gender of the child (male/female), number of siblings (continuous), size of the child at birth (small, average, more than average) as a proxy for birth weight, early initiation of breastfeeding (yes/no), receipt of ICDS services at anganwadi centres during 12 months preceding the survey (yes/no), age-adjusted child immunization status (no/partial/full) as child characteristics. Maternal characteristics included mother's age during first delivery (continuous) and its square (continuous), educational attainment (continuous), employment status (not-working/working), degree of exposure towards media (additive index of three binary variables—reading newspaper at least once in a week, watching television at least once in a week, listening radio at least once in a week) (continuous), height, BMI (continuous) and level of anaemia (no, mild/moderate and severe). Institutional delivery of the index child (yes/no) is considered as a proxy of mother's contact with health personnel. Further, normalized factor scores of variables indicating decision-making at household, freedom of movement, economic independence were incorporated as maternal level variable (continuous) representing degree of women's empowerment.[1] Similarly, normalized factor scores of variables representing maternal dietary practices were also included under maternal characteristics.[2] Household affluence, socio-religious category (Hindu SC/ST, Hindu OBC/others, Muslims/others), and place of residence (rural/urban) were used as household level variable. Asset index was developed using principal component analyses (PCA) based on possession of durable household assets, availability of sanitation and safe drinking water and landholding as suggested by Filmer and Pritchett (2001).

This study considers six regions. Southern includes Kerala, Tamil Nadu, Karnataka, Andhra Pradesh and Telangana. Northern region comprises Delhi, Rajasthan, Punjab, Haryana, Jammu & Kashmir and Himachal Pradesh. North-eastern region includes Sikkim, Manipur, Arunachal Pradesh, Mizoram, Nagaland, Tripura, Meghalaya and Assam. Central includes Uttar Pradesh, Uttarakhand, Chhattisgarh and Madhya Pradesh. Eastern region comprises Bihar, West Bengal, Jharkhand and Odisha. Western includes Gujarat, Maharashtra and Goa.

7.2.2 Methods

Distributions of HAZ scores were first estimated for all the regions separately using kernel density smoothing techniques to assess differentials in HAZ scores for various regions. We then computed regional differentials at each quantile and provided difference in HAZ distribution across quantiles. Differences in HAZ scores due to differential characteristics in differing regions are considered as covariate effects. Coefficient effect considers differences in HAZ scores across the entire distribution of HAZ scores in differing regions. Decomposing the regional differences in HAZ outcomes into covariate and coefficient effect remained the main objective of the present study.

OLS or logit/probit-type regressions were not followed as it uses mean regional differences in HAZ scores, but not quantile. Employing OLS after segmentation of HAZ into deciles would also introduce sample selectivity bias (Koenker & Hallock, 2001). Quantile regression method (Koenker & Bassett, 1978) was not suitable as it does not capture the effect of a change in a predictor variable in a population with different characteristics rather influences group of individuals with specific values of covariates. Blinder–Oaxaca decomposition method for unconditional quantile regression models (Firpo et al., 2009; Fortin et al., 2011) was also not followed as it would decompose the regional HAZ scores differentially along the entire distribution.

In order to estimate the impact of changing the distribution of explanatory variables on marginal (unconditional) quantiles of outcome variable using regression of transformation, recentred influence function (RIF) of the dependent variable (Y) on the explanatory variables (X) has been proposed (Firpo et al., 2009). This method helps to estimate the contribution of each explanatory variable for HAZ decomposition. This approach thus extends the Blinder and Oaxaca decomposition to other distributional statistics than the mean (Fortin et al., 2011).

In our study, we derived the RIF of the response variable such as HAZ score to estimate the unconditional quantile regression. The RIF for the τth quantile is presented by the following expression:

$$\mathrm{RIF}(Y, q_\tau) = q_\tau + \frac{\tau - I(Y \leq q_\tau)}{f_y(q_\tau)} \tag{7.1}$$

where $f_Y(q_\tau)$ is the marginal density function of Y at the point q_τ estimated by kernel methods; q_τ is the sample quantile; $I(Y \leq q_\tau)$ is an indicator function indicating whether the value of the outcome variable is below q_τ. RIF provides linear approximation to nonlinear functional ($\nu(Y)$) (such as median) of the Y distribution and thus allows computing partial effects for single covariates (Firpo et al., 2009). Firpo et al. (2009) have also shown that the RIF quantile regression may be executed by estimating OLS of the new dependent transformed variable on the covariates (X). In our case, considering two regions (A and B), RIF regressions for HAZ score in both regions are estimated as:

$$E\left[\mathrm{RIF}\left(Y_{i\in g}; q_\tau\right)|X_{i\in g}\right] = X_{i,g}\beta_{\tau,g} \quad g = A, B \tag{7.2}$$

Coefficients $\beta_{\tau,g}$ represent the approximate marginal effects of the predictor variables on the HAZ quantile q_τ for children age 0–59 months in region $g = A$, B.

To decompose the observed differences of HAZ scores between two regions A and B (e.g. southern vs. northern) into covariate (differing endowments of observed determinants of HAZ) and coefficient (differing strength of relationships between observed determinants and HAZ) effects, it is essential to estimate the counterfactual HAZ distribution. By combining the covariates of region A with the distribution characteristics of region B, we obtained the counterfactual HAZ distribution (C). This is the distribution of HAZ scores in B region that would have been prevailed if the households in the B region had the same returns to their characteristics as the households in the A region.

If q_{τ_A} and q_{τ_B} are given quantiles of the HAZ score distribution in A and B regions respectively whereas q_{τ_C} is the same quantile of the counterfactual C distribution, then the overall difference between B and A regions, the HAZ scores at any given quantile can be decomposed as:

$$q_{\tau\_B} - q_{\tau\_A} = [q_{\tau\_B} - q_{\tau\_C})] + [q_{\tau\_C} - q_{\tau\_A}] \quad (7.3)$$

where $[q_{\tau\_C} - q_{\tau\_A}]$ represents the covariate effect and $[q_{\tau\_B} - q_{\tau\_C})]$ represents the coefficient effect.

Each of the covariate and coefficient effects are decomposed into the contribution of individual covariates using RIF regression as presented in Eq. (7.2). This was performed to obtain unconditional quantile effects of covariates on HAZ scores.

Using the RIF unconditional quantile estimation, the following decomposition of HAZ score can be obtained for any given quantile:

$$\widehat{q_{\tau\_B}} - \widehat{q_{\tau\_A}} = \left[\overline{X_B}\left(\widehat{\beta_C} - \widehat{\beta_B}\right) + \widehat{R^{\text{Coeff}}}\right] + \left[\left(\overline{X_A}\widehat{\beta_A} - \overline{X_B}\widehat{\beta_C}\right) + \widehat{R^{\text{Cov}}}\right] \quad (7.4)$$

where $\widehat{q_{\tau\_B}} - \widehat{q_{\tau\_A}}$ represents the raw difference of HAZ scores in B and A at the τth quantile and X represents the covariate averages. Since the $\widehat{\beta_C}$ was estimated from RIF regression of the counterfactual HAZ score distribution, $\left(\widehat{\beta_C} - \widehat{\beta_B}\right)$ presents the difference in the effects of covariates between regions and $\overline{X_B}\left(\widehat{\beta_C} - \widehat{\beta_B}\right)$ represents the coefficient effect. $\left(\overline{X_A}\widehat{\beta_A} - \overline{X_B}\widehat{\beta_C}\right)$ represents the differences in HAZ scores attributable to the differences in characteristics of endowments between B and A hence represents the covariate effect. $\widehat{R^{\text{Coeff}}}$ and $\widehat{R^{\text{Cov}}}$ are the errors related to the estimation of coefficient and covariate effects.

Attempt was taken to minimize endogeneity problem while choosing predictor variables as mentioned in the previous literature (Cavatorta et al., 2015; Srinivasan et al., 2013). However, endogeneity could still persist among different predictor variables and leading to difficulties in interpreting parameters. It is important to mention that the objective of the CD exercise is not identifying causality, rather judge the relative importance of covariate and coefficient effects in explaining variations in HAZ scores (Srinivasan et al., 2013; O'Donnell et al., 2009).

7.3 Results

7.3.1 Descriptive Statistics of HAZ Scores Across Regions

Under-five children from southern India are least likely to be stunted (HAZ score −1.14), but worst affected in central (HAZ score −1.70) and eastern region (HAZ score −1.64). However, at the bottom quantile, children belonging to the north-eastern India have marginally better HAZ scores compared to their counterparts in the southern region. Across the quantiles, HAZ scores are comparable between the northern and north-eastern regions (Table 7.1).

Table 7.1 Percentile of HAZ score in six regions of India in 2015–16

Percentile	Northern	North-Eastern	Central	Eastern	Western	Southern
10	−3.25	−3.12	−3.65	−3.58	−3.52	−3.16
25	−2.29	−2.30	−2.72	−2.71	−2.51	−2.22
50	−1.32	−1.39	−1.80	−1.74	−1.59	−1.26
75	−0.25	−0.35	−0.76	−0.72	−0.49	−0.20
90	0.84	0.85	0.30	0.40	0.79	1.05
Total	−1.23 (0.02)	−1.25 (0.02)	−1.70 (0.02)	−1.64 (0.02)	−1.42 (0.03)	−1.14 (0.03)

Note value in () represent Standard error

7.3.2 Sample Characteristics of Study Children Across Regions

Table 7.2 depicts sample characteristics of the children across regions. There was no regional variation in mean age of the children. Percentage of girls is disproportionately lesser than boys. Such differences are higher in northern and central regions. Children born with lesser than average size are higher in the central region (13%). North-eastern region reports the highest incidence of early breast feeding (67.8%) while central reports lowest (32.6%). More than 6 out of 10 children are observed to be benefitted by ICDS services in southern and eastern regions, but that is lower in northern and north-eastern regions. Complete immunization is found higher in southern region.

Mother's age at first birth is found lowest in eastern side (20.5 years) but highest in northern region (22 years). Completed years of schooling among mothers is found highest in southern (9.2 years) but lowest in eastern part (4.9 years). BMI of mothers follows the similar pattern. Mild and moderate anaemia among women is highest in the eastern region (47.7%), while severe anaemia is highest in central (17.2%). Mothers from southern region have dietary diversity compared to the other regions. Extent of exposure of women to mass media is observed highest in southern region while lowest in eastern part. Nearly 97% women in south opt institutional delivery while it is only 65% in eastern region. Proportion of working mothers is found lowest in the eastern India (14%) and highest in north-eastern (21.8%) with highest empowerment.

Proportion of non-SC/ST Hindus are higher in the sample except for north-eastern region. Percentage of Muslims and other minorities are relatively higher in the southern and northern parts. Proportion of the poorest households is highest in the eastern area (48.3%). Southern region has highest urban residents (43.6%) followed by western (43.5%).

Table 7.2 Sample characteristics of child aged 0–59 months according to background characteristics by regions, 2015–16

	Northern	North-Eastern	Central	Eastern	Western	Southern
Child HAZ [mean (SE)]	−1.23(0.02)	−1.25 (0.02)	−1.70(0.02))	−1.64 (0.02)	−1.42(0.03)	−1.14(0.03)
Age of child in month (mean)	29.80	30.01	30.11	29.91	30.14	30.01
Age^2 (mean)	1173.10	1189.77	1200.32	1182.78	1201.01	1168.98
Child sex (%)						
Male	53.13	50.77	52.01	50.63	51.71	50.10
Female	46.87	49.23	47.99	49.37	48.29	49.90
Birth size (%)						
Normal	78.76	72.03	72.44	70.28	64.77	61.20
Average and above	11.39	17.27	14.10	18.22	24.30	29.03
Small	9.85	10.70	13.46	11.50	10.93	9.78
Early breastfeeding (%)						
No	60.57	32.22	67.36	55.68	44.62	42.32
Yes	39.43	67.78	32.64	44.32	55.38	57.68
No. of Sibling (mean)	1.31	1.57	1.57	1.50	1.14	0.95
Benefitted ICDS services (%)						
No	53.18	53.01	42.62	36.26	41.68	34.82
Yes	46.82	46.99	57.38	63.74	58.32	65.18
Immunization (%)						
No	7.21	17.41	8.28	7.53	11.50	3.54
Partial	35.63	36.38	44.96	36.81	42.24	35.50
Full	57.16	46.21	46.76	55.66	46.26	60.96
Mother's characteristics						
Institutional delivery (%)						
No	15.35	34.89	27.09	29.39	9.17	3.36
Yes	84.65	65.11	72.91	70.61	90.83	96.64
Age of mother at first birth (mean)	22.00	21.70	20.94	20.53	21.35	21.64
BMI of mother (mean)	21.97	21.71	20.92	20.32	21.14	22.52
Mother's anaemia (%)						
No	42.86	53.46	41.36	36.10	46.83	47.56
Mild/moderate	40.82	34.79	41.42	47.72	37.55	37.24

(continued)

Table 7.2 (continued)

	Northern	North-Eastern	Central	Eastern	Western	Southern
Severe	16.32	11.74	17.22	16.18	15.62	15.19
Mother's height (mean)	154.65	150.78	151.28	149.89	152.45	152.80
Mother's Education (mean)	6.78	6.73	5.74	4.85	7.32	9.21
Working mother (%)						
No	86.50	78.24	82.34	86.04	79.18	81.43
Yes	13.50	21.76	17.66	13.96	20.82	18.57
Maternal dietary index (mean)	4.92[0–10]	4.88[0–10]	4.01[0–10]	5.25[0–10]	4.57[0–10]	5.55[0–10]
Empowerment (mean)	6.45[0–10]	7.16[0–10]	6.24[0–10]	6.05[0–10]	6.44[0–10]	6.78[0–10]
Media exposure (mean)	1.32[0–3]	1.28[0–3]	1.04 [0–3]	0.81[0–3]	1.31[0–3]	1.63[0–3]
Religion and caste composition (%)						
Hindu/SC/ST	34.34	69.16	35.21	35.27	27.65	27.94
Hindu/Others	48.02	19.10	50.67	50.09	60.44	55.60
Muslim/Others	17.64	11.74	14.12	14.64	11.90	16.66
Wealth index (%)						
Poorest	10.56	18.91	30.45	48.30	9.28	3.60
Poorer	16.41	32.09	24.20	24.89	18.90	14.80
Middle	21.10	24.08	17.86	14.49	22.82	28.57
Richer	22.09	16.21	14.43	8.25	23.75	30.87
Richest	29.84	8.72	13.06	4.07	25.18	22.16
Place of residence (%)						
Urban	27.55	23.78	23.64	15.26	43.45	43.61
Rural	72.45	76.22	76.36	84.74	56.55	56.39
Total	7928	5234	10,653	7770	3175	3936

7.3.3 Recentered Influence Function (RIF) Quantile Regression

Although all the variables are found to have significant influence on childhood stunting, such associations vary across quantiles and regions (Tables 7.3, 7.4 and 7.5). In all the regions, HAZ scores of children are found to get significantly lowered with increase in age which indicates growth faltering among young children. This effect is observed in all the regions while moving towards upper quantile, particularly up to 75th quantile. Significant negative effect of smaller birth size (proxy for low

Table 7.3 Unconditional Re-centred Influence Function (RIF) quantile regression results for Northern and North-Eastern regions in India (2015–16)

	Northern region					North-Eastern region				
	10	25	50	75	90	10	25	50	75	90
Child characteristic										
Age of child	−0.050***	−0.053***	−0.057***	−0.086***	−0.096***	−0.022***	−0.031***	−0.054***	−0.09***	−0.083***
Age^2	0.001***	0.001***	0.001***	0.001***	0.001***	0.000***	0.000***	0.001***	0.001***	0.001***
Female	0.153***	0.06***	0.053***	0.089***	0.172***	0.243***	0.11***	0.176***	0.179***	0.216***
Birth size										
Normal										
Average and above	−0.066*	0.074***	−0.026	0.123***	0.342***	0.022	0.207***	0.215***	0.116***	0.503***
Small	−0.028	−0.135***	−0.137***	−0.233***	−0.197***	−0.169***	−0.102***	−0.287***	−0.500***	−0.426***
Early Breastfeeding (yes)	0.121***	0.102***	0.06***	0.092***	0.187***	−0.006	−0.037*	−0.017	−0.063***	−0.119***
No. of Sibling	−0.064***	−0.013	0.001	0.024***	0.046***	−0.044***	−0.084***	−0.084***	−0.066***	−0.054***
Benefitted ICDS services	−0.168***	−0.15***	−0.073***	−0.211***	−0.309***	0.103***	−0.046**	−0.117***	−0.005	−0.027
Immunization										
No										
Partial	0.053	0.148***	0.138***	0.116***	0.044	0.124***	0.065**	0.010	−0.068*	0.175***
Full	0.233***	0.197***	0.155***	0.069*	0.060	0.000	−0.154***	−0.140***	−0.286***	−0.197***
Mother's characteristics										
Institutional delivery (yes)	−0.110***	−0.060**	−0.066***	−0.087***	−0.054	0.063*	0.004	−0.027	−0.110***	−0.043

(continued)

Table 7.3 (continued)

	Northern region					North-Eastern region				
	10	25	50	75	90	10	25	50	75	90
Age of mother at first birth	0.008**	0.008***	0.018***	0.024***	0.007	0.002	0.014***	0.007***	0.023***	0.034***
BMI of mother	0.000***	0.000***	0.000***	0.000***	0.000***	0.001***	0.000***	0.001***	0.000***	0.000***
Mother's Education	0.014***	0.02***	0.022***	0.018***	0.011***	0.017***	0.006**	0.016***	−0.012***	−0.031***
Mother's anaemia										
Mild/moderate	0.058**	−0.042**	−0.022	−0.166***	−0.106***	−0.066**	0.063***	0.045**	−0.133***	0.063*
Severe	−0.107***	−0.143***	−0.202***	−0.159***	−0.130***	−0.044	−0.127***	0.050*	−0.008	0.034
Mother's height	0.006***	0.006***	0.006***	0.005***	0.004***	0.005***	0.006***	0.005***	0.005***	0.004***
Working mother	−0.057	−0.007	0.063***	−0.131***	−0.123***	0.226***	0.242***	0.086***	0.010	0.065*
Maternal dietary index	−0.028***	−0.007**	0.001	−0.030***	−0.034***	0.010**	−0.005	−0.003	−0.006	0.007
Empowerment	−0.002	0.016**	0.002	−0.028***	0.008	0.007	0.024**	0.049***	0.050***	0.114***
Media exposure	0.243***	0.184***	−0.001	−0.040	−0.043	0.269***	0.182***	0.008	0.048	−0.106**
Religion and caste composition										
Hindu/SC/ST										
Hindu/Others	0.012	0.066***	0.112***	0.035	0.105***	0.196***	0.215***	0.163***	−0.034	−0.150***
Muslim/Others	0.022	0.078***	0.193***	0.307***	0.323***	−0.092**	−0.158***	−0.152***	−0.123***	−0.325***
Wealth index	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000	0.000***	0.000***
Place of residence										

(continued)

Table 7.3 (continued)

	Northern region					North-Eastern region				
	10	25	50	75	90	10	25	50	75	90
Urban										
Rural	0.252***	0.148***	0.186***	0.172***	0.145***	0.066**	0.057**	0.053**	0.071**	0.153***
Constant	−12.467***	−12.414***	−11.564***	−7.84***	−4.037***	−12.371***	−11.815***	−10.188***	−6.911***	−5.111***
R square	0.049	0.090	0.117	0.100	0.062	0.048	0.098	0.130	0.129	0.069
Adj. R square	0.048	0.090	0.117	0.099	0.061	0.047	0.097	0.129	0.129	0.069

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 7.4 Unconditional Re-centred Influence Function (RIF) quantile regression results for Central and Eastern regions in India (2015–16)

	Central regions					Eastern regions				
	10	25	50	75	90	10	25	50	75	90
Child characteristic										
Age of child	−0.057***	−0.067***	−0.076***	−0.104***	−0.128***	−0.032***	−0.052***	−0.067***	−0.091***	−0.095***
Age^2	0.001***	0.001***	0.001***	0.001***	0.002***	0.000***	0.001***	0.001***	0.001***	0.001***
Female	0.081***	0.029**	0.056***	0.030**	0.025	0.003	0.046***	0.023*	−0.001	0.098***
Birth size										
Normal										
Average and above	−0.120***	−0.092***	−0.039***	−0.029	−0.058*	−0.045*	0.058***	0.104***	0.122***	0.023
Small	−0.299***	−0.298***	−0.329***	−0.312***	−0.363***	−0.356***	−0.253***	−0.299***	−0.206***	−0.051
Early breastfeeding (yes)	−0.022	−0.037***	0.029***	0.034**	−0.037*	0.041**	−0.043***	0.006	−0.091***	−0.031
No. of Sibling	−0.041***	−0.068***	−0.046***	−0.005	−0.020***	−0.119***	−0.068***	−0.031***	−0.032***	0.041***
Benefitted ICDS services	−0.025	−0.037***	−0.057***	−0.102***	−0.154***	−0.066***	−0.090***	−0.093***	−0.142***	−0.136***
Immunization										
No										
Partial	0.157***	0.022	0.035*	0.009	−0.101**	0.367***	0.220***	0.020	−0.120***	−0.116**
Full	0.462***	0.192***	0.022	−0.132***	−0.305***	0.426***	0.239***	−0.027	−0.314***	−0.266***
Mother's characteristics										
Institutional delivery (yes)	0.000	0.081***	0.032***	0.035**	−0.030	0.201***	0.102***	0.010	−0.017	−0.080***

(continued)

Table 7.4 (continued)

	Central regions					Eastern regions				
	10	25	50	75	90	10	25	50	75	90
Age of mother at first birth	−0.012***	−0.008***	0.011***	0.024***	0.023***	0.000***	0.003	0.014***	0.030***	0.029***
BMI of mother	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.001***	0.001***	0.000***
Mother's Education	0.038***	0.031***	0.023***	0.024***	0.017***	0.008***	0.02***	0.026***	0.01***	0.02***
Mother's anaemia										
Mild/moderate	−0.031*	0.005	−0.025**	0.009	0.006	0.020	0.000***	−0.005	−0.097***	−0.106***
Severe	−0.205***	−0.113***	−0.135***	−0.083***	0.085***	−0.122***	−0.136***	−0.034*	−0.236***	−0.058
Mother's height	0.004***	0.006***	0.005***	0.006***	0.005***	0.005***	0.005***	0.006***	0.006***	0.006***
Working mother	−0.029	−0.084***	−0.141***	−0.186***	−0.200***	−0.134***	−0.046**	0.005	0.037	0.188***
Maternal dietary index	−0.001	0.004**	−0.001	0.012***	0.018***	0.030***	0.027***	0.017***	0.009***	0.021***
Empowerment	0.003	−0.001	−0.007*	−0.003	0.021***	0.060***	0.029***	0.003	0.028***	0.042***
Media exposure	0.163***	0.048***	0.036***	0.014	−0.026	−0.021	0.006	−0.008	−0.134***	−0.273***
Religion and caste composition										
Hindu/SC/ST										
Hindu/Others	0.12***	0.119***	0.107***	0.152***	0.124***	0.064***	−0.035**	−0.027*	−0.062***	−0.026
Muslim/Others	0.221***	0.072***	0.052***	0.022	0.017	−0.143***	−0.145***	−0.195***	−0.292***	−0.306***
Wealth index	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Place of residence										

(continued)

Table 7.4 (continued)

	Central regions					Eastern regions				
	10	25	50	75	90	10	25	50	75	90
Urban										
Rural	0.062***	−0.009	0.051***	0.033*	−0.106***	0.021	−0.042**	−0.104***	−0.115***	−0.184***
Constant	−10.048***	−11.282***	−9.477***	−9.104***	−6.741***	−11.892***	−11.104***	−11.284***	−9.856***	−7.643***
R square	0.0416	0.0933	0.1283	0.1293	0.0817	0.0499	0.0978	0.1454	0.1228	0.0701
Adj. R square	0.0414	0.0931	0.1281	0.1291	0.0815	0.0495	0.0975	0.145	0.1225	0.0698

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 7.5 Unconditional Re-centred Influence Function (RIF) quantile regression results for Western and Southern regions in India (2015–16)

	Western regions					Southern regions				
	10	25	50	75	90	10	25	50	75	90
Child characteristic										
Age of child	−0.042***	−0.053***	−0.080***	−0.113***	−0.113***	−0.013***	−0.027***	−0.036***	−0.057***	−0.058***
Age^2	0.001***	0.001***	0.001***	0.001***	0.001***	0.000***	0.000***	0.000***	0.001***	0.000***
Female	0.166***	0.011	0.114***	0.164***	0.164***	0.205***	0.153***	0.097***	0.003	0.036
Birth size										
Normal										
Average and above	−0.035	0.006	−0.142***	−0.054	−0.054	0.008	0.014	−0.003	−0.039	−0.202***
Small	−0.473***	−0.190***	−0.186***	−0.239***	−0.239***	−0.317***	−0.152***	−0.304***	−0.36***	0.000
Early breastfeeding (yes)	0.065	−0.006	−0.009	−0.101***	−0.101***	−0.073**	−0.099***	−0.041**	0.110***	0.302***
No. of Sibling	−0.039	0.026*	−0.001	0.004	0.004	−0.042*	−0.066***	−0.044***	−0.056***	−0.106***
Benefitted ICDS services	−0.139***	0.013	0.021	0.11***	0.110***	0.039	−0.043*	−0.129***	−0.078***	−0.266***
Immunizations										
No										
Partial	−0.039	−0.156***	−0.314***	−0.427***	−0.427***	0.512***	0.321***	0.274***	0.079	−0.780***
Full	−0.001	−0.092**	−0.36***	−0.665***	−0.665***	0.443***	0.174***	0.056	−0.256***	−0.823***
Mother's characteristics										
Institutional delivery (yes)	0.068	0.257***	0.221***	0.113**	0.113**	0.329***	0.199***	0.255***	0.275***	0.288***

(continued)

Table 7.5 (continued)

	Western regions					Southern regions				
	10	25	50	75	90	10	25	50	75	90
Age of mother at first birth	−0.022***	0.007**	0.017***	0.012***	0.012***	0.005	0.018***	0.024***	0.03***	0.043***
BMI of mother	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Mother's education	0.055***	0.039***	0.028***	0.025***	0.025***	0.040***	0.040***	0.017***	0.019***	0.004
Mother's anaemia										
Mild/moderate	−0.304***	−0.244***	−0.14***	−0.136***	−0.136***	0.126***	−0.039*	−0.052**	−0.139***	−0.651***
Severe	0.123**	−0.007	−0.089***	−0.217***	−0.217***	0.274***	−0.043	−0.109***	−0.212***	−0.483***
Mother's height	0.003***	0.004***	0.004***	0.005***	0.005***	0.005***	0.005***	0.006***	0.007***	0.009***
Working mother	−0.224***	−0.304***	−0.217***	−0.071**	−0.071**	−0.072	−0.051*	0.165***	0.017	−0.131**
Maternal dietary index	−0.013**	0.007*	0.020***	0.054***	0.054***	−0.021***	−0.026***	−0.027***	0.002	0.010
Empowerment	−0.121***	−0.064***	−0.012	0.016	0.016	−0.007	−0.002	−0.003	−0.014	0.029*
Media exposure	−0.338***	−0.101**	−0.023	−0.082*	−0.082*	0.493***	0.384***	0.093*	0.082	0.188**
Religion and caste composition										
Hindu/SC/ST										
Hindu/Others	−0.007	0.052*	0.029	−0.155***	−0.155***	0.502***	0.299***	0.162***	0.041	0.003
Muslim/Others	0.330***	0.118***	0.001	−0.201***	−0.201***	0.372***	0.115***	0.037	0.157***	−0.174**
Wealth index	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
Place of residence										
Urban										
Rural	−0.098**	−0.221***	−0.298***	−0.302***	−0.302***	−0.111***	−0.072***	−0.077***	−0.108***	−0.425***

(continued)

Table 7.5 (continued)

	Western regions					Southern regions				
	10	25	50	75	90	10	25	50	75	90
Constant	−7.850***	−8.984***	−8.224***	−7.175***	−7.175***	−13.324***	−11.069***	−10.927***	−11.098***	−10.669***
R square	0.0543	0.1107	0.1621	0.1494	0.0979	0.0465	0.0939	0.1101	0.0992	0.063
Adj. R square	0.0534	0.1099	0.1613	0.1486	0.0971	0.0458	0.0932	0.1094	0.0985	0.0623

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

birth weight) on growth faltering is observed across regions. The effect is lesser for the children, belonging to the highest quantile of HAZ distribution in eastern and southern regions. No apparent gender disparity against girls in childhood stunting is found across the regions. Association between early initiation of breastfeeding and childhood stunting is not found consistent across the regions. In northern area, although significant positive association between early initiation of breastfeeding and child's HAZ score is observed across quantiles, such association is negative at 25th, 75th and 90th quantiles in north-eastern region (Table 7.3). In southern region, effect of early initiation of breastfeeding on childhood stunting gradually becomes significantly positive as it moves towards the upper quantile of the HAZ distribution (Table 7.5). Higher sibling size significantly tends to reduce HAZ scores for the indexed child belonging to the bottom quantile in every region except for western. Effect of receiving ICDS services is found mixed and varied across quantiles and regions. Age-adjusted full immunization shows a significant positive effect on child's HAZ score at the bottom quantile in the northern, central, eastern and southern regions; however, the direction of association is reversed while moving towards higher quantile of the distribution.

Child's stunting is found to be influenced by mother's age during her first delivery. Mother's height and BMI significantly influence child's growth across quantiles and regions. While moving towards upper quantile of HAZ distribution, significant positive influence of mother's schooling on child's HAZ scores is visible in all the regions except north-eastern. Anaemic mothers generally have stunted children except for the bottom quantile from western and southern regions. Association of mother's dietary diversity and her child's stunting vary across regions and quantiles. Women's empowerment strongly influences child's stunting at the upper quantiles. Exposure to mass media of mothers significantly enhances HAZ scores of children across quantiles except for eastern and northern regions. Significant positive effect of institutional delivery is observed in enhancing child's HAZ scores of children from the bottom quantiles in all regions except northern. In western and southern regions, urban residence is positively associated with child's HAZ scores compared to rural residence even after controlling the potential confounding factors. Effect of household assets possession has mild but positive influence on child's growth.

7.3.4 Counterfactual Decompositions

Considerable variations in counterfactual HAZ distributions as well as covariate and coefficient effects across regions in comparison with southern as benchmark are presented in Tables 7.6, 7.7, 7.8, 7.9 and 7.10. Table 7.11 provides a summary of direction of covariate and coefficient effects across regions. Contribution of individual characteristics in disentangling the covariate and coefficient effects in detail is not reported for the brevity of space.

The *negative sign* of the observed raw gap in HAZ scores between southern and other regions indicates lower raw HAZ scores in other regions as compared to

Table 7.6 Oaxaca–Blinder decomposition of HAZ scores of Southern and Northern regions of India, 2015–16

	10	25	50	75	90
Northern HAZ score	−3.282***	−2.311***	−1.348***	−0.295***	0.753***
Southern HAZ score	−3.141***	−2.177***	−1.187***	−0.130**	1.223***
Observed raw gap in HAZ scores	−0.141	−0.134**	−0.161***	−0.166**	−0.470***
Covariate effect	0.165**	0.032	0.047	0.184***	0.115
(% contribution)	−117.1	−24.0	−29.0	−111.0	−24.5
Coefficient effect	−0.306**	−0.166**	−0.208***	−0.350***	−0.585***
(%contribution)	217.1	124.0	129.0	211.0	124.5

	Covariate effect					*Coefficient effect*				
	10	*25*	*50*	*75*	*90*	*10*	*25*	*50*	*75*	*90*
Aggregate effect	0.165**	0.032	0.047	0.184***	0.115	−0.306**	−0.166**	−0.208***	−0.350***	−0.585***
Child characteristics	−0.034	−0.039	0.042	0.069	−0.032	1.754	−0.680	−0.564**	3.495	−2.015**
%	−5.7	−15.7	13.9	12.4	−8.3	−652.7	−436.0	−84.0	−543.0	262.3
Mother's characteristics	0.419***	0.141***	0.120***	0.311***	0.289***	−15.906	4.171***	7.989***	−13.832	10.775**
%	69.2	57.0	39.5	56.0	75.7	5,917.3	2,675.5	1,189.5	2,149.2	−1,402.6
Household's characteristics	0.152***	0.111***	0.089***	0.131***	0.083***	1.646	0.302***	0.249***	2.072*	1.330**
%	25.0	44.8	29.3	23.5	21.8	−612.2	194.0	37.0	−322.0	−173.1
Spatial characteristics	0.069**	0.034**	0.053**	0.045**	0.041**	−0.837	−0.148*	−0.091*	0.070	−0.138
%	11.4	13.8	17.3	8.1	10.8	311.4	−94.8	−13.6	−10.9	18.0
Constant						13.074	−3.490**	−6.911***	7.552	−10.720**
Total	0.605***	0.248***	0.303***	0.555***	0.382***	−0.269	0.156*	0.672***	−0.644	−0.768***
Residuals	−0.440	−0.216	−0.257	−0.371	−0.267	−0.038	−0.322	−0.880	0.294	0.183

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 7.7 Oaxaca–Blinder decomposition of HAZ scores of Southern and North-eastern regions of India, 2015–16

	10	25	50	75	90
North-Eastern HAZ score	−3.088***	−2.281***	−1.371***	−0.305***	0.856***
Southern HAZ score	−3.141***	−2.177***	−1.187***	−0.130**	1.223***
Observed raw gap in HAZ scores	0.052	−0.104*	−0.184***	−0.176**	−0.366***
Covariate effect	−0.327***	−0.315***	−0.276***	−0.117**	0.016
(% contribution)	−623.8	301.4	150.5	66.5	−4.5
Coefficient Effect	0.379***	0.210***	0.093	−0.059	−0.383**
(%contribution)	723.8	−201.4	−50.5	33.5	104.5

	Covariate effect					*Coefficient effect*				
	10	*25*	*50*	*75*	*90*	*10*	*25*	*50*	*75*	*90*
Aggregate effect	−0.327***	−0.315***	−0.276***	−0.117**	0.016	0.379***	0.210***	0.093	−0.059	−0.383**
Child characteristics	−0.071***	−0.067***	−0.067**	−0.020	−0.117***	0.108	0.425	1.324*	0.853	1.066
%	13.5	12.5	14.2	9.0	−858.0	241.7	−2,063.2	−5,036.1	6,991.7	10,242.8
Mother's characteristics	−0.346***	−0.327***	−0.307***	−0.119***	0.072**	−0.511	0.871	−2.573	−0.123	−0.118
%	65.9	61.4	65.4	54.0	527.7	−1,140.2	−4,227.1	9,786.4	−1,008.3	−1,131.9
Household's characteristics	−0.123***	−0.157***	−0.098***	−0.106***	0.018	0.052	0.057	0.125	0.022	0.068
%	23.4	29.4	21.0	48.2	132.0	115.7	−278.3	−475.5	176.6	650.7
Spatial characteristics	0.015**	0.017**	0.003	0.024***	0.041***	0.031	−0.001	−0.141	−0.107	−0.306
%	−2.9	−3.2	−0.6	−11.1	298.3	69.7	7.0	536.4	−877.5	−2,943.3
Constant						0.364	−1.372	1.239	−0.632	−0.699
Total	−0.525***	−0.533***	−0.469***	−0.220***	0.014	0.045	−0.021	−0.026	0.012	0.010
Residuals	0.199	0.219	0.193	0.103	0.003	0.334	0.231	0.119	−0.071	−0.393

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 7.8 Oaxaca–Blinder decomposition of HAZ scores of Southern and Central regions of India, 2015–16

	10	25	50	75	90
Central HAZ score	−3.637***	−2.699***	−1.788***	−0.765***	0.299***
Southern HAZ score	−3.141***	−2.177***	−1.187***	−0.130**	1.223***
Observed raw gap in HAZ scores	−0.496***	−0.522***	−0.601***	−0.635***	−0.924***
Covariate effect	−0.384***	−0.417***	−0.340***	−0.366***	−0.336***
(% contribution)	77.4	79.8	56.6	57.6	36.3
Coefficient effect	−0.112	−0.106*	−0.261***	−0.269***	−0.588***
(%contribution)	22.6	20.2	43.4	42.4	63.7

	Covariate effect					*Coefficient effect*				
	10	*25*	*50*	*75*	*90*	*10*	*25*	*50*	*75*	*90*
Aggregate effect	−0.384***	−0.417***	−0.340***	−0.366***	−0.336***	−0.112	−0.106	−0.261***	−0.269***	−0.588***
Child characteristics	−0.052**	−0.029	−0.013	0.077***	0.136***	−2.246	−0.949	−0.722	−0.776	−0.746
%	9.4	4.8	2.6	−13.9	−27.1	4,856.5***	−2,680.1	−982.2	1,839.5	970.3
Mother's characteristics	−0.453***	−0.489***	−0.380***	−0.537***	−0.503***	0.793	0.088	−1.202	3.922	2.420
%	81.80	79.81	75.86	97.18	99.70	−1,713.75*	249.82	−1,634.82	−9,295.79	−3,145.93
Household's characteristics	−0.068***	−0.089***	−0−0.123***	−0.103***	−0.106***	0.205	0.088	0.107	0.062	0.234
%	12.3	14.5	24.6	18.6	21.1	−442.7	248.1	145.0	−147.9	−304.8
Spatial characteristics	0.019	−0.005	0.015**	0.010	−0.032**	−0.013	−0.023	0.041	0.013	−0.164

(continued)

Table 7.8 (continued)

		10		25		50		75		90
%	−3.5	0.9	−3.0	−1.9	6.3	28.8	−65.8	56.0	−31.0	213.6
Constant						1.216	0.832	1.850	−3.264	−1.820
Total	−0.554***	−0.613***	−0.501***	−0.552	−0.504***	−0.046	0.035	0.074	−0.042	−0.077
Residuals	0.170	0.196	0.161	0.186	0.169	−0.066	−0.141	−0.335	−0.227	−0.511

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 7.9 Oaxaca–Blinder decomposition of HAZ scores of Southern and Eastern regions of India, 2015–16

	10	25	50	75	90
Eastern HAZ score	−3.550***	−2.713***	−1.723***	−0.708***	0.409***
Southern HAZ score	−3.141***	−2.177***	−1.187***	−0.130**	1.223***
Observed Raw gap in HAZ scores	−0.409***	−0.536***	−0.536***	−0.579***	−0.814***
Covariate effect	−0.633***	−0.670***	−0.734***	−0.734***	−0.634***
(% contribution)	154.8	124.8	137.1	126.9	77.9
Coefficient Effect	0.224**	0.133**	0.199***	0.155*	−0.180
(%contribution)	−54.8	−24.8	−37.1	−26.9	22.1

	Covariate effect					*Coefficient effect*				
	10	*25*	*50*	*75*	*90*	*10*	*25*	*50*	*75*	*90*
Aggregate effect	−0.633***	−0.670***	−0.734***	−0.734***	−0.634***	0.224**	0.133**	0.199***	0.155*	−0.180
Child characteristics	−0.101***	−0.035**	−0.006	0.042*	0.096***	−0.492	−0.344	0.215	0.372	−2.185
%	10.3	3.3	0.5	−3.5	−8.9	−1,155.5	−217.8	327.6	159.5	−1,702.0
Mother's characteristics	−0.720***	−0.756***	−0.819***	−0.665***	−0.624***	0.400	−2.862	0.381	−0.418	−9.941
%	73.5	71.8	69.4	54.8	58.3	938.6	−1,811.8	579.3	−179.3	−7,744.8
Household's characteristics	−0.169***	−0.237***	−0.307***	−0.532***	−0.447***	0.137	−0.024	0.077	0.040	−0.181
%	17.2	22.5	26.1	43.8	41.8	321.0	−15.5	117.8	17.1	−141.1
Spatial characteristics	0.010	−0.024	−0.047***	−0.060***	−0.095***	−0.024	−0.029	0.079	0.299	0.202
%	−1.0	2.3	4.0	4.9	8.8	−55.3	−18.1	120.0	128.3	157.0
Constant						0.022	3.417	−0.686	−0.060	12.234
Total	−0.980***	−1.053***	−1.179***	−1.214***	−1.070***	0.043	0.158	0.066	0.233	0.128
Residuals	0.348	0.383	0.445	0.480	0.437	0.181	−0.025	0.133	−0.078	−0.308

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 7.10 Oaxaca–Blinder decomposition of HAZ scores of Southern and Western regions of India, 2015–16

	10	25	50	75	90
Western HAZ score	−3.381***	−2.390***	−1.519***	−0.374***	0.969***
Southern HAZ score	−3.141***	−2.177***	−1.187***	−0.130***	1.223***
Observed Raw gap in HAZ scores	−0.240***	−0.213***	−0.332***	−0.244***	−0.254**
Covariate effect	−0.068	−0.138***	−0.127***	−0.168***	−0.287***
(% contribution)	28.4	64.8	38.2	68.9	112.7
Coefficient effect	−0.172*	−0.075	−0.205***	−0.076	0.032
(%contribution)	71.6	35.2	61.8	31.1	−12.7

	Covariate effect					*Coefficient effect*				
	10	*25*	*50*	*75*	*90*	*10*	*25*	*50*	*75*	*90*
Aggregate effect	−0.068	−0.138***	−0.127***	−0.168***	−0.287***	−0.172	−0.075	−0.205***	−0.076	0.032
Child characteristics	0.030	0.030	0.072***	0.106***	0.083	−1.274*	−0.808**	−0.430	−0.556	0.166
%	−27.7	−12.4	−30.3	−32.2	−15.0	4,182.0	3,886.0	−7,956.7	3,232.6	−433.4
Mother's characteristics	−0.079	−0.253***	−0.305***	−0.431***	−0.654***	1.313	2.431**	0.821	0.520	−1.470
%	73.3	103.0	127.7	130.5	117.9	−4,309.7	−11,687.4	15,212.8	−3,026.0	3,843.7
Household's characteristics	−0.062***	−0.029**	−0.013	−0.013	0.002	0.285**	0.084	0.116*	0.061	0.287**
%	56.9	11.8	5.5	3.8	−0.3	−934.0	−402.3	2,146.5	−354.8	−751.3
Spatial characteristics	0.003	0.006	0.007*	0.007*	0.015*	−0.033	−0.018	−0.025	−0.001	−0.007
%	−2.6	−2.4	−2.9	−2.1	−2.7	106.9	88.0	−460.8	5.0	18.1
Constant						−0.321	−1.709	−0.477	−0.042	0.986
Total	−0.108	−0.245	−0.239***	−0.331***	−0.555	−0.030	−0.021	0.005	−0.017	−0.038
Residuals	0.040	0.108	0.112	0.162	0.268	−0.142	−0.054	−0.211	−0.059	0.071

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 7.11 Summary of direction of covariate and coefficient effects (statistically significant) across regions with benchmark region

Southern as benchmark	Covariate effects	Coefficient effects
Versus Northern region	Positive (i.e. decreases disparities) and small	Negative (i.e. increases disparities) and large
Versus North-eastern region	Negative (i.e. increases disparities) and large	Positive (i.e. decreases disparities except 90th quantile) and small (except bottom 10th quantile)
Versus Central region	Negative (i.e. increases disparities) and large (except 90th quantile)	Negative (i.e. increases disparities except bottom 10th quantile) and small (except 90th quantile)
Versus Eastern region	Negative (i.e. increases disparities) and large	Positive (i.e. decreases disparities except 90th quantile) and small
Versus Western region	Negative (i.e. increases disparities except 10th quantile) and large except 10th and 50th quantiles	Negative (i.e. increases disparities except 25th, 75th, 90th quantiles) and small except 10th and 50th quantiles

southern in all quantiles, except for the lowest quantile of the north-eastern region. Negative figures at the lower panels of the Tables 7.6, 7.7, 7.8, 7.9 and 7.10 indicate an increase in the regional disparity of HAZ scores, while positive figures describe the contribution of characteristics to diminish it. These results also report the significant contribution of covariate and coefficient effects in enhancing the cross-region disparities across quantiles.

While comparing the covariate, coefficient effects and overall HAZ scores of the southern region with that of northern part, coefficient effects are found to significantly contribute in increasing HAZ disparity in every quantile (124% at 25th quantile to 217% at 10^{th} quantile), while covariate effects try to reduce disparities significantly (Table 7.6). The contribution of maternal-level endowments in reducing disparities are the highest among all other endowments. Contribution of returns to endowments at the child level significantly enhances disparities at 50th and 90th quantiles. Mother's dietary diversity followed by mother's height and household wealth are the highest contributing factors in reducing disparities in the child's stunting for the bottom quantile.

While comparing disparities in child's HAZ scores between the southern and central regions, covariate and coefficient effects are found significant. Contribution of covariate effects starts to decline while moving towards the upper quantile of the HAZ distribution. Influence of maternal endowments in increasing disparities is found highest. Differences in maternal education, BMI and child's age are highest contributing factors in enhancing disparities.

Regarding such comparison between eastern and southern states, covariate effects overwhelmingly are found to dominate over coefficient across quantiles (77.9% at highest and 154.8% at bottom quantile). Although coefficient effects have contributed in reducing such disparities, their magnitudes are small (22.1% at highest quantile and 54.8% at the lowest quantile) (Table 7.9). Contribution of unequal maternal endowments is the largest contributor of increasing disparities ranging from 73.5% at the bottom to 58.3% at the highest quantile (Table 7.9). Contribution of the household endowments appears as modest contributor which increases while moving towards the upper quantile. Contribution of maternal height and BMI for increasing disparities is high though it varies across the quantiles.

In the comparison of north-eastern region with southern, coefficient effects try to reduce the disparities at 10th and 25th quantiles but enhance at the 90th quantile. Covariate effects significantly increase the disparities; however, the effects get diminished while moving towards highest quantile (Table 7.7). Contribution of maternal endowments in enhancing such disparities is highest among other endowments. Mother's height is also found as a crucial contributing factor in enhancing disparities.

Contribution of covariate and coefficient effects in increasing disparities of child stunting is mixed and varied across quantiles while comparing the western to southern region. Effects of the covariates in increasing disparities were nearly 72%, 69% and 113% at bottom, 75th and 90th quantiles, respectively. Contributions of mother characteristics (Table 7.10), namely, mother's educational attainment, are found highest contributor for increasing disparities (Table 7.11).

7.4 Discussion

Stunting is an indicator of chronic malnutrition among children. This study has reported that eight states from north-central (Uttar Pradesh, Bihar, Madhya Pradesh and Jharkhand), western (Rajasthan, Gujarat and Maharashtra) and eastern (Odisha) region are contributing to 83% prevalence of stunting. Changes in the prevalence of stunting among children in India through past decades are not consistent; moreover, it is found to vary across and within the states (Kim et al., 2019; Liou et al., 2020; Menon et al., 2018). Regional variations of undernutrition among under-5 years children in India are well-documented by a number of studies (Cavatorta et al., 2015; Khan & Mohanty, 2018; Menon et al., 2018; Mohsena et al., 2015). However, these studies could not point out whether covariate and coefficient effects differ across HAZ distribution.

We have used distribution-wide RIF regression and counterfactual decomposition method to understand drivers of disparity in childhood stunting across the regions of India. We preferred this method as it is less restrictive than mean regression and allows to disentangle covariate and coefficient effects for each quantile. This could be thus extremely valuable for the policy makers and programme implementers. Results indicate that both covariate and coefficient effects with varying proportions across quantiles are associated with regionally differential stunting of children. With respect to the southern region, disparities in child's stunting are largely due to covariate effects in the eastern and north-eastern regions with exceptions in some quantiles. Such disparities are largely accounted for coefficient effects in the northern region. In the central and western regions, coefficient as well as covariate effects are contributing to enhance disparities. The empirical analyses presented in this article first identified a wide set of covariates from the literature and then selected the final set based on the model fit. Hence, the plausibility of insufficient coverage of covariates in influencing the results could be low for the inherent informational constraints of NFHS data.

This study has some limitations too. Firstly, the results are at best indicative but not conclusive as cross-sectional data are not appropriate for identifying causal effects. Secondly, our model specifications are limited by the nature of the NFHS data. Group-wise decomposition methods demand requirement of identical sets of covariates across groups (Cavatorta et al., 2015), and interpretations of coefficient effects are thus not very definite. Nonetheless, the present study helps in highlighting important region-specific dimensions for reduction of childhood stunting in India.

Regional disparity in infrastructure majorly leads to the regional imbalance in growth and development of Indian states. Regional disparity in terms of per capita income (PCI), social and economic infrastructure, human development are multidimensional phenomenon in India (Bakshi et al., 2015; Jose, 2019; Planning Commission, 2002). Significant variations across states with respect to culture, attitudes, dietary habits of population, functioning of institutions, availability and accessibility of public services and political scenario are established. The coefficient of variation in PCI across the states increased from 28% in 1980s to 41% in 2011–2012, whereas coefficient of variation in human development indicators (HDI) of the states dropped from 0.313 (1999–2000) to 0.235 (2007–2008) (Bakshi et al., 2015). Since disparity in HDI highlights the inequalities in education and health indicators across states, drop in the coefficient variation of HDI indicates improvement in education and health indicators in poorer states and its diminishing gap in comparison with national average. Policy advocacy and implementation are also important to describe the regional disparity. A recent study using NFHS 4 data showed coefficient effect to play a lead role in the lower tail of distribution of stunting among poor performing states, and incompetent policy coverage on controlling the contributors was found responsible for the worse outcomes in those states (Banerjee & Dwivedi, 2020).

Clearly, performance of southern states with respect to child stunting appears to be significant with its comparators. Earlier studies argued that the southern states have not only observed demographic and epidemiologic transition but also have advanced level of human development indicators and better provisions of public services (Paul et al., 2004). As argued by Cavatorta et al. (2015), coefficient effects in such comparison amass several potential effects and do not provide specific information regarding factors or actions. However, health and nutritional-centric policies and programmes have an important role in this context. As documented in the literature, dramatic improvement in child nutritional status in Vietnam during 1990 was supported by remarkable consistency of the strong coefficient effects with health, food and nutrition policies introduced in that period (O'Donnell et al., 2009). In India also, comparison between superior performing state (Tamil Nadu) and the inferior performing states showed effective implementation of ICDS, Public Distribution System, Noon Meal

Scheme in the school to play an important role in child anthropometric outcomes. Arguably, such programmes have potential to influence both the slope coefficients and the intercept independently. For example, growth monitoring can arrest growth and height can be improved independently (Cavatorta et al., 2015).

States in the central region are not only underdeveloped in terms of human development indicators but also the provision of various services and amenities are poor (Paul et al., 2004) which resulted in poor nutritional outcomes for children. Further, our results also suggest that the differences in implementation of various nutrition-centric policies between the central and southern regions are also responsible for such outcome. Surprisingly, such differences between southern and western regions are also observed, which requires deeper investigations.

Our results also indicate that equalizing few endowments have potential to reduce disparities in nutritional outcomes among children between the southern, eastern and the north-eastern regions. Among the endowments, mother's BMI, education and household affluence are amenable by defining policy priorities and implementing those. Other studies in Maharashtra and Odisha also showed that childhood stunting was reduced because of enabling environment of national programme and effective implementation of state-level interventions targeting poverty, food security, health and nutrition (Haddad et al., 2014; Kohli et al., 2017). To note, India has prioritized public provision for nutrition-sensitive programmes in the recent past aiming reduction in child undernutrition, though separate policy document in nutrition is yet to come up in many states. We recommend inter-regional variations of factors affecting childhood stunting and level of implementation should be focussed in nutritional policy of different states, particularly central and northern states. Additionally, there should be enough scope to corroborate policies on agriculture and livelihood generation with in the nutrition policy. It may be mentioned that currently, in rural Bihar, healthy practices regarding reproductive, maternal, neonatal and child health have increased significantly in 11 districts through the intervention supported by 18 centrally sponsored and 30 state-specific specific schemes (Saggurti et al., 2018).

We believe that continuous effort on nutrition sensitive programmes may reduce child undernutrition in the long run. We suggest interventions integrating income generation, health and nutrition awareness should be further scaled-up in other underdeveloped states as well. Convergence and coordination among the allied administrative departments along with a justifiably funded comprehensive framework is highly essential to deliver best outcome of the schemes (Acharya et al., 2017). Previously also, it was suggested that identification and differentiation between severe and moderate stunting cases and adopting multi-sectoral approach to counter that can be helpful in managing and reducing childhood stunting in India (Banerjee & Dwivedi, 2020). In line with Gillespie et al. (2013), we conclude that apart from scaling up the nutrition-sensitive interventions, considering the policy processes, outcomes and their political underpinnings are also needed to be critically addressed to reduce childhood stunting in India.

Notes

1. Women's empowerment index was created from factor scores of the principal component analyses using different binary variables indicating women's household decision-making power, freedom of movement, etc. In NFHS 3, variables were—final say on how to spend money, final say on own health care, final say on household purchases, final say on visit relatives or friends, work for cash in the past 12 months, having bank account. In NFHS 4, the variables were—who decides on own health care, who decides on how to spend money, who decides on household purchases, who decides on visit relatives or friends, owning house/land, work for cash in the past 12 months, having bank account, and having mobile. Factor scores were normalized before using them in models.
2. Maternal dietary diversity index was also normalized. Factor scores created from consumption of milk, pulses/beans, green leafy vegetables, fruits, egg, fish, and chicken were categorized as consumed almost regularly or irregularly using principal component analysis.

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Chapter 8
How Long We Will Wait to Celebrate the First Birthday of Infants in India?

Dishari Dasgupta, Krittika Dirghangi, Sankha Mitra, Subangi Saha, and Mousumi Dutta

8.1 Introduction

To address the world's major development challenges with health and its related areas, the United Nations set up eight specific goals known as Millennium Development Goals (MDGs) in 2000 and targeted to achieve these goals by 2015. Among these eight goals, MDGs 4 and 5 are related to infant mortality rate (IMR).[1] IMR is regarded as an important indicator of the socio-economic development (Daugherty & Kammeyer, 1995) and health status of a nation. It reflects the overall living standard of the people and the effectiveness of policies for improving the child and maternal health. MDGs state that IMR should be reduced to two-thirds between 1990 and 2015. More specifically, the MDG sets a target of reducing IMR to 27 per thousand live births by 2015. India at present has an IMR of 33 per 1000 live births.

If we look at the history of IMR in India, until 1920, it had fluctuated at a high level (230 infant live births per 1000 live births) due to chronic food shortages, influenza, and severe epidemics like smallpox, malaria and typhoid, and poor sanitary conditions. Since 1920, there has been a steady decline in IMR, and the reduction has been faster after the 1970s due to the government's efforts to extend health services to the villages (Jain, 1985). The government's universal national immunization program (*free vaccine for all children*), promoted in the mid-1980s, helped to reduce IMR drastically from 110 in 1981 to 70 in 1997 (Claeson et al., 2000).

[1] Following the definition of World Bank (2018), IMR has been defined as:
$\text{IMR} = \frac{\textbf{number of deaths under one year of age occurring among live births}}{1000\ \textbf{live births occurring among the population}}$ (in a given geographical area in a given year).

D. Dasgupta · K. Dirghangi · S. Saha · M. Dutta (✉)
Department of Economics, Presidency University, Kolkata, India
e-mail: mousumi.econ@presiuniv.ac.in

S. Mitra
Humanities and Social Sciences Department, Indian Institute of Technology, Delhi, India

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Despite the improvements in IMR, 1 in every 13 children died in the first year of life during mid-1990s (International Institute for Population Sciences, 1995). The Government of India implemented several policies like the Integrated Child Development Services (ICDS, started in 1975), National Rural Health Mission (introduced in 2005), National Policy on Children (introduced in 2013), National Policy on Early Childhood Care and Education (introduced in 2013) to address the challenges related to IMR. In fact, the country was in a race against time to achieve these targets, and the IMR dropped down by an average rate of 4.56% per year during 2010 to 2014 (Kamath, 2015).

Despite this progress, India still is the highest contributor in global share of under-five mortality rate (Bora & Saikia, 2018). Studies indicate that though the nation has improved its position in terms of IMR, there are still a lot of discrepancies across different states, across rural and urban sectors (Saikia et al., 2016; Singh et al., 2011; The Million Death Study Collaborators, 2010; Jain, 1985), across diverse socio-economic classes (Amonker & Brinker, 1997), across various caste (Dommaraju et al., 2008) and religious groups, etc. Studies have recognized that a very high proportion of total infant deaths occur in the neonatal period (Vaid et al., 2007) and identified determinants of NMR and PNMR. Papers based mainly on National Family Heath Survey (NFHS) data and Sample Registration System (SRS) data have identified the factors like mother's age at birth, availability of health care facilities, female unemployment and literacy, political competition, parental education, pervasive and persistent influence of ethnicity, geo-spatial factors, toilet facility, affecting IMR and NMR (Athreya & Chunkath, 1998; Barenberg et al., 2016; Choudhury, 2015; Ghosh & Bharati, 2010; Mukherjee et al., 2019; Verma et al., 2005).

The focus of the present study is on state-wise variations of IMR in India. We have considered a period of two decades (1997–2017) to understand the rural–urban trends in IMR across different states; using choropleth map, we have identified the hotspots over the years, and statistical analysis has captured the range of variation and nature of inequality across states, while a regression analysis has identified macro-determinants of state-level IMRs.

The structure of the paper is as follows:

Section 8.2 presents research questions, while Sect. 8.3 illustrates the data sources, provides justification for choice of variables, presents the profile of the sample, and explains the methodology. The section after that consists of analysis of rural and urban trends of IMR, choropleth map-based analysis, statistical and regression analysis, and their implications. Section 8.5 summarizes the findings and suggests some policy measures.

8.2 Research Questions

Unlike most of the research in IMR which are based on individual level data, we have undertaken a state-level analysis and tried to identify the targeted macro-policies which may help to eradicate the state-wise variations leading toward the success of the nation in achieving MDG and/or SDG targets in IMR. The study will address the following questions:

- What are the trends in IMR across states (excluding the union territories and the North Eastern states)? Is there still a considerable rural–urban gap?
- Are there any hotspots?
- What are the macro-determinants of IMR across different states in India?
- What might be directions of public policy to achieve MDG?

8.3 Data and Methods

8.3.1 Data

We have considered the ***Sample Registration System*** (SRS) bulletins for the period 1997–2017 both for studying the trends of IMR and developing the relevant choropleth maps.

For the regression analysis apart from the SRS bulletins, we have considered several macro-indicators which can be considered as policy variables at state levels. The data for these variables have been collected from different sources like.

- Office of Registrar General, Government of India
- India Handbook of Statistics of Reserve Bank of India
- Indiastat Online
- Ministry of Statistics and Program Implementation data for the years 2005–2016
- Niti Aayog

A complete list of variables along with the data source is given in Table 8.1.

Interpolation technique has been used to prepare the dataset as per requirement. The selection of variables can be justified as follows:

Per capita state domestic product (SDP) has been used as a proxy of per capita income (PCY). We have adjusted the data by inflation rate:

$$\text{SDP per capita of year } j = \text{Nominal SDP per capita of year } j * \frac{\text{Inflation rate of base year(2011)}}{\text{Inflation rate of year } j}$$

Variables such as per capita electricity consumption and urbanization have been used as indicator of standard of living. PCY and these variables have been used in the analysis following the Theory of Demographic Transition (Thompson, 1934; Landry, 1934; Notestein, 1945) which states that as the income rises from a low value and standard of living starts improving, the death rates fall. Arik and Arik (2009) find per capita GDP to be a significant determinant of IMR. Fayissa and Traian (2013) estimate a health production function for 13 East European countries, and the findings of the study suggest that GDP per capita and residence in urban areas, along with

Table 8.1 Variables with data source

Variables	Definition	Data source
IMR	Infant mortality rate—number of deaths per 1000 live births of children under one year of age	Sample registration system, SRS bulletins
PCY	Per capita SDP	Reserve Bank of India handbook of statistics
PCE	Per capita electricity—annual per capita consumption of electricity in Kilowatt hour	Indiastat online
Urbanization	Ratio of urban population to total population	Registrar general of census in India, primary census abstract
F_LITERACY	The ratio of the literate female population aged 7 years and above to the total female population in the same age group and is expressed as a percentage	Registrar general of census in India, primary census abstract
Immunization	Percentage of children fully immunized	Niti Aayog
HOSP	Hospitals per lakh population	Ministry of statistics and program implementation, statistical yearbook
MILK_PC	Availability of milk per capita	Reserve Bank of India handbook of statistics

some other factors significantly reduce IMR. Baird et al. (2011) in a study conducted for 59 developing countries find a negative relation between per capita income and IMR, female infant mortality being more sensitive to negative income shocks.

A number of researches show that availability of better medical facilities increases the possibility of better antenatal and postnatal cares offered by trained health providers, delivery at a health facility with trained medical attention and proper hygienic conditions, and this helps in reducing IMR (Jain, 1985; Rutstein, 2000). Vaid et al. (2007) also find that better health care facilities address issues like perinatal asphyxia, pre-maturity and acute respiratory distress, deaths due to diarrhea and respiratory infections which are the causes of fifty percent death in neonatal period. In a study across the high focus states of India by Gupta et al. (2016), the findings suggest that districts with higher proportion of 24-h primary health care facilities have lower IMRs. Farag et al. (2012) in a study conducted using data from 133 middle- and low-income countries finds health spending to be significant in reducing IMR. The findings highlight the importance of investing in health care to reduce IMR. Another important factor is immunization. According to Shimouchi et al. (1994), immunization coverage (IMC) may work as a single indicator representing the availability of primary health care (PHC) services in developing countries. In our study, we have considered hospital per lakh population as an indicator of medical facilities and percentage of immunized children across states to capture state-wise variations in IMR.

The slow decline or stagnancy in IMR despite of presence of adequate health care facilities and services might be explained by low rates of female literacy. Boehmer and Williamson (1996) and Gokhale et al. (2002) show that higher the female literacy, better the use of maternal and child health care (MCH) services reducing the rate of infant mortality. A study by Saurabh et al. (2013) also found IMR to be declining with improving female literacy rates, for Indian states. Schell et al. (2007) found female education to be a significant determinant of IMR in low-income countries. Pamuk et al. (2010) find mother's education to be more impactful in infant survival than household wealth and conclude that policies for increasing female education should be primary policies to address the issue of child health. The present paper considers the ratio of the literate female population aged 7 years and above to the total female population in the same age group explaining the state IMRs.

Apart from income, urbanization, health care facilities, and female literacy, nutritional status of the mother is an important determinant of nutritional status of babies and IMR. To capture the nutrition aspects, we planned to consider the availability of food and milk across states to explain state-wise variations in IMR. In absence of continuous data on availability of food grains in our study period, we have considered the availability of milk per capita indicating the state of nutrition across different states. Further, we may note that milk is a merit want.

Table 8.2 presents state-wise profile of our sample in terms of IMR, PCY, consumption of electricity, urbanization, female literacy, immunization, availability of medical facilities, and consumption of milk for the years 2005–06, 2011–12, and 2016–17.

From the sample profile, we can infer that the infant mortality rate (IMR) has reduced steadily over the years from 2005–06 to 2016–17. As for the 2016–17 data, Madhya Pradesh and Kerala have the highest (47) and lowest (10) IMR, respectively, among all the states.

Per capita income (PCY) too increased steadily over the years for all states indicating that the standard of living of the people has improved. Per capita electricity consumption (ELEC_PC) have also increased from 2005–06 to 2016–17 for all states excepting Odisha. Urbanization (URBANIZATION) has also increased steadily from 2005–06 to 2016–17 with the rate of increase being maximum for Maharashtra among all the states.

Female literacy rate (F_LIT) also increased over the years for all states which could be attributed to the fact of declining IMR.

Immunization rate (IMMUNIZATION) has also increased over the years with Tamil Nadu being the exception. In Tamil Nadu, the immunization rate has reduced from 80.9 in 2005–06 to 69.7 in 2016–17. Hospital per lakh population (HOSP) has steadily increased from 2005–06 to 2016–17 indicating improvement of medical facilities with Andhra Pradesh being the exception. In Andhra Pradesh, values have reduced from 0.62 in 2005–06 to 0.31 in 2016–17. Increase in hospital per lakh population is maximum for Kerala with 0.56 in 2005–06 to 3.83 in 2016–17.

Availability of milk per capita (MILK_PC) has also increased for all states over the years.

Table 8.2 Sample profile

2005–2006

States	IMR	PCY	ELEC_PC	Urbanization	F_LIT	Immunization	HOSP	MILK_PC
Andhra Pradesh	57	32,885	784	0.27	53.88	46.0	0.62	0.09
Assam	68	21,434	169	0.07	59.28	31.4	0.32	0.02
Bihar	61	9582	83	0.10	40.46	32.8	0.10	0.05
Chhattisgarh	63	23,439	549	0.16	55.22	48.7	0.54	0.03
Gujarat	54	44,021	1315	0.36	63.04	45.2	0.83	0.12
Haryana	60	49,297	1079	0.26	53.78	65.3	0.56	0.21
Himachal Pradesh	49	43,052	852	0.06	70.80	74.2	2.05	0.13
Jammu and Kashmir	50	27,079	684	0.23	48.36	66.7		0.11
Jharkhand	50	21,353	603	0.21	45.50	34.2	0.14	0.04
Karnataka	50	36,398	733	0.32	61.38	55.0	0.72	0.07
Kerala	14	43,062	419	0.26	89.58	75.3	0.57	0.06
Madhya Pradesh	76	19,378	549	0.25	53.86	40.3	0.45	0.09
Maharashtra	36	48,896	927	0.30	70.56	58.8	1.04	0.06
Odisha	75	21,959	700	0.11	55.90	51.8		0.03
Punjab	44	42,178	1376	0.32	66.30	60.1	0.58	0.32
Rajasthan	68	23,623	587	0.23	47.20	26.5	0.74	0.13
Tamil Nadu	37	41,065	999	0.44	68.00	80.9	0.59	0.08
Telangana	57	33,775	784	0.27	53.88	46.0		
Uttar Pradesh	73	16,570	325	0.19	48.20	23.0	0.15	0.09
Uttarakhand	42	34,304	680	0.23	63.80	60.0		0.12

(continued)

Table 8.2 (continued)

States	IMR	PCY	ELEC_PC	Urbanization	F_LIT	Immunization	HOSP	MILK_PC
2005–2006								
West Bengal	38	28,803	405	0.28	64.0	64.3	0.70	0.04
2011–2012								
Andhra Pradesh	43	69,000	1157	0.28	59.10	68.0	0.56	0.14
Assam	55	41,142	250	0.15	66.30	59.1	0.49	0.03
Bihar	44	21,750	134	0.11	51.50	49.0	0.22	0.06
Chhattisgarh	48	55,177	672	0.23	60.20	57.3	0.85	0.04
Gujarat	41	87,481	1663	0.4	69.72	56.6	0.74	0.16
Haryana	44	106,085	1628	0.34	65.90	71.7	0.61	0.26
Himachal Pradesh	38	87,721	1289	0.11	75.90	75.8	2.18	0.16
Jammu and Kashmir	41	53,173	1015	0.27	56.40	66.6	0.73	0.13
Jharkhand	39	41,254	790	0.23	55.40	59.7	1.66	0.05
Karnataka	35	90,269	1081	0.37	68.10	78.0	1.50	0.09
Kerala	12	97,912	594	0.26	92.10	81.5	1.34	0.08
Madhya Pradesh	59	38,551	672	0.28	59.20	42.9	0.63	0.11
Maharashtra	25	99,564	1204	0.44	75.90	78.6	1.22	0.08
Odisha	57	48,370	1146	0.17	64.00	59.5	4.17	0.04
Punjab	30	85,577	1799	0.39	70.70	83.6	0.77	0.34
Rajasthan	52	57,192	927	0.24	52.10	53.8	1.20	0.20
Tamil Nadu	22	92,984	1277	0.54	73.40	77.3	0.81	0.10

(continued)

Table 8.2 (continued)

States	IMR	PCY	ELEC_PC	Urbanization	F_LIT	Immunization	HOSP	MILK_PC
2005–2006								
Telangana	43	91,121	1157	0.28	59.10	68.0	0.56	
Uttar Pradesh	57	32,002	450	0.22	57.20	40.9	0.43	0.11
Uttarakhand	36	100,305	1232	0.28	70.00	71.5	6.89	0.14
West Bengal	32	51,543	564	0.28	70.50	64.9	0.72	0.05
2016–2017								
Andhra Pradesh	34	97,086	928	0.28	63.45	65.3	0.31	0.14
Assam	44	53,745	200	0.17	72.15	47.1	3.89	0.03
Bihar	38	25,825	165	0.11	60.70	61.7	0.99	0.08
Chhattisgarh	39	65,948	735	0.26	64.35	76.4		0.05
Gujarat	30	131,281	1352	0.42	75.25	50.4	0.80	0.21
Haryana	33	148,193	1245	0.37	76.00	62.2		0.35
Himachal Pradesh	25	122,208	1119	0.12	80.15	69.5		0.19
Jammu and Kashmir	24	60,946	632	0.28	63.10	75.1	1.05	0.19
Jharkhand	29	48,826	576	0.24	63.65	61.9	1.68	0.06
Karnataka	24	131,260	927	0.39	73.70	62.6	0.35	0.12
Kerala	10	129,256	565	0.25	94.20	82.1	3.83	0.08
Madhya Pradesh	47	53,253	582	0.28	63.65	53.6		0.19
Maharashtra	19	132,899	1001	0.50	80.35	56.3		0.09
Odisha	44	66,240	398	0.19	70.80	78.6	4.26	0.05

(continued)

Table 8.2 (continued)

2005–2006

States	IMR	PCY	ELEC_PC	Urbanization	F_LIT	Immunization	HOSP	MILK_PC
Punjab	21	105,848	1505	0.42	74.40	89.1	0.87	0.41
Rajasthan	41	71,076	694	0.24	56.20	54.8	1.10	0.30
Tamil Nadu	17	121,378	1206	0.60	77.90	69.7	1.39	0.10
Telangana	31	121,568	1192	0.28	63.45	68.1		0.06
Uttar Pradesh	43	38,965	368	0.23	64.70	51.1	2.00	0.14
Uttarakhand	38	138,286	1042	0.30	75.20	57.7		0.17
West Bengal	25	60,618	467	0.29	76.00	84.4	1.72	0.06

8.3.2 Methodology

Firstly, we consider the trends in IMR for all India and rural and urban counterparts for the years 1997–2017. This is followed by the analysis of all the states (excluding Goa, Himachal Pradesh, North Eastern states, and the union territories). For the study of performance of states, the states were broadly divided into three categories:

- Category 1: The states achieving MDG 4 by 2011
- Category 2: The states achieving MDG 4 by 2017
- Category 3: The states yet to achieve MDG 4 after 2017

These have been done to study the performance of the country and the states in terms of IMR over the two decades. The trend analysis helps us to compare the states in terms of their success in reducing IMR and assess the nature of their progress over the years.

Next, choropleth maps of IMR have been prepared for the years 1997, 2005, 2011, and 2017 to study the transition in performance of states over the years and to identify the hotspots. Geo Da software has been used to develop the maps. Keeping the target rate (27 per thousand live births) in mind, the states have been broadly classified into five categories:

- IMR below 15
- IMR between 15 and 25
- IMR between 25 and 28
- IMR between 28 and 40
- IMR above 40

For preparing the choropleth maps for IMR (overall, rural, and urban), all the states (including Goa, Himachal Pradesh, and North Eastern states) were considered. While the states in the first two categories have already achieved the MDG 4 target, those in Category 3 (IMR between 25 and 28) are just achieving it. The last two categories consist of states that are yet to achieve the MDG 4 target. The states having low IMR have been assigned lighter color shades, and those having high IMR have been assigned dark color shades. The transition of a state from a darker to a lighter color shade denotes a decline in IMR over the years. Maps have been prepared for all India, rural and urban India.

Finally, to understand the impact of various macro-economic indicators on IMR, a panel data analysis has been considered for the period 2005–2016 for all the major states in the country. The total number of states considered is 21, whereas the number of time points is 12 years giving 252 observations for the analysis. Our data are a balanced panel data.

8.4 Results

8.4.1 Trends in Rural–Urban IMR

Although the country has made an impressive progress, there is still a significant difference between urban and rural India as is evident from Fig. 8.1. Urban India has achieved MDG 4 target of 27 before the year 2015, whereas rural India is yet to achieve MDG 4.

The present study focuses on inter-state comparisons in achieving MDG 4. In that respect, the trends in IMR across different states have been prepared and analyzed. As mentioned earlier, we have categorized the states into three groups—the states achieving MDG 4 by 2011, the states achieving MDG 4 by 2017, and the states yet to achieve MDG 4.

8.4.1.1 States Achieving MDG 4 by 2011

Kerala, Maharashtra, and Tamil Nadu are the states which have the historically lower IMR compared to the other states. Among these states, Kerala has achieved MDG target 4 even before 1997 and has maintained a low value of IMR over the years which is remarkable as shown in Fig. 8.2a. Performance of Maharashtra presented in Fig. 8.2b is the next best with the urban region attaining MDG 4 by 2005. Rural Maharashtra has attained MDG 4 by 2014. Performance of Tamil Nadu in attaining MDG 4 is quite balanced as both its rural and urban counterparts have attained the target by 2010 which is evident from Fig. 8.2c.

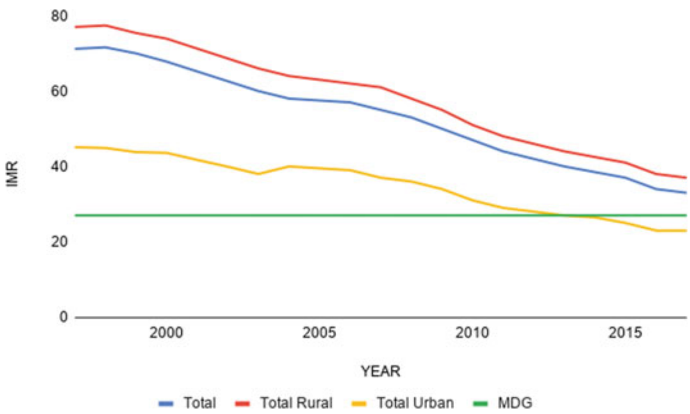

Fig. 8.1 Rural–urban gap in IMR

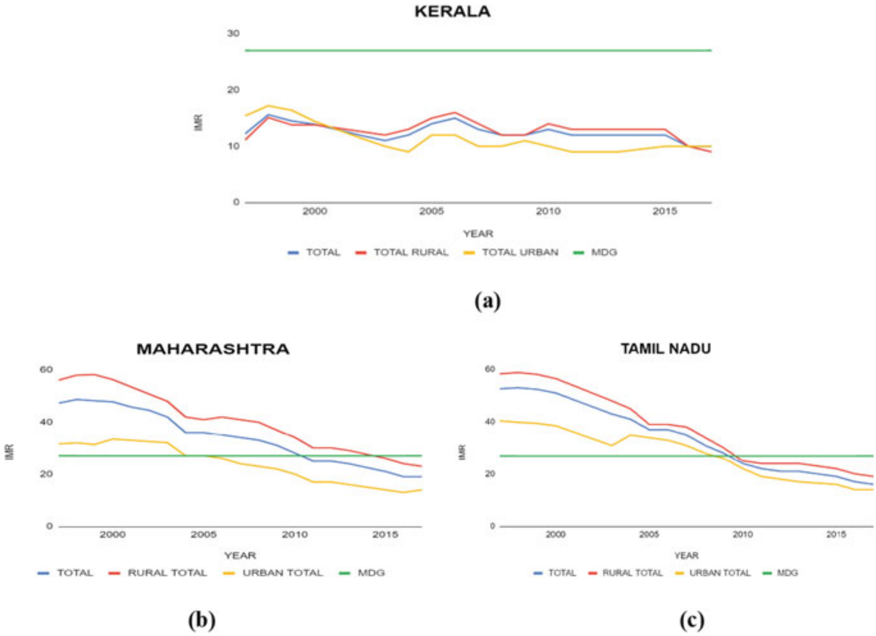

Fig. 8.2 States achieving MDG 4 by 2011

8.4.1.2 States Achieving MDG 4 by 2017

Punjab, Karnataka, and West Bengal are the states achieving MDG 4 by 2017. These states have shown an improvement in the IMR value over the years. Punjab as a whole has attained the target by 2012 with its urban and rural counterparts attaining the target by 2010 and 2014, respectively, as can be seen in Fig. 8.3a. Karnataka, on the other hand, has attained the target by 2015. Performance of its urban region is much better compared to its rural region as the urban had attained the target in 2010, whereas the rural has attained the same a little later than 2015 as shown in Fig. 8.3b. Urban regions of West Bengal too have attained the target by 2010, whereas the state attained the target within 2016 as shown in Fig. 8.3c. In case of West Bengal, the speed at which IMR falls begins to slow down after 2002.

8.4.1.3 States not Achieving MDG 4 by 2017

Majority of the Indian states fall under this category. Andhra Pradesh, Odisha, Haryana, Jharkhand, Telangana, Gujarat, Uttarakhand, and the BIMARU states, namely Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh, are yet to achieve MDG 4 as of 2017. Some of the states belonging to this category had IMR value as high as 100 during 1997 and still is unable to reach the MDG target. However, the

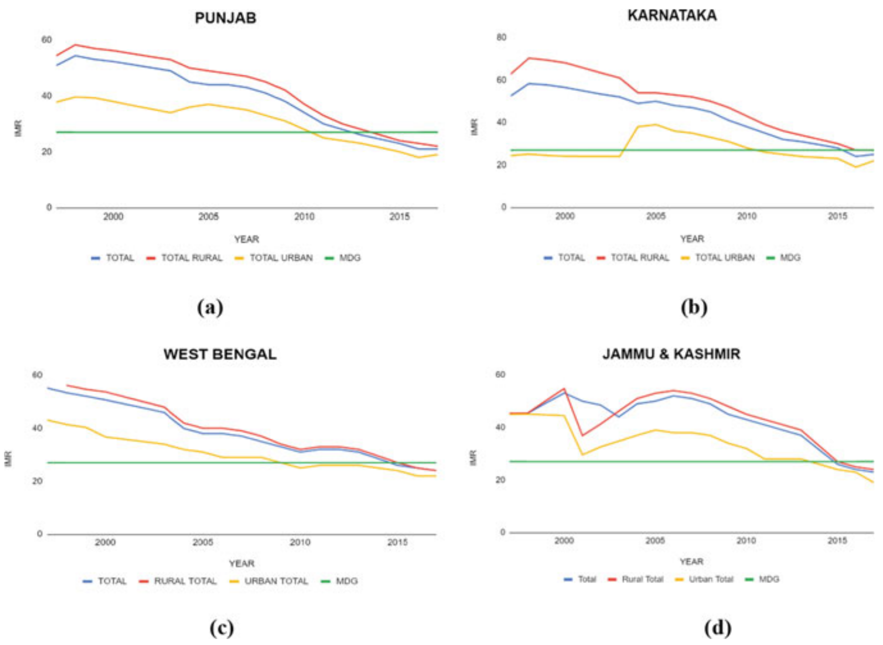

Fig. 8.3 States achieving MDG 4 by 2017

urban counterparts of Andhra Pradesh, Haryana, Jharkhand, Telangana, and Gujarat have been able to achieve MDG 4 around 2015 as shown in the figures below. Uttarakhand (Fig. 8.4g) has shown a peculiar trend where the overall IMR of the state had declined sharply during 2006 followed by a sharp rise in IMR in 2007. The BIMARU states (Figs. 8.4(j), (k), (l), and (m)) had IMR value as high as 100 during the initial years, whereas the average of all states has an IMR of 50. The urban counterparts of these states are in somewhat better position, but the states as a whole still perform poorly.

8.4.2 Choropleth Maps

We have prepared the choropleth maps of IMR across the states, for the four years—1997, 2005, 2011, and 2017, to understand the overall progress in IMR over the years. As we can see from Fig. 8.5, almost the entire map for 1997 has the darkest shade, meaning that the IMR of these states in that year was above 40. In the Northeast, two states have shown better performance as compared to the rest of the country, Manipur with IMR 30 and Mizoram with IMR 19. We can also see that Kerala is far ahead than the rest of the country with IMR 12, followed by Goa (IMR 19).

Moving on to the map for 2005, from Fig. 8.6, we can see that while there are quite a few states which still have IMR above 40, a few states have shown progress. Manipur (13) has entered the first category, followed by Goa (16), Mizoram (18), and Nagaland (20) which belong to the second category. All these states have already achieved MDG 4 (IMR 27) by 2005. Among the states which had the darkest shade in 1997, Maharashtra has shown improvement, with IMR 36 in 2005, followed by Tamil Nadu (37), Arunachal Pradesh (37), and West Bengal (38).

Comparing Figs. 8.6 and 8.7, we can see that there has been a considerable amount of progress during the period between 2005 and 2011. Although a few states still have IMR 40, several states have entered the 28–40 categories including, Punjab (30), Karnataka (35), Himachal Pradesh (38), and Jharkhand (39). The states having entered the categories of 25–28, that is, have achieved MDG 4, are Sikkim (26) and

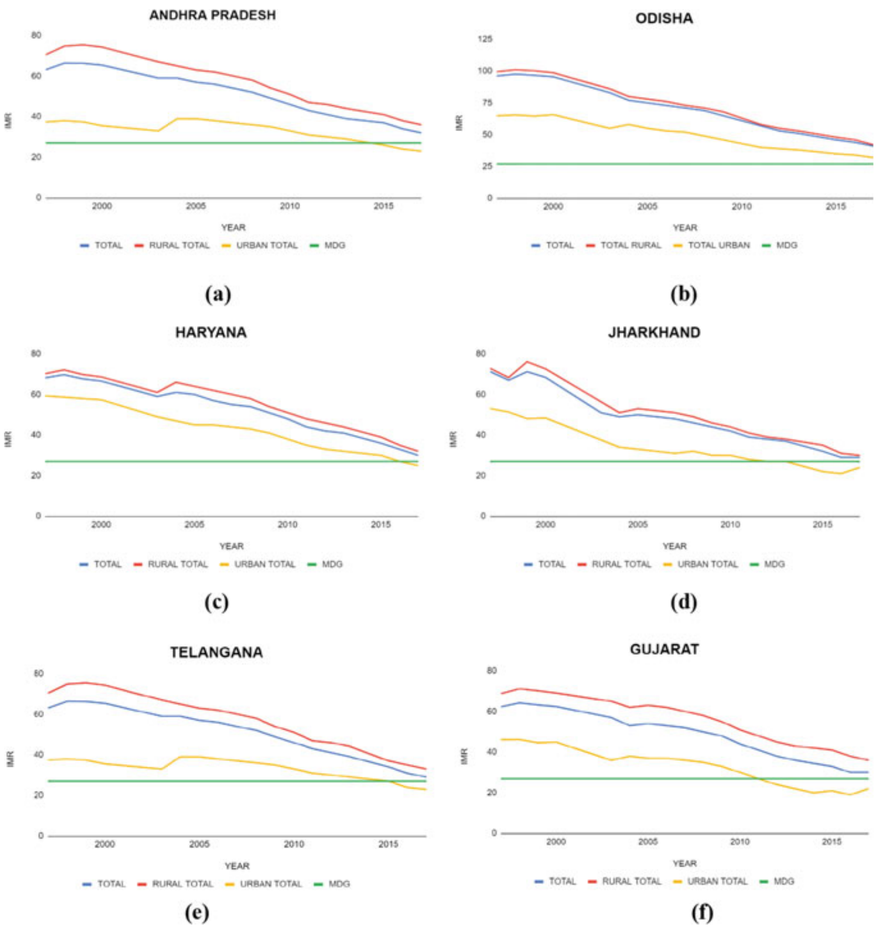

Fig. 8.4 States not achieving MDG 4 till 2017

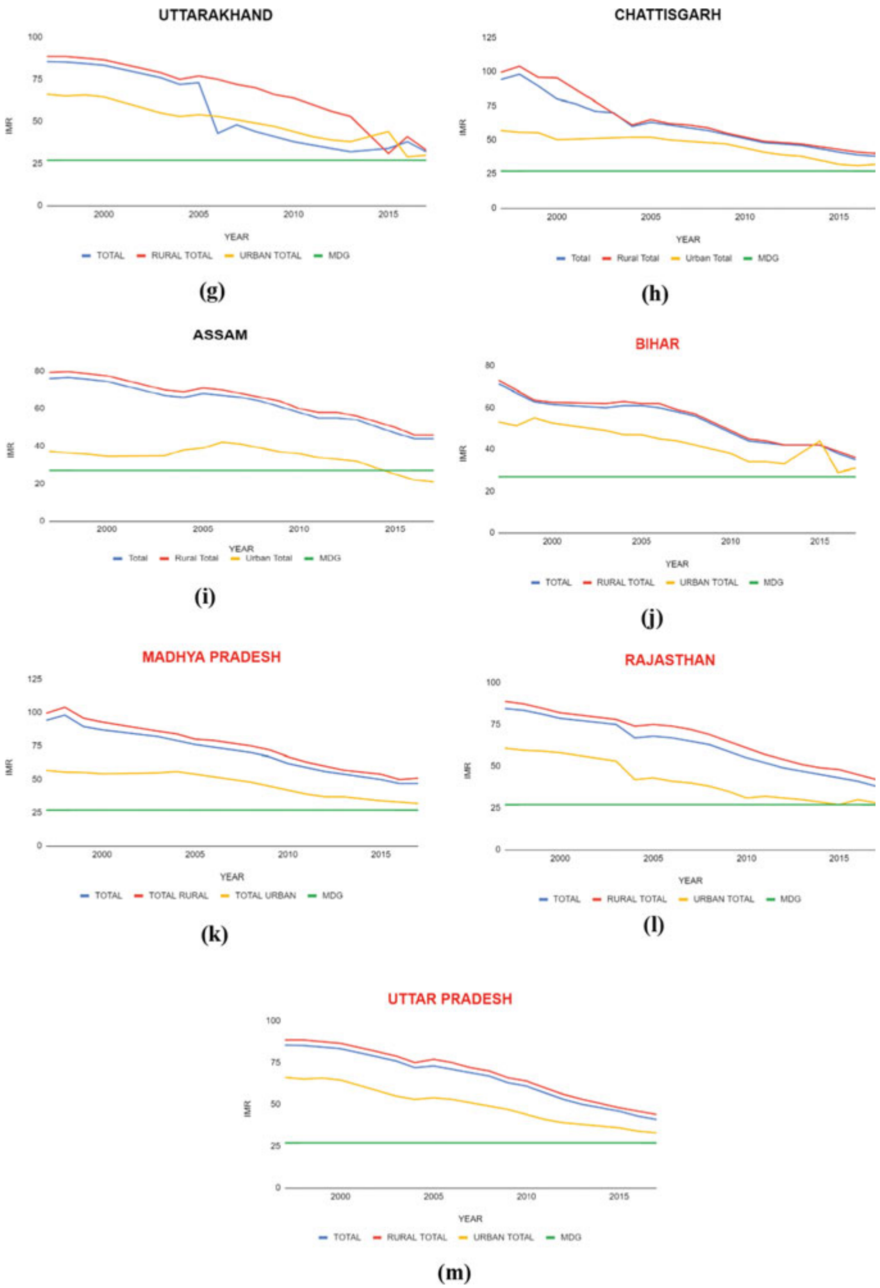

Fig. 8.4 (continued)

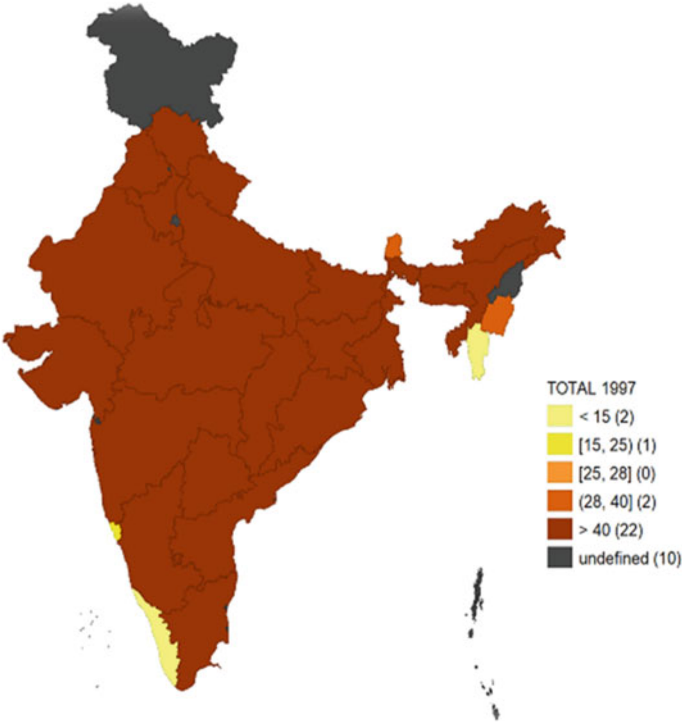

Fig. 8.5 State-wise IMR in 1997

Maharashtra (25). Tamil Nadu (22) has jumped to the category having the second lightest shade. The states having the lightest shade in 2011 are Goa (11), Kerala (12), and Manipur (11).

From Figs. 8.7 and 8.8, we can see the progress in IMR from 2011–2017. As we can see, several more states have achieved MDG 4 by 2017. These states are Himachal Pradesh (22), Karnataka (25), Punjab (21), and West Bengal (24). A few more states are yet to achieve IMR as of 2017 and fall in the Categories 28–40, and they are Andhra Pradesh (32), Bihar (35), Chhattisgarh (38), Gujarat (30), Haryana (30), Jharkhand (29), Rajasthan (38), and Tripura (29). However, states like Arunachal Pradesh (42), Assam (44), Madhya Pradesh (47), Odisha (41), and Uttar Pradesh (41) are still very far behind. They still have IMR above 40 and are nowhere close to achieving MDG 4.

It can be observed from Figs. 8.5, 8.6, 8.7 and 8.8 that the maximum progress has been in the period between 2011 and 2017. There has also been good progress between 2005 and 2011.

Figures 8.9, 8.10, 8.11 and 8.12 aim to show the progress of Urban IMR in the period between 1997 and 2017. As we can see from Fig. 8.9, the urban regions of at least 4 states had already achieved MDG 4 by 1997. However, there were many states whose urban areas still had IMR above 40, followed by around 9 states which

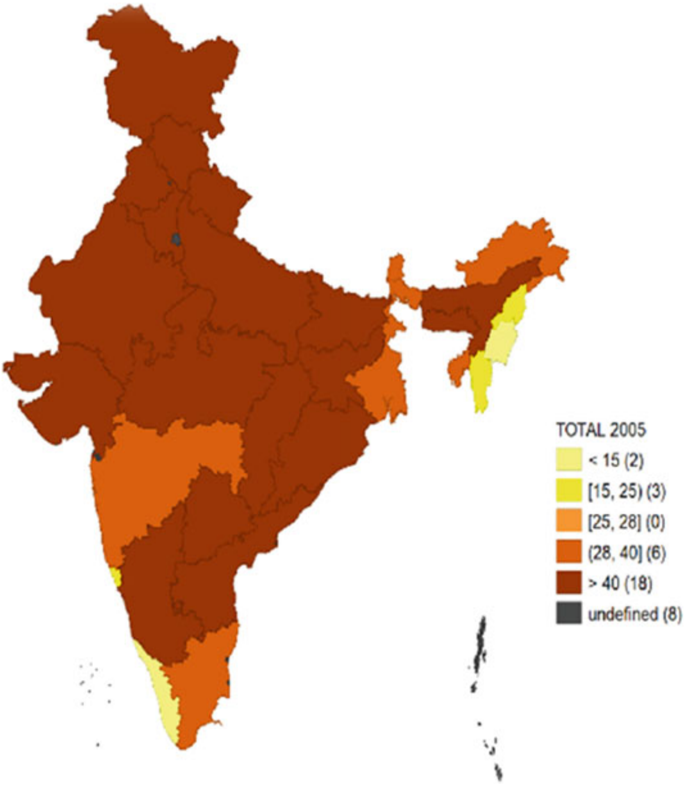

Fig. 8.6 State-wise IMR in 2005

had IMR in the range 28–40 in their urban region. Moving on to Fig. 8.10, in 2005, we do not see much progress, except that the urban regions of very few states have achieved MDG 4, followed by 3 to 4 states which could be said to achieve IMR 27 very soon. But, there still are a number of states which still have urban regions with IMR above 40.

From Figs. 8.10 and 8.11, we can see that there has been good improvement in the period between 2005 and 2011. The urban areas of several states have achieved MDG 4 by 2011, including Kerala, Tamil Nadu, Maharashtra, Himachal Pradesh, and majority of the North Eastern states. Figure 8.12 shows us clearly that the urban areas of majority of the states have achieved MDG 4 by 2017. No state has its urban region with IMR above 40. There still are a few states that are yet to achieve MDG 4 as of 2017.

Figs. 8.13, 8.14, 8.15 and 8.16 aim to show the progress of rural IMR during the study period. Evidently, from Fig. 8.13, we can see that almost all the rural areas of the country have IMR above 40, and only Kerala and Manipur have achieved MDG 4 in 1997. There has been almost no progress in the period between 1997 and 2005,

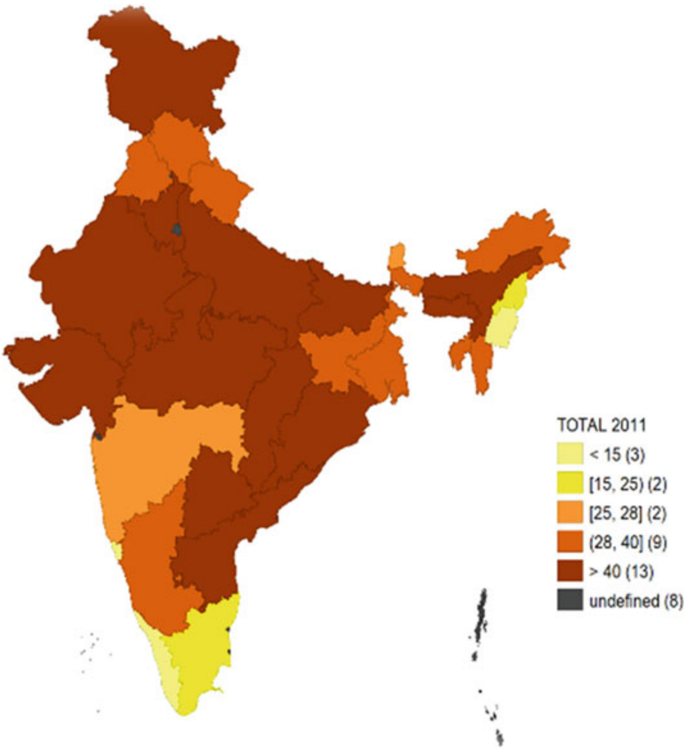

Fig. 8.7 State-wise IMR in 2011

as we can see from Fig. 8.14. Almost all the rural areas throughout the country still have IMR above 40. Only 3 to 4 states have shown progress.

There has been progress in the period between 2005 and 2011. As we can see from Fig. 8.15, even though there remain a large number of states with their rural areas having IMR above 40, and a number of rural areas have achieved IMR in the category 28–40. Three to four states have achieved MDG 4 in their rural areas, and a few others could be said to achieve IMR 27 soon. From Fig. 8.16, we can observe that from 2011 to 2017, there has been good improvement in the IMR of the rural areas of the country. Several states have achieved MDG 4, and several could achieve it soon, as of 2017, but there still are a number of states which have rural areas with IMR above 40, even in 2017.

It is evident from the choropleth map analysis that while all states have shown improvement over the two decades, the urban regions have shown better performance than their rural counterparts. The reason behind this is the rural areas are not as developed as the urban areas. At macro-level, urbanization, better availability of food and milk, hospital facilities, immunization, electricity, more focus on education of women could be fair reasons why the urban regions have shown a better performance.

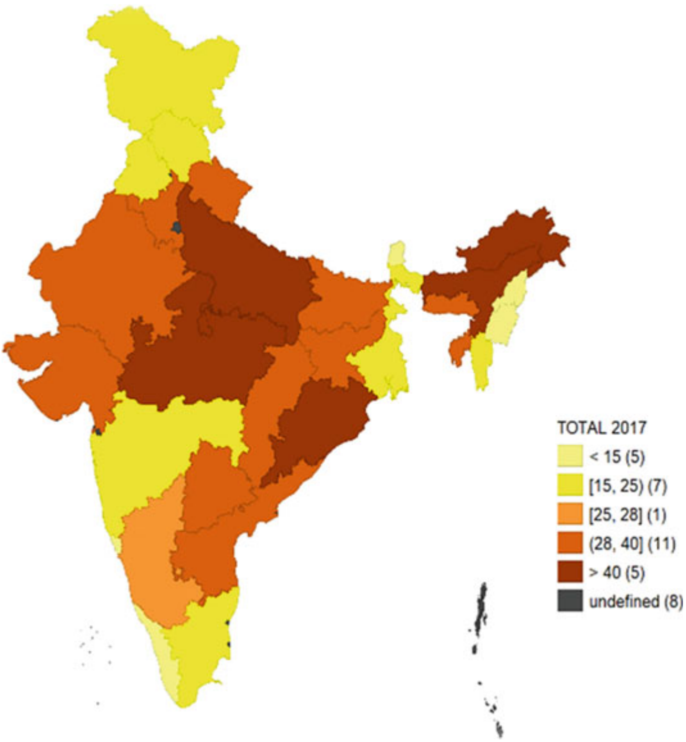

Fig. 8.8 State-wise IMR in 2017

Over the last few decades, however, the government has taken several policy measures and introduced programs that have been effective in improving IMR in both rural and urban areas. The rural–urban gap remains, owing to the more job availability, sanitation facilities, food security in urban areas, than their rural counterparts, but it has reduced from what it used to be in 1997 because of policies taken by the central and state governments. A few states, like the BIMARU states (Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh), were yet to achieve MDG 4 in 2017. According to several studies, the performances of BIMARU states were dragging down the GDP of the country. The literacy rates in Bihar and UP were extremely poor, requiring a complete overhaul of the education system, particularly at the primary level. In the phase from 2008–2011, these states showed rapid development, faster than several other states, causing their IMR to reduce at that point considerably. However, again from 2015 approximately, their growth rates were faltering, which is why IMR did not show much improvement in that phase, leading to the inability to reach MDG 4 level by 2017. Several other states which initially had very high IMR showed great improvement in two decades because of several state-level programs and policies and achieved MDG 4 level by 2017.

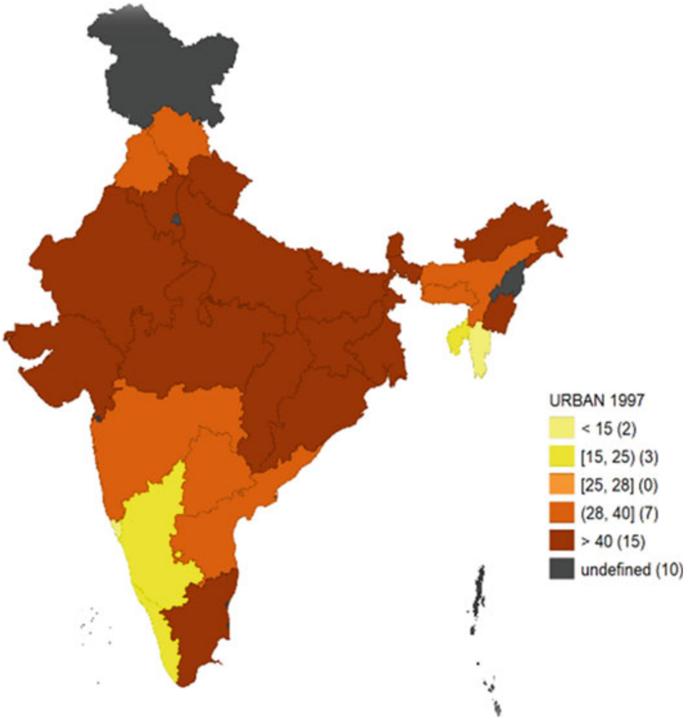

Fig. 8.9 IMR in urban area in 1997

Tables 8.3 and 8.4 present several estimates to check the evidences of urban–rural gap in achieving progress in terms of IMR.

The data we collected on IMR helped us calculate mean, median, and coefficient of variation for India as a whole and also for the urban and rural parts separately. As mean is largely influenced by outliers, we have considered the median as it is more suited for a skewed distribution. We have also used coefficient of variation to understand the variability of IMR across the years. From Table 8.5, we see that we have a decreasing mean and median for all the three categories over the time which is good, but the values are big even at the end of our study period (2017).

From Table 8.5, it can be clearly seen that the value of coefficient of variation is high, and it does not decline with time, implying that the variation in IMR across the states is not declining over time. The persisting variation in IMR across states over time is also evident from the Gini coefficients[2] given in Table 8.5. The values, though not very high, are more or less constant over time, ranging between 0.18 and 0.22 and implying a failure of existing policies to address the variation across states.

[2] *Gini coefficient* $= \frac{\sum_{i=1}^{29}\sum_{j=1}^{29}|x_i - x_j|}{2\sum_{i=1}^{29}\sum_{j=1}^{29}x_j}$, *where* x_i, x_j = IMR *of i*th *and j*th *states, respectively.*

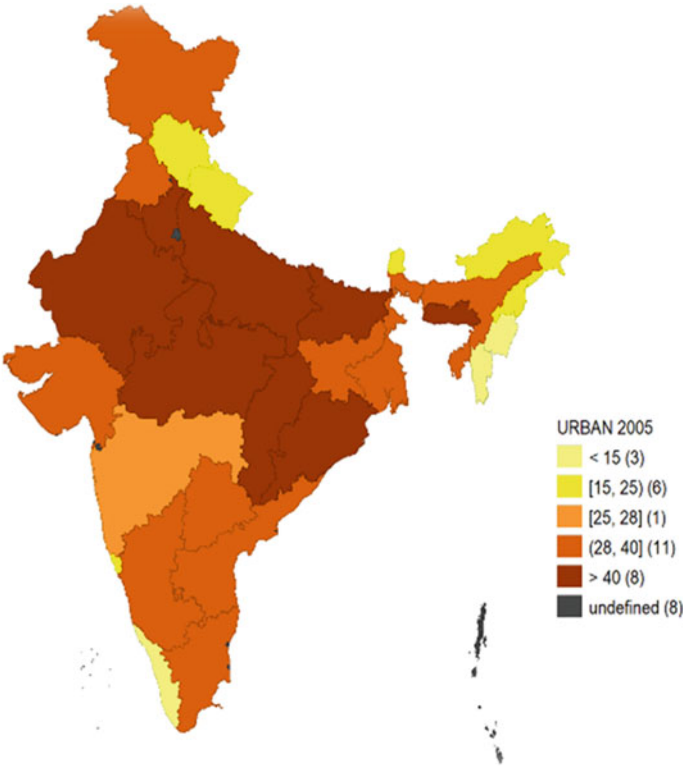

Fig. 8.10 IMR in urban area in 2005

8.4.3 Regression Analysis

To study the impact of various macro-economic variables on IMR, a regression analysis has been done considering the regression model

$$Y_{it} = \beta X_{it} + u_i + e_{it}$$

where Y_{it} : IMR and Xit consists of the following explanatory variables:

- PCY: SDP per capita
- ELECTRICITY_PC: per capita electricity consumption
- URBANIZATION: ratio of urban population to total population
- F_LITERACY: female literacy rate
- IMMUNIZATION: percentage of children fully immunized
- HOSP: hospitals per lakh population
- MILK_PC: availability of milk per capita.

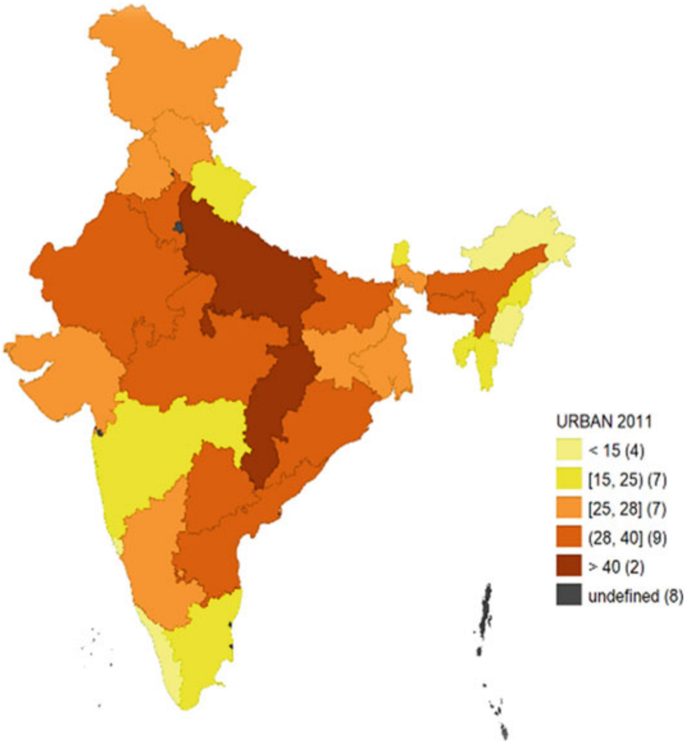

Fig. 8.11 IMR in urban area in 2011

u_{i} Individual specific effect
e_{it} Random error.

Breusch–Pagan Lagrange multiplier test provides chi-square statistic, $\chi^2_{(1)} = 240.61$, with p-value equal to zero indicating that the model is a panel data model. Wu-Hausman test indicates that the model is a fixed effect model. The *within effect model* has been presented in Table 8.5.

The variables (logarithm of) per capita income, urbanization, female literacy, milk per capita are significant at 1% level of significance. This implies that these variables have a significant impact on IMR in at state level. All the coefficients of these variables are negative imply that for an increase in per capita income, urbanization, female literacy, milk per capita, IMR falls significantly. For the variables, urbanization and milk per capita, the values of the coefficients are considerably high −44.41 and −88.04, implying that for unit increase in value of these variables, there is a sharp fall in the IMR.

Percentage of children fully immunized is significant at 5% level of significance. The sign of the coefficient is negative. For 1% improvement in immunization, IMR falls by 0.06%. Per capita electricity consumption and hospitals per lakh population have not appeared to be significant in our model.

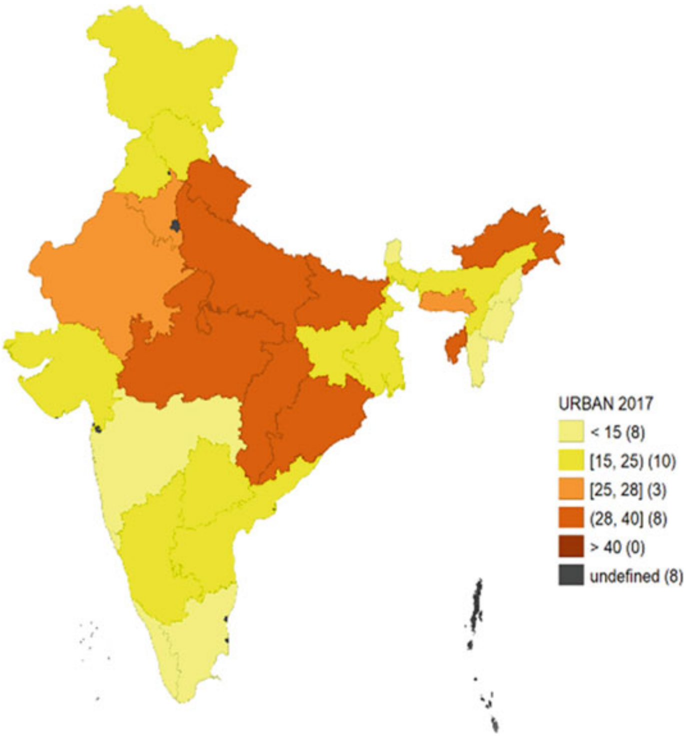

Fig. 8.12 IMR in urban area in 2017

Table 8.6 indicates that West Bengal has been considered as a reference point to compare the state-fixed effects. Coefficient for West Bengal is given by 154.91. Andhra Pradesh and Karnataka are quite similar to West Bengal in terms of these fixed effects. Bihar and Madhya Pradesh are different at 5% and 10% level, respectively. Rest of the states are different at 1% level.

Andhra Pradesh, Chhattisgarh, Gujarat, Haryana, Jharkhand, Kerala, Maharashtra, Odisha, Punjab, Rajasthan, Telangana, and Uttar Pradesh are doing better compared to West Bengal. On the other hand, West Bengal is doing better than states like Assam, Bihar, Himachal Pradesh, Jammu and Kashmir, Tamil Nadu, and Uttarakhand imply an intercept term lesser than.

8.5 Summary and Conclusion

IMR is one of the key indicators of development of a state. Achieving a lower rate of infant mortality must be a target for all the governments. The introduction of

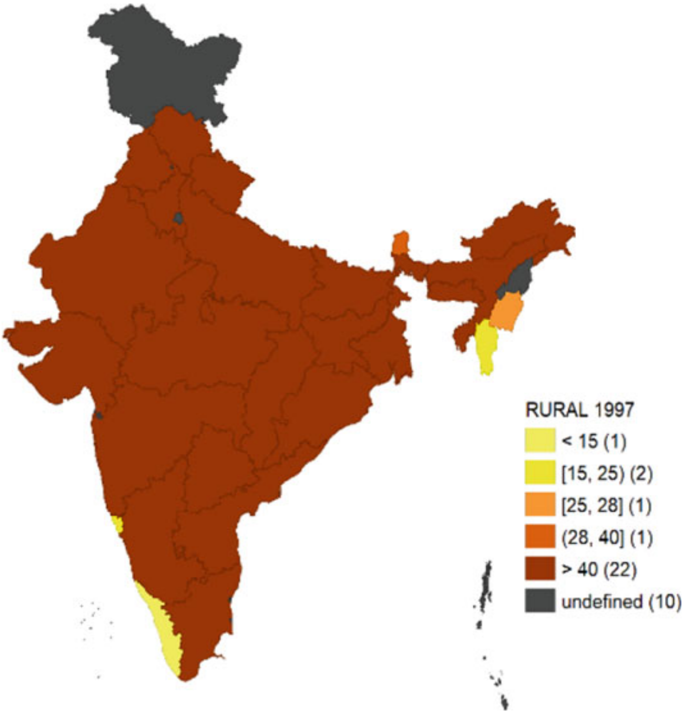

Fig. 8.13 IMR in rural area in 1997

Millennium Development Goals by the United Nations has set up a deadline that can act as a nudge to introduce certain public policies for achieving those targets soon.

In our descriptive analysis using trend lines and choropleth maps, we find an inter-state variation as well as a rural and urban gap in IMR. In 1997, the states like Tamil Nadu, Maharashtra, and West Bengal had an IMR below 60, whereas states like Uttar Pradesh, Madhya Pradesh, Rajasthan, and Odisha had an IMR above 80. Over the years, a decline in IMR has been witnessed for all the states. However, the rate of decline has not been uniform, across the states. There has been a constant urban–rural gap in the performance of the states, but it has reduced in the two decades for most of the states, from 99.5(rural)–66.2(urban) in 1997 to 51(rural)–34(urban) in 2017. For some states like Chhattisgarh and West Bengal, the convergence is remarkable, whereas for states like Madhya Pradesh, the gap is still huge.

The regression analysis suggests that the IMR can be reduced at macro-level by increasing per capita income, urbanization, immunization, female literacy and providing better access to merit wants like milk consumption.

Thus, the poor performance of states like Andhra Pradesh in achieving the MDG target may be explained by the fact that there has been only a marginal increase in the urbanization rate and availability of milk from 2011 to 2016. In addition, the percentage of population immunized reduced from 68 in 2011 to 65.3 in 2016.

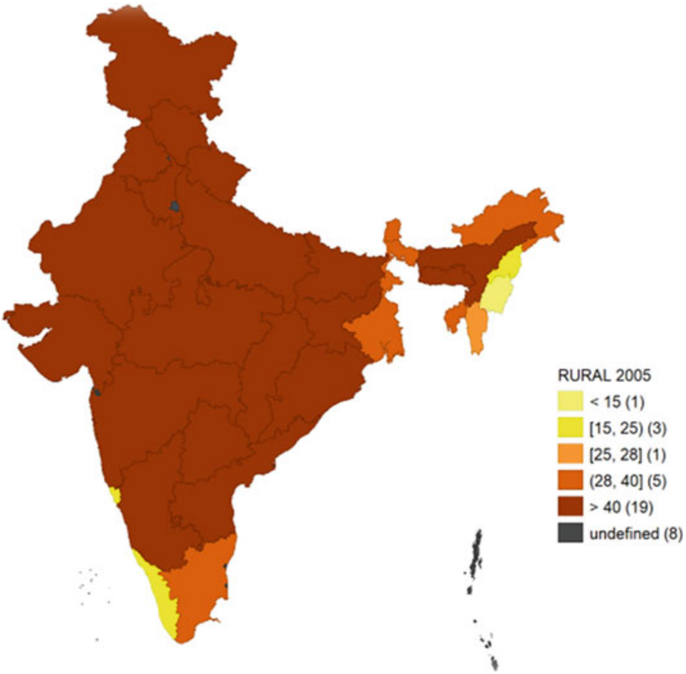

Fig. 8.14 IMR in rural area in 2005

Similarly, the failure of the BIMARU states in achieving the MDG target can be explained by the poor performance of the macro-economic indicators over the years. Further, stagnancy in the IMR in some states, like West Bengal, in the recent years can be explained by declining rates of income growth. The significant presence of state-fixed effects in regression analysis suggests the need for state-specific policies as well to address the IMR.

The female literacy rates of all states including the BIMARU states have increased over the years with the rate of increase being smaller in BIMARU states than the other states. Successful implementation of schemes like "*Beti Bachao Beti Padhao*" (2015) introduced by the central government to address the issues of girl child welfare and education may help to improve the female literacy across the states. The state-level initiatives, like "*Kanyashree Prakalpa"* in West Bengal (2013), *Karnataka Bhagyashree Scheme* in Karnataka, *Majhi Kanya Bhagyashree Scheme* in Maharashtra may open a new dimension in women education and may result in reduction of IMR.

An increase in public health expenditure, setting hospitals with improved health care facilities, and more effective immunization program might ensure the rapid decline in IMR. Regarding public health expenditure, we may mention that the National Health Accounts (NHA) data of 2001–02 show that the total health expenditure (per capita) of the states like Madhya Pradesh, Uttar Pradesh, Bihar, where

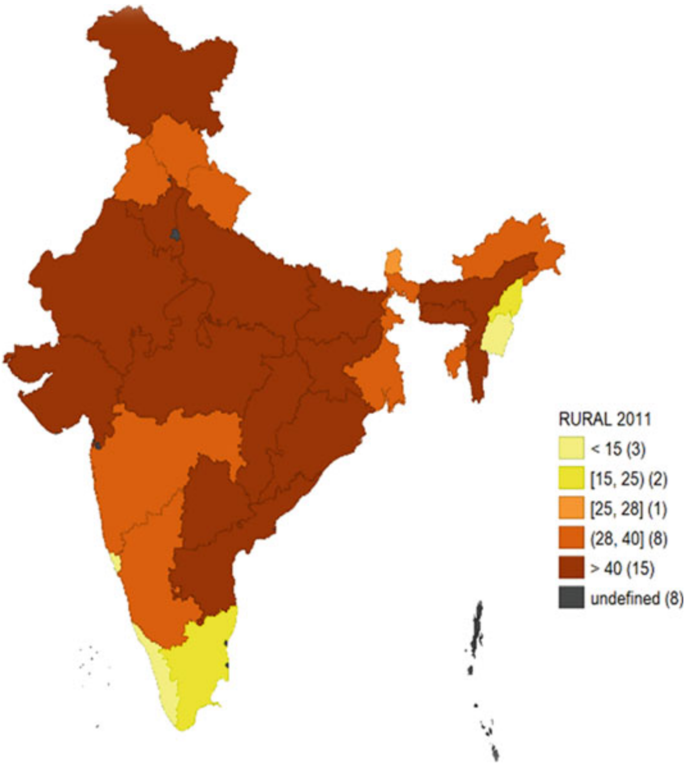

Fig. 8.15 IMR in rural area in 2011

IMR was above 60 in that period and was substantially lower than states like Kerala, Goa (states which already had IMR below 15 in 1997). More specifically, Kerala's share of health expenditure in total expenditure was 5.8% in 2001 and has remained as high in the following two decades, ranging from 4.7 to 5.8%. This is followed by Tamil Nadu and Maharashtra where the share of the state budget spent on health expenditure was 4.9% and 4.3%, respectively, during 2001 to 2017. A comparatively higher share of the state budget spent on health expenditure was probably one of the major reasons why these three states achieved MDG 4 by 2011.

States like Punjab, Karnataka, and West Bengal, achieving MDG 4 by 2017, also showed an increase in the proportion of total expenditure spent on public health and maternal and child welfare since 2005. In 2005, Punjab, Karnataka, and West Bengal spent 3.4%, 3.3%, and 3.9%, respectively, of the total expenditure on health, and these percentages increased to 3.8%, 4.4%, and 4.9%, respectively, in the subsequent years. On the other hand, although there has been some increase in the share of total expenditure spent on public health in the states like Bihar, Madhya Pradesh, Uttar Pradesh, within 2011–2017, the share of total expenditure spent on public health care was low compared to other states. The IMR has been always higher in these states.

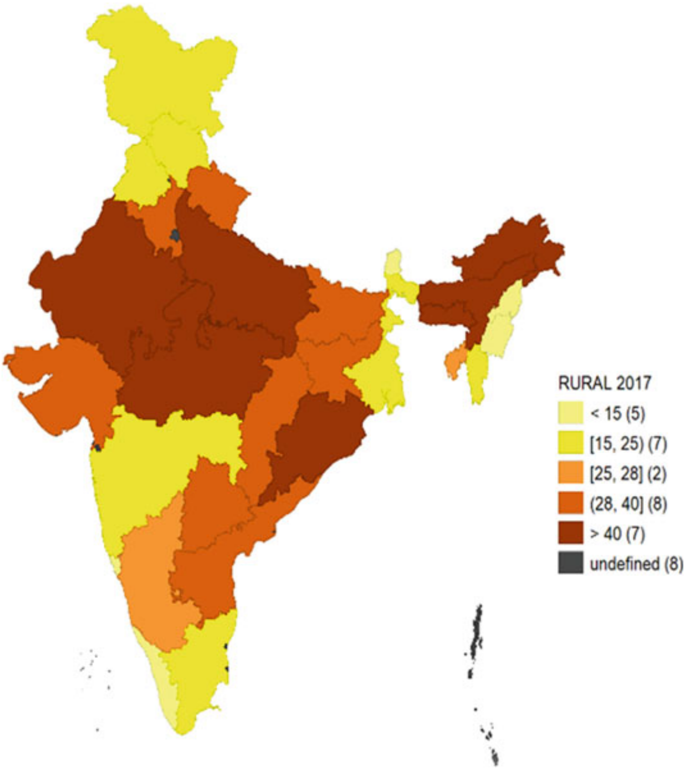

Fig. 8.16 IMR in rural area in 2017

Table 8.3 State-wise variations in maximum and minimum IMR

Year	Total		Rural		Urban	
	maximum	Minimum	Maximum	Minimum	Maximum	Minimum
1997	96.2	12.2	99.5	11.1	66.2	7.2
2005	76	13	80	12	55	10
2011	59	11	63	6	41	9
2017	47	7	51	7	34	7

Table 8.4 Variations in IMR across states

Year	Total				Rural				Urban			
	Mean	Median	CV	Gini	Mean	Median	CV	Gini	Mean	Median	CV	Gini
1997	59.6	62.5	38.9	0.2	63.2	68.7	41.4	0.18	41.7	41.1	38.2	0.2
2005	46.1	49.5	40.7	0.21	49.4	53	40.5	0.21	33.1	37	41.4	0.19
2011	36.9	38	37.3	0.19	39.4	41	37.7	0.19	26.3	27	36.2	0.18
2017	27.3	29	42.2	0.22	29.2	30	41.5	0.21	21.4	22	41.2	0.19

Table 8.5 Results of fixed effect model

Variables	Coefficient	Std. error	*T*	*P*-value
LNPCY	−1.71[a]	0.56	−3.03	0.00
LNELECTRICITY_PC	0.38	0.85	0.45	0.65
Urban	−44.41[a]	9.85	−4.51	0.00
F_LITERACY	−1.14[a]	0.10	−11.92	0.00
Immunized	−0.06[b]	0.02	−2.48	0.02
HOSP	−0.02	0.10	−0.19	0.85
MILK_PC	−88.04[a]	13.61	−6.47	0.00
Constant	158.47[a]	7.21	21.97	0.00
Number of observations	152			
Number of states	21			
R-square (within)	0.9278			
F (7124)	227.61[a]			
Corr (u_i, Xb)	−0.5706			

[a] implies that coefficients are significant at 1% level; [b] implies that coefficients are significant at 5% level

Thus, an increase in the share of health expenditures by state governments could be an effective step toward reducing IMR in these states so that they can reach the MDG 4 target of IMR 27 in the coming years.

In this context, we may mention some of the successful state initiatives. *Karunya Health Scheme* (Kerala, 2012), *Mahatma Jyotiba Phule Jan Arogya Yojana* (Maharashtra), *Chief Minister's Comprehensive Health Insurance Scheme* (Tamil Nadu, 2012), *Mukhyamantri Amrutum Yojana* (Gujarat, 2012) are some of the schemes introduced to provide necessary health care facilities and health insurances, particularly to the poor and lower middle-class families.

Apart from health-related expenditures investments in rural sector, extending the urban facilities in rural areas by providing stable electricity connections, houses with safe drinking water and sanitation facilities, setting schools with proper infrastructure and sanitation facilities and ensuring food security are the different key macro-concerns to address the issues related to IMR. Policies like *Ryuthu Bandhu Scheme* (Telangana), *Kudumbashree* (Kerala), *Yuvasree* (West Bengal), Krushak Assistance for Livelihood and Income Augmentation (KALIA) (Odisha) are some policies ensuring employment and income generation, particularly in the agricultural sector. To address the issue of food security, state governments have taken up initiatives like *Amma Unavagam* (Tamil Nadu, 2012), *Indira Canteens* (Karnataka, 2017), *Chhattishgarh Food Security Act* (2012) (Table 8.7).

Table 8.6 State-fixed effects

States	Coefficient	Std. err	T	P-value
Andhra Pradesh	3.59	2.88	1.25	0.22
Assam	−21.49	2.48	−8.68	0.00
Bihar	−3.50	1.76	−1.99	0.05
Chhattisgarh	17.68	1.67	10.58	0.00
Gujarat	20.76	1.93	10.78	0.00
Haryana	9.69	2.92	3.32	0.00
Himachal Pradesh	−7.52	1.45	−5.19	0.00
Jammu and Kashmir	−19.36	1.47	−13.14	0.00
Jharkhand	3.23	1.63	1.99	0.05
Karnataka	1.23	3.55	0.35	0.73
Kerala	14.72	1.28	11.46	0.00
Madhya Pradesh	3.76	2.16	1.74	0.09
Maharashtra	6.62	2.23	2.97	0.00
Odisha	26.65	2.95	9.03	0.00
Punjab	5.48	1.75	3.13	0.00
Rajasthan	6.54	2.56	2.56	0.01
Tamil Nadu	−11.70	2.75	−4.25	0.00
Telangana	4.55	1.54	2.95	0.00
Uttar Pradesh	8.02	1.66	4.83	0.00
Uttarakhand	−6.50	2.10	−3.10	0.00
West Bengal (Ref)				
Constant	154.91	7.36	21.04	0.00

However, to sum up, the study suggests that the macro-determinants of IMR are inter-related. Adopting policies to ensure good performance with respect to one determinant while neglecting others may impede the decline in IMR. To celebrate the first birthday of all infants in India all over the country, policy decisions should be taken in a more comprehensive manner, in all states. Proper resource allocation must be ensured for implementation of such policies. Special consideration should be given to redistributing public resources so that areas with high poverty have adequate access to health facilities.

Table 8.7 State-wise different schemes on public health and nutrition

States	Programs	Description
Andhra Pradesh	Dr. YSR Aarogyasri	This is the flagship schemes of all the health schemes taken by the state government to give the poor access to good health care. The Dr. YSR Aarogyasri Health Care Trust was set up to facilitate the effective implementation of the scheme
Chhattisgarh	Chhattisgarh Food Security Act (2012)	Health insurance with coverage up to Rs. 3 lakhs for below poverty line and lower middle-class families
Gujarat	Mukhyamantri Amrutam Yojana (2012)	Health insurance with coverage up to Rs. 3 lakhs for below poverty line and lower middle-class families
Karnataka	Indira Canteens	Serves food in civic wards of districts and taluka places of Karnataka
	Karnataka Bhagyashree Scheme	Financial assistance is provided to the girl child through her mother/father/guardian subject to fulfillment of certain eligibility criteria
Kerala	Kudumbashree	A state poverty eradication mission, under the local self-government department
	Karunya Health Scheme (2012)	Provides health insurance coverage for the underprivileged at a nominal premium charge
Maharashtra	Majhi Kanya Bhagyashree Scheme	A program to encourage girls to receive a proper education by financially aiding their respective families
	Mahatma Jyotiba Phule Jan Arogya Yojana	This scheme provides free medical assistance in 488 government empaneled hospitals for 971 types of diseases
Odisha	Krushak Assistance for Livelihood and Income Augmentation (KALIA)	The state provides financial assistance to farmers before the sowing season commences
	Sishu Abond Matru Mrityuhara Purna Narakaran Abhiyan (SAMPURNA)	Launched on 2017, this scheme was introduced to increase institutional deliveries in order to reduce IMR and MMR. The program provides Rs. 1000 transport cost to pregnant women to help them reach hospitals from inaccessible areas

(continued)

Table 8.7 (continued)

States	Programs	Description
Tamil Nadu	Amma Unavagam	The very first food subsidization program run by a state in India
	Chief Minister's Comprehensive Health Insurance Scheme (2012)	Provides quality health care to unprivileged families which fall under the low-income group
Telangana	Ryuthu Bandhu Scheme	Financial help of Rs. 10,000 is offered to each farmer per year
	Aarogyasri	The scheme provides coverage for the services to the beneficiaries up to Rs. 2.5 lakhs per family, per annum on floater basis. Beneficiaries fall below poverty line
West Bengal	Kanyashree Prakalpa	The scheme provides an annual scholarship of Rs. 1000 and a one-time grant of Rs. 25,000 to every girl child aged 13–18
	Yuvashree	This is a scheme which aims to provide employment assistance to the unemployed youths of West Bengal

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Chapter 9
Incidence of Wasted Pregnancy and Health Facilities: An Empirical Study of the Indian Women

Supravat Bagli and Debanjali Ghosh

9.1 Introduction

Maternal and child health is an important issue of concern to the medical practitioner, policymakers and academicians across the globe. Enhancement of maternal and child health has been an important agendum of MDGs and SDGs. According to WHO, maternal health refers to the health of women during pregnancy, childbirth and the postpartum period. Whilst motherhood is often a positive and fulfilling experience, for many women, it is still associated with suffering, ill-health and even death. However, maternal death is quite a widespread phenomenon in some developing countries with 78% of the total deaths worldwide occurring there. In India, the maternal mortality ratio was 241 per lakh live births in 2011. It is quite high as compared to emerging economy standards, Brazil (44) and China (27). Another major indicator of maternal health is wasted pregnancies. The union of the incidence of stillbirth and miscarriage may be considered as wasted pregnancy. A fetus lost after 28 weeks of gestation is known as stillbirth, whilst the termination of pregnancy before 28 weeks is termed as miscarriage. In a study, Blencowe et al. (2016) have stated that India had the highest number of stillbirths in 2015 with an estimated 0.6 million stillbirths annually, thereby accounting for 22.6% of the global burden.

From the IHDS-II (2011–12), we find that 23.5% of the pregnancies ended in fetal loss (wasted pregnancy). One third of the deliveries have occurred beyond the purview of health institutions, and 13% of women did not even receive antenatal care services. Physical health indicators were also performing badly as 29% of women suffered from anemia during pregnancy and reported health condition of 27% of women were not at satisfactory level. Therefore, maternal healthcare utilization is

S. Bagli (✉)
Department of Economics, Presidency University, Kolkata 70073, India
e-mail: supravat.econ@presiuniv.ac.in

D. Ghosh
Analyst-Data Sciences, HSBC, Kolkata, India

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States	Wasted Pregnancy (%)
Jammu & Kashmir	18.94
Himachal Pradesh	29.67
Punjab	41.20
Chandigarh	25.80
Uttarakhand	28.89
Haryana	26.98
Delhi	20.26
Raasthan	29.86
Uttar Pradesh	40.85
Bihar	23.35
Sikkim	15.53
Arunachal Pradesh	8.71
Nagaland	22.44
Manipur	8.23
Mizoram	7.54
Tripura	15.88
Meghalaya	8.95
Assam	10.75
West Bengal	15.86
Jharkhand	29.44
Orissa	13.90
Chhattisgarh	22.20
Madhya Pradesh	31.69
Gujarat	22.20
Daman & Diu	55.10
Dadra Nagar Haveli	13.55
Maharashtra	25.97
Andhra Pradesh	8.264
Karnataka	12.68
Goa	13.12
Kerala	12.87
Tamil Nadu	19.45
Pondicherry	9.04

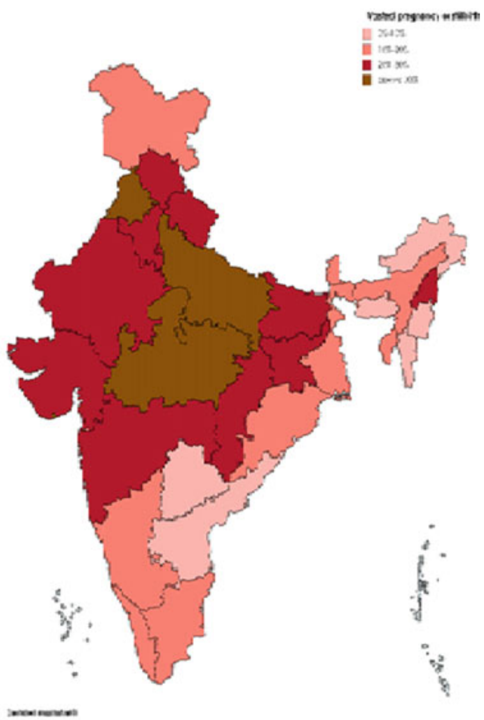

Fig. 9.1 Regional distribution of wasted pregnancies in India. *Source* Authors' compilation based on IHDS-2 data

inadequate in India. Figure 9.1 shows that the incidence of wasted pregnancy is more in the northern and central states compared to the eastern and the southern states in India.

Maternal health plays a vital role in child health development after all in human development. That is why, further improvement of maternal health is considered as a sustainable development goal. So, improving maternal health remains a primary concern for the Governments of India. Section 9.2 presents a brief review of the literature and specifies the research questions. In Sect. 9.3, we explain the methodology and the database used in this chapter. Section 9.4 is devoted to findings and discussion. Finally, Sect. 9.5 concludes the paper along with some policy prescriptions.

9.2 Literature Review

In most developing countries, the condition of mothers remains quite deplorable. Now, we review the existing literature to identify the factors affecting maternal health across the countries. Rana et al. (2005) examine fertility patterns, presence of pregnancy wastage and their relationship to the general health of women in rural Chandigarh, India. Association between fertility patterns and pregnancy wastage in accordance with female health indicates that anemic and underweight subjects have a higher fertility rate and wasted pregnancies. It was also postulated that the mental well-being levels of mothers were negatively related to pregnancy wastage. Similar observations had been made by Gardosi et al. (2013) in his analysis about the main risks related to stillbirth in a multiethnic English population of 92,218 pregnant women for the period 2009–2011. In addition to the above-mentioned factors, ethnicity (African, African-Caribbean, Indian, and Pakistani) and potentially reducible risk factors like maternal obesity, smoking patterns, pre-existing diabetes, antepartum hemorrhage, anemia and fetal growth restriction (low birthweight) together accounted for 56.1% of the stillbirths. Similarly, Altijani et al. (2018) have identified the risk factors associated with stillbirths across nine high stillbirth rate states in India. Socioeconomic disparities in stillbirth are also quite prevalent, whilst maternal and fetal complications and risky lifestyle choices of mothers (chewing tobacco) are found to be preventable risk factors that require strong health awareness campaigns.

In the study surrounding healthcare utilization among mothers, Halim et al. (2010) have studied the correlation and consequences of antenatal care utilization in Nepal. They have applied two-stage least squares, binomial logit and Heckman selection bias estimates to the Nepal Health and Demographic Surveys data of 1996 and 2001 to indicate that maternal education, even at low levels, significantly increases the use of antenatal care; paternal education plays a more valuable role in the use of routine antenatal care than expected. On the other hand, when mothers avail routine professional antenatal care and maintain good health, their children remain healthy through infancy and early childhood. Matijasevich et al. (2010) have, therefore, focused on the effect of two measures of socioeconomic positions, maternal education, and family income on maternal and infant health outcomes between ALSPAC and Pelotas cohorts. Maternal health outcomes measures include smoking during pregnancy, caesarian section and unassisted delivery. Infant health outcomes consist of premature birth, intra-uterine birth restriction (IUGR) and breastfeeding for less than 3 months. An inverse correlation (higher prevalence among the poorest and less educated) exists for almost all outcomes, with the exception of cesarean sections where a positive relation is revealed. Desai and Wu (2010) have also claimed that individual-specific factors like age, education and marital pattern (married to relative or someone in same city/town or not) are significant factors in delivery care (delivered in hospital, delivered at home with assistance and delivered without assistance). Additionally, probability of assisted delivery depends on a district-specific intercept component along with a few household-level information like household wealth and distance from public health facility summed up to individual level. Mehrotra and Chand (2012) have reported that Indian women did not receive proper prenatal and antenatal care simply because of a lack of awareness and the absence of proper healthcare centers in the vicinity. Religion, economic status and education are statistically significant, but own employment does not have much effect on probability of taking decision of delivery at healthcare center, incidence of Anemia, getting access to prenatal care and antenatal care, and attitudes toward family planning. The study by Ankura (2018) shows use of reproductive health services closely connected with demographic factors (birth order, religion, caste and mother's age) and socioeconomic variables (i.e., mother's education, spouse education and the standard of living indicator). Patra et al. (2014) have also estimated differentials in health knowledge by background characteristics of women, such as age group of women, place of residence, educational level of women, caste, religion and wealth quintile of women using multinomial logistic regression. Second, the effects of health knowledge on pregnancy complications, post-delivery complications, antenatal care, delivery care and post-natal care are assessed.

So far, the safe motherhood policy in India has been in place for almost three decades. Over the years many researches have been conducted, and various policies have been implemented to improve the reproductive health of women. Yet the data indicate that not much progress has been made in this area. Moreover, improvement of reproductive health does not imply a reduction of maternal mortality rate, wasted pregnancies and infant mortality rates. The focus should be on policies that can ensure the holistic development of mothers. So, attention should be given to the accessibility of maternal health care as well as the physical health of women in the reproductive age group. The existing literature mostly takes a one-dimensional approach focusing either on the direct or on the indirect indicators. Moreover, there is a dearth of empirical analysis on early pregnancy loss through miscarriages and Medically Terminated Pregnancies due to the lack of reliable data in India (Saleem et al., 2018). Our study tries to investigate the actual condition of maternal health in India across three dimensions—maternal health outcome (direct measure), access to healthcare services and general health of women in the reproductive age group (indirect measures). With this end in view, we point out twin research issues explored in this paper.

- First, we assess the impact of physical health and healthcare facilities on maternal health outcomes called wasted pregnancy for the women in India.
- Second, we examine how socioeconomic factors like income, education, awareness and social identity like caste and place of residence affect maternal health and access to healthcare facilities which affect the prevalence of wasted pregnancy in India.

9.3 Data and Methodology

9.3.1 Data Sources and Econometric Models

We use the Indian Human Development Survey (IHDS-2) data for analysis. The survey was conducted by the researchers from the University of Maryland, USA, in association with the National Council of Applied Economics Research, New Delhi, in 2010–11. It is a nationally representative survey of 42,154 households in 1503 villages and 971 urban areas throughout India. The survey contains 14 modules, namely household, individual, eligible woman in the age group 15–49 years, birth history, medical staff, medical facilities, etc. The module of eligible woman survey which covered 39,543 women, mostly including maternal health-related variables, has been used in this study. For analysis, this study focuses on the last child birth with an analytical sample of 15,223. Since our research has required certain household characteristics like per capita income and access to media exposure and communication services in addition to the individual-level variables, we merged the household- and the individual-level data with the eligible women dataset.

Stillbirth or miscarriage (23.5% of pregnancies) in India is fairly high as compared to global standards. There might be various health-related reasons behind this high rate of wasted pregnancies. Our primary objective is to identify the factors affecting the incidence of wasted pregnancies in India. The existing literature has reported the association of the occurrence wasted pregnancy with various factors like access to healthcare services, general health of mothers and with different socioeconomic factors like caste, place of residence, per capita income, education (both own and spouse) and awareness. But all these factors cannot directly cause the occurrence of wasted pregnancy. For example, health condition of the women and access to healthcare facilities directly affects the occurrence of wasted pregnancy, whereas the socioeconomic factors like education and household income cannot directly affect the occurrence of wasted pregnancy. The socioeconomic factors affect the incidence of wasted pregnancy through affecting the health and health-related factors. To avoid the multicollinearity and model misspecification problems we should not consider the health-related factors and socioeconomic factors in the same model to investigate the factors affecting the incidence of wasted pregnancy in India. The simultaneous inclusion of health-related factors and the socioeconomic factors create the problem of the inclusion of irrelevant explanatory variable which underestimate/overestimate the effect of health factors on the incidence of wastage pregnancy of Indian women. The inclusion of education along with the access to antenatal care may hinder the true effect of the access to antenatal care on the incidence of wasted pregnancy. Therefore, in the first step, this study assesses the impact of access to healthcare facilities and physical health of woman on the prevalence of wasted pregnancy. Since our variable, incidence of wasted pregnancy, is a binary variable, we apply a simple logit regression model in this step.

In the second step, each selected indicator of health condition and utilization of healthcare facilities has been modeled as a function of selected socioeconomic–demographic traits of the women/households. In this step, we formulate four models.

(A) **Model for the access to antenatal care**: Access to antenatal care may be taken as a binary variable indicating value '1' if the pregnant woman received antenatal are during her pregnancy and '0' otherwise. Hence, we apply a simple logistic regression model to assess the impact of socioeconomic–demographic factors on the access to antenatal care for Indian women.

(B) **Model for decision to choose the place of delivery**. In this study, decision to choose the place of delivery has essentially three categories without any inherent order. Again, this variable, having three categories, violates the linearity assumption of OLS model. Thus, multinomial logit model is to be applied for estimating the probability of getting access to the desirable place of delivery. The multinomial logit is a method that generalizes logit regression to multi-category problems (having more than two discrete outcomes). One simple method of getting the multinomial logit model is to formulate k-1 independent binary logistic regression models for k outcomes, where one outcome is considered to be the base category. All the other outcomes are separately regressed relative to the base outcome. Here, we have taken the incidence of delivery at home without assistance as our base category.

(C) **Incidence of anemia**: The incidence of anemia depends on many health-related factors. This paper has tried to explain the probability of the incidence of anemia conditional on a set of socioeconomic–demographic factors. Whether a pregnant woman is suffering from anemia or not can be thought a binary in nature. So, we formulate binary logit model to estimate the probability of suffering from anemia during pregnancy conditional on a set of socioeconomic traits of the women/household.

(D) **General health condition of women**: It has four categories as per the working specification in our data source. There is no innate ordering, so we formulate a multinomial logit model considering very good health condition of the women as our reference category.

Therefore, this study would explore the significant health and healthcare service-related factors responsible for high rate of wastage pregnancy and thereby the socioeconomic factors affecting the health and access to healthcare facilities responsible for incidence of wasted pregnancy in India. It will definitely send a useful message to the policymakers for curbing the high rate of wasted pregnancy in India.

9.3.2 Working Definition of the Variables Used in the Model for the Prevalence of Wasted Pregnancy

Wasted pregnancy: It is a direct measure of maternal health. In our data, it takes value ‘1’ if the pregnancy resulted in a miscarriage or stillbirth and ‘0’ otherwise. This binary variable is the dependent variable in the first step of the analysis. Let us now define the independent variables affecting the wasted pregnancy.

Antenatal care: This is a measure of the utilization of maternal healthcare services. Antenatal care is the healthcare service received by the pregnant women during the early periods of pregnancy. The variable is binary in nature which takes value ‘1’ if a woman has received antenatal care and value 0 otherwise.

Place of delivery: This is also an indicator of maternal healthcare utilization. Place of delivery refers to the type of facility where the delivery has taken place. It is a categorical variable which takes value ‘1’ if the delivery has taken place at home, ‘2’ if the woman went to private healthcare centers for delivery and '3' if she received treatment in government health facilities.

Incidence of anemia: This gives an idea of the health conditions of the mothers. It indicates whether a pregnant woman is suffering from anemia or not. We attach value '1' if woman is suffering from anemia and '0' otherwise. Thus, the incidence of anemia is a dichotomous variable.

General health condition: To understand the general health condition of women, we consider self-reported health conditions of the pregnant women. It gives an idea about the physical health of the women during pregnancy. In accordance with the IHDS-II questionnaire, it has four categories—very good condition of health, good condition of health, satisfactory health condition and poor health condition. We assume value '1' for 'very good health condition', '2' for 'good health condition', '3' for 'satisfactory health condition' and '4' for 'poor health condition'. Therefore, general health condition of women is a categorical variable.

9.3.3 Socioeconomic–Demographic Traits Affecting the Health and Access to Healthcare Facilities

We consider a set of socioeconomic–demographic traits of the women and their households as explanatory variables to estimate the models for access to antenatal care, decision to choose the place of delivery, incidence of anemia and general health condition. Let us now specify these variables.

Place of residence: The place of residence of the woman says whether the woman resides in rural area or urban area. It takes value '0' if the woman lives in an urban area and '1' in the case of rural households.

Social religious groups (SRGs): It is a categorical variable which identifies the different social groups to which an individual in India belongs to. We value '1' for the women belonging to Hindu forward castes, '2' identifies the women who belong to other backward classes or Muslims, '3' refers to Dalit women and '4' represents Adivasis or tribal women.

Per capita income: It is the annual per capita income of the household of the sample women. Usually, per capita income has diminishing returns for getting access to health and healthcare services. For this reason, we take the natural logarithm of per capita income in this study. This is a continuous variable.

Own education: This indicates whether the woman is literate or not. This variable takes value '1' if the woman is literate, '0' otherwise.

Spouse's education: It has been recorded whether husband is literate or not. Value '1' has been attached for the literate husband and '0' otherwise.

Communication services: This binary variable indicates whether a woman has access to communication services like telephones, handset of mobile phones and personal computer system.

Media exposure: This variable takes value '1' if a woman has media exposure, i.e., watch television shows regularly/listen to radio, and read newspapers and '0' otherwise.

Access to maternity benefit: We create a binary variable for this issue putting value '1' if the household of the pregnant woman received any kind of monetary benefits during pregnancy from Government schemes and zero otherwise.

Age at Marriage: This is defined as a categorical variable which takes value '1' if the age of the woman at marriage was less than 15 years, '2' if age at the time of marriage was between 15 and 18 years. '3' represents age at marriage between 18 and 25 years, '4' refers to 25–30 years and '5' represents age more than 30 years at the time of marriage.

Freedom of women: This variable takes value '1' if a woman has to ask for permission for going to healthcare centers, '0' otherwise.

9.3.4 Statistics of Wasted Pregnancy in Respect of Selected Health-Related and Socioeconomic Factors

Table 9.1 presents the percentage distribution of the prevalence of wasted pregnancy in India in accordance with the selected health-related and socioeconomic factors.

We see that delivery at home is riskier compared to risk of delivery at government or private healthcare centers with more than one third of the deliveries at home resulting in stillbirth or miscarriage. In the sample 43.29% of the pregnant women not receiving antenatal care are suffering from wasted pregnancy with 24.01% of those who receive antenatal care are having a wasted pregnancy. Nearly one third of the anemic pregnant women have wasted pregnancy in the year 2010–11. More than one quarter of the women having satisfactory health and closely one third of women having poor health are suffering from wasted pregnancy. We have taken access to antenatal care and place of delivery as measure of the degree of the utilization of healthcare service by the pregnant women. These indicators significantly affect the incidence of wasted pregnancies.

The incidence of wasted pregnancy is higher in case of illiterate women and illiterate husbands compared to their literate counterparts. The incidence of wasted pregnancy is the highest among the Dalits/SCs among the SRGs. Compared to other women, women whose age at marriage is below 15 years are more vulnerable in respect of incidence of wasted pregnancy. However, the distribution of incidence of wasted pregnancy is not highly skewed across the different categories of the socioeconomic and demographic variables. So, we are only taking physical health

Table 9.1 Distribution of the prevalence of wasted pregnancies across selected socioeconomic–demographic factors

	Prevalence of wasted pregnancy (%)	
Socioeconomic–demographic traits	Yes	No
Place of delivery		
Government hospital/healthcare center	23.01	76.99
Private nursing home	23.07	76.93
Home without assistance	34.42	65.58
Access to antenatal care		
No	43.29	56.70
Yes	24.01	75.99
Women suffering from anemia		
No	22.7	77.3
Yes	30.34	69.66
General health condition of the women		
Very good	22.82	77.18
Good	21.82	78.17
Satisfactory	26.63	73.36
Poor	31.21	68.78
Own education		
No	24.96	75.04
Yes	22.56	77.44
Spouse's education		
No	24.80	75.20
Yes	22.71	75.29
Per capita income		
Poorest (Yearly PCI < ₹7109)	25.73	74.27
Poor (₹7109 ≤ PCI < ₹12,176 Yearly)	24.20	75.80
Middle income (₹12,176 ≤ PCI < 19,392 Yearly)	23.16	76.84
Richer (₹19,392 ≤ PCI < ₹360,000 Yearly)	22.57	77.43
Richest (₹360,000 ≤ PCI < ₹4,161,000 Yearly)	22.25	77.75
Social caste of the women		
All Hindu forward castes	23.27	76.73
Other backward classes and Muslims	24.56	75.44
Dalit/scheduled castes	26.07	73.93
Adivasi or scheduled tribes	21.71	80.29
Access to communication services		
No	23.14	76.86

(continued)

Table 9.1 (continued)

	Prevalence of wasted pregnancy (%)	
Socioeconomic–demographic traits	Yes	No
Yes	22.04	77.96
Media exposure		
No	25.34	74.66
Yes	22.67	77.33
Access to maternity benefit		
No	23.54	76.46
Yes	21.68	78.31
Age at marriage		
Age < 15	26.62	73.38
15 ≤ Age < 18	23.80	76.20
18 ≤ Age < 25	22.69	77.31
25 ≤ Age < 30	21.14	78.86
Age ≥ 30	23.49	76.51
Place of residence		
Urban	22.73	77.27
Rural	23.89	76.11

Source authors' calculation based on IHDS-2 data

indicators and healthcare utilization parameters as explanatory variables in regression model for wasted pregnancy.

Table 9.2 reveals the socioeconomic and demographic factors which crucially affect access to antenatal care and place of delivery. It is quite clear that healthcare utilization is better in urban areas than in rural areas with 18.45% of the pregnant women not receiving antenatal care and 38.17% deliveries occurring at home in the rural localities. In contract to all forward classes in India, the OBCs/Muslims Dalits/SCs and the tribals/STs are worse off in terms of access to antenatal care. The similar picture is revealed in case of the utilization of healthcare facility for delivery of child. Women belonging to higher income groups are definitely better off in terms of healthcare utilization as they can afford high-priced healthcare services. The poorest group is worse off with 21.32% pregnant ladies not getting proper antenatal care and almost half of the pregnant women forced to deliver at home without trained assistance. In India, more than half of the illiterate pregnant women deliver at home without assistance. One fourth of the women whose spouse is illiterate do not get antenatal care, and half of them deliver at home.

Among the pregnant women having media exposure 23% are deprived of antenatal care and 48.53% of them have non-institutional delivery. Only one sixth of pregnant women having access to communication services do not have antenatal care, whilst

Table 9.2 Distribution of the access to antenatal care and place of delivery across the socioeconomic and demographic traits

Socioeconomic and demographic traits	Access to antenatal care		Place of last delivery		
	No	Yes	Home without assistance	Private health facility	Government healthcare center
Place of residence					
Urban	6.42	93.58	17.19	43.18	39.63
Rural	18.45	81.55	38.17	20.24	41.59
Social castes					
All Hindu forward castes	4.96	95.04	18.16	44.1	37.74
OBC/Muslims	14.42	85.58	32.31	28.39	39.3
Dalit/SCs	14.48	85.52	36.79	17.21	46
Adivasi /STs	16.39	83.61	47.01	8.94	44.06
Per capita income brackets					
Poorest (Yearly PCI < ₹7109)	21.32	78.68	46.55	13.82	39.63
Poor (₹7109 ≤ PCI < ₹12,176 Yearly)	15.08	84.92	38.05	19.35	42.6
Middle income (₹12,176 ≤ PCI < 19,392 Yearly)	10.78	89.22	29.5	25.66	44.83
Richer (₹19,392 ≤ PCI < ₹360,000 Yearly)	7.67	92.33	22.36	35.57	42.07
Richest (₹360,000 ≤ PCI < ₹4,161,000 Yearly)	4.36	95.64	13.91	52.2	33.89
Own literacy					
No	26.13	73.87	51.14	12.5	36.36
Yes	6.08	93.92	22.21	34.49	43.31
Spouse's literacy					
No	25.2	75.8	51.22	11.43	37.36
Yes	9.12	90.88	26.42	30.9	42.68
Media exposure					
No	22.93	77.17	48.53	10.3	41.17
Yes	6.51	93.49	22.92	36.3	40.78
Access to communication services					
No	17.14	83	38.41	20.98	40.6
Yes	8.02	91.98	25.08	33.58	41.34

(continued)

Table 9.2 (continued)

Socioeconomic and demographic traits	Access to antenatal care		Place of last delivery		
	No	Yes	Home without assistance	Private health facility	Government healthcare center
Access to maternity benefit					
No	13.26	86.74	33.55	28.46	37.98
Yes	8.14	91.86	7.55	9.22	83.23
Age at marriage					
Age < 15	30.29	69.71	52.92	12.49	34.59
15 ≤ Age < 18	18.63	81.37	42.29	19.01	38.70
18 ≤ Age < 25	7.81	92.19	24.68	31.91	43.40
25 ≤ Age < 30	4.45	95.55	11.85	46.68	41.47
Age ≥ 30	3.85	96.15	11.65	57.28	31.07
Freedom of women/permission to visit healthcare center alone					
No	14.23	85.77	29.25	30.09	40.66
Yes	12.24	87.76	32.25	26.7	41.05

Source Authors' calculation based on IHDS-2 data

38.41% of them settle for non-institutional deliveries. One third of the women who have to ask for permission have non-institutional deliveries.

The incidence of anemia and the reported health condition have been considered for explaining the risk of miscarriage and stillbirth. Now, we present incidence of anemia and reported general health condition of women across the selected socioeconomic–demographic factors in Table 9.3. The table shows that physical health indicators are not changing across place of residence. If we consider the variable socioreligious groups, we can find an interesting observation. The physical health of tribals is better than that of all other castes, even the forward castes, both in terms of anemia and general health with only 21.29% pregnant women among tribals suffering from anemia and 12.79% women not having good health. The physical health is deteriorating as we go down the income ladder. In particular, the poorest section is worst off with 32% pregnant women suffering from anemia and 29% women not having good health. 36.72% of illiterate women have suffered from anemia during pregnancy, and 26.5% of them do not have good health. 36.35% of women who have illiterate spouses suffer from anemia during pregnancy, and 25% of them have satisfactory or poor health. 35.04% of women who lack media exposure suffer from anemia, whilst 24% do not enjoy good health. 35% of women not having access to communication services have got anemia during pregnancy, and 23% suffered from poor or satisfactory health condition.

The percentage distribution of the prevalence of wasted pregnancy is not changing much across the different categories of each socioeconomic and demographic factors,

Table 9.3 Incidence of anemia and general health condition across the socioeconomic and demographic traits

Socioeconomic and demographic traits	Anemic or not		General health condition			
	No	Yes	Very good	Good	Satisfactory	Poor
Place of residence						
Urban	71.78	28.22	28.21	51.4	13.49	6.9
Rural	70.69	29.31	26.04	51.29	15.43	7.24
Socioreligious groups						
All Hindu forward castes	74.71	25.29	30.67	51.66	13.88	3.79
Other backward classes/Muslims	69.26	30.74	26.04	52.69	14.59	6.68
Dalit/SCs	68.47	31.53	23.74	54.61	15.24	6.41
Adivasi/STs	78.31	21.69	32.97	53.28	11.96	1.79
Per capita income brackets						
Poorest (Yearly PCI < ₹7109)	68.15	31.85	22.56	48.76	16.25	12.43
Poor (₹7109 $\leq$ PCI < ₹12,176 Yearly)	70.11	29.89	24.68	48.8	15.62	10.9
Middle income (₹12,176 $\leq$ PCI < 19,392 Yearly)	70.32	29.68	26.4	51.73	13.66	8.21
Richer (₹19,392 $\geq$ CI < ₹360,000 Yearly)	72.74	27.26	28.34	53.35	12.46	5.84
Richest (₹360,000 $\leq$ PCI < ₹4,161,000 Yearly)	75.91	24.09	28.91	54.39	12.75	3.96
Mother's literacy						
No	63.48	36.52	22.66	50.8	16.5	10.04
Yes	75.71	24.29	28.71	53.57	13.57	4.15
Spouse's literacy						
No	63.65	36.35	25.29	49.59	14.72	10.4
Yes	73.49	26.51	30.75	51.16	13.83	4.27
Access to media exposure						
No	64.96	35.04	23	51.95	16.69	8.35
Yes	72.89	27.11	28.66	53.6	13.33	4.4
Access to communication services						
No	69.49	35.41	24.08	52.36	16.78	6.78
Yes	72.49	27.51	26.21	53.66	15.4	4.73
Access to maternity benefit						
No	71.26	28.74	26.53	53.11	14.53	5.81
Yes	67.78	32.22	28.92	51.27	14.62	5.19
Age at marriage						
Age < 15	66.17	33.83	19.85	50.98	19.24	9.92

(continued)

Table 9.3 (continued)

Socioeconomic and demographic traits	Anemic or not		General health condition			
	No	Yes	Very good	Good	Satisfactory	Poor
$15 \leq$ Age < 18	69.51	30.49	23.91	54.30	14.16	7.63
$18 \leq$ Age < 25	72.27	27.73	29.15	52.37	14.10	4.38
$25 \leq$ Age < 30	75.32	24.68	28.37	55.76	13.26	2.59
Age ≥ 30	66.67	33.33	30.10	54.37	11.65	3.88

Source authors' calculation based on IHDS-2 data

whilst these factors play a significant role in healthcare utilization like access to antenatal care or institutional delivery and overall health of mothers like incidence of anemia and general health condition during pregnancy. So, we are using a two-stage methodology, where we are only taking physical health indicators and healthcare utilization factors as our explanatory variables in the regression where the prevalence of wasted pregnancy is our dependent variable.

In the next stage, we are estimating the healthcare utilization and overall health parameters of women using socioeconomic factors.

9.4 Findings and Discussion

In this section, we interpret and discuss the results of the models explained in Sect. 9.3. Table 9.4 displays the estimated impact of access to healthcare services and general health condition on the incidence of wasted pregnancy of women in India. The overall model is good fitted as we find LR statistic is significant at 1% level. Coefficients of all the explanatory variables are statistically significant at 5% level.

The odds ratio for the variable antenatal care is less than one so, compared to a woman receiving antenatal care, a woman not getting the antenatal care has a 4.48 percentage points higher probability of getting a miscarriage or stillbirth in India. For the variable whether the pregnant woman suffering from anemia, the odds ratio is above one implying an Indian woman getting anemia during pregnancy is 7.04 percentage points more likely to get a miscarriage or stillbirth. As we move on to the second indicator of physical health, we see a similar result. All the odds ratios are greater than one. Therefore, a woman reporting very good health conditions vis-vis a woman with satisfactory and poor health conditions has a lower chance of suffering a miscarriage or stillbirth, even though it is not significantly different between a woman with good health and a woman reporting very good health. Thus, in India compared to women with good or very good health condition, women with satisfactory and poor health conditions are at a higher risk of wasted pregnancy. The odds ratios and marginal effects of the indicator of healthcare utilization, place of delivery, indicate that compared to the incidence of delivery at home, if the delivery is took place at a private hospital or at a government health service center, then the

Table 9.4 Results of logistic regression for prevalence of wasted pregnancy in India

Explained variable	Prevalence of wasted pregnancy ('1'= yes and '0' otherwise)			
Explanatory variables	Odds ratio	Marginal effects	Std. Err.	$P > z$
Access to antenatal care	0.79	−0.045	0.05	0.00
Incidence of anemia	1.46	0.070	0.06	0.00
General health condition (ref: Very good)				
Good	1.00	0.0005	0.05	0.96
Satisfactory	1.34	0.056	0.09	0.00
Poor	1.71	0.109	0.15	0.00
Place of delivery (ref: Home without assistance)				
Private nursing home	0.85	0.031	0.05	0.00
Government hospital/clinic	0.81	0.041	0.04	0.00
Constant	0.39		0.03	0.00
Summary statistics				
LR $chi^2(7)$	208.18			
Prob > chi^2	0.00***			
McFadden Pseudo R^2	0.137			

Source Authors' calculation based on IHDS-2 data

probability of getting a wasted pregnancy is going down by 3.05 and 4.08 percentage points, respectively.

Therefore, the health condition and access to healthcare facilities of the Indian women are very much important to curb the high degree of prevalence of wasted pregnancy in India and thereby to improve the maternal health condition in India to satisfy SDGs. It motivates us investigate the socioeconomic and demographic factors affecting the healthcare utilization parameters and general health of the women in India.

Let us now examine the socioeconomic and demographic variables which are affecting physical health indicators and the healthcare utilization parameters of Indian women. Table 9.5 shows that all the models are good fitted. The models on healthcare utilization factors (antenatal care and place of delivery) have McFadden's $R^2 > 0.1$ implying good fit. However, McFadden's R^2 for the models on physical health is <0.1, thereby implying moderate fit. LR tests for checking the viability of the multinomial logit models prove that our models are valid.

Place of Residence: In the antenatal care model, the variable rural has an odds ratio of less than 1 which implies odds move against antenatal care if a person belongs to a rural household compared to an urban household. In other words, if a person is from a rural household instead of the urban one, the probability of getting access to antenatal care goes down by 1.5 percentage points. The coefficient for the variable rural has a negative sign for both the place of delivery private health care vis-à-vis home without assistance and government hospital vis-a-vis home without assistance segments in the place of delivery model. It implies that instead of urban if a woman is residing at a rural location, the log odds of selecting a private health facility or government clinic over home reduces by 0.77 and 0.42 units, respectively. Physical

Table 9.5 Estimates of the likelihood of the access to antenatal care, place of delivery, incidence of anemia and general health conditions of pregnant women in India

Dependent variable:	Access to antenatal care (yes = 1)		Place of delivery (Ref: Home without Assistance)		Incidence of anemia (yes = 1)		General health condition (Ref: Very good)		
			Private health care	Government hospital			Good	Satisfactory	Poor
Independent variables	Odds ratio	Coeff.	Coeff.	Coeff.	Odds ratio	Coeff.	Coeff.	Coeff.	Coeff.
Place of residence	0.83	−0.19 (0.08)	−0.77 (0.06)	−0.42 (0.06)	0.97	−0.03 (0.05)	−0.04 (0.05)	0.12 (0.07)	−0.12 (0.10)
SRGs									
Hindu OBC and Muslims	0.68	−0.39 (0.11)	−0.38 (0.07)	−0.18 (0.07)	1.18	0.17 (0.06)	0.12 (0.06)	0.06 (0.08)	0.35 (0.13)
Dalit/SCs	0.72	−0.33 (0.11)	−0.87 (0.08)	−0.12 (0.08)	1.22	0.20 (0.06)	0.21 (0.07)	0.12 (0.09)	0.26 (0.15)
Adivasi/STs	0.83	−0.19 (0.13)	−1.49 (0.13)	−0.37 (0.09)	0.69	−0.37 (0.09)	−0.02 (0.09)	−0.20 (0.12)	−0.63 (0.21)
Ln (per capita income)	1.18	0.17 (0.04)	0.47 (0.03)	0.16 (0.03)	0.88	−0.12 (0.02)	−0.04 (0.03)	−0.08 (0.04)	−0.24 (0.05)
Own education	2.56	0.94 (0.07)	0.82 (0.07)	0.65 (0.06)	0.79	−0.23 (0.05)	−0.07 (0.06)	−0.28 (0.08)	−0.50 (0.11)
Spouse education	1.32	0.28 (0.07)	0.46 (0.08)	0.24 (0.06)	0.93	−0.07 (0.04)	−0.15 (0.07)	−0.24 (0.08)	−0.25 (0.11)
Media exposure	1.76	0.57 (0.07)	0.79 (0.07)	0.12 (0.05)	0.91	−0.09 (0.05)	−0.12 (0.06)	−0.29 (0.08)	−0.37 (0.10)
Communication services	1.17	0.16 (0.07)	−0.15 (0.6)	−0.04 (0.05)	0.37	−0.32 (0.04)	−0.21 (0.05)	−0.49 (0.07)	−0.22 (0.09)

(continued)

Table 9.5 (continued)

Dependent variable:	Access to antenatal care (yes = 1)		Place of delivery (Ref: Home without Assistance)		Incidence of anemia (yes = 1)		General health condition (Ref: Very good)		
			Private health care	Government hospital			Good	Satisfactory	Poor
Independent variables	Odds ratio	Coeff.	Coeff.	Coeff.	Odds ratio	Coeff.	Coeff.	Coeff.	Coeff.
Maternity benefit	2.21	0.79 (0.14)	0.75 (0.18)	2.40 (0.13)	1.12	0.11 (0.08)	−0.14 (0.08)	−0.11 (0.12)	−0.17 (0.17)
Age at marriage									
15 ≤ Age < 18	1.44	0.36 (0.08)	0.17 (0.11)	0.17 (0.08)	0.91	−0.09 (0.07)	−0.10 (0.09)	−0.40 (0.11)	−0.15 (0.14)
18 ≤ Age < 25	2.46	0.90 (0.09)	0.63 (0.11)	0.53 (0.08)	0.86	−0.15 (0.07)	−0.30 (0.09)	−0.53 (0.11)	−0.69 (0.14)
25 ≤ Age < 30	2.70	1.00 (0.22)	1.18 (0.18)	0.98 (0.16)	0.79	−0.23 (0.12)	−0.21 (0.13)	−0.43 (0.17)	−0.98 (0.31)
Age ≥ 30	6.51	1.87 (0.73)	1.59 (0.39)	0.78 (0.38)	1.41	0.34 (0.24)	−0.16 (0.27)	−0.33 (0.37)	−0.34 (0.56)
Women's freedom	1.14	0.13 (0.06)	−0.20 (0.06)	−0.03 (0.05)	N/A	N/A	N/A	N/A	N/A
Constant	0.39	−0.94 (0.36)	−5.47 (0.34)	−1.85 (0.28)	1.45	0.37 (0.25)	1.38 (0.27)	0.77 (0.36)	1.71 (0.50)

(continued)

Table 9.5 (continued)

Dependent variable:	Access to antenatal care (yes = 1)		Place of delivery (Ref: Home without Assistance)		Incidence of anemia (yes = 1)		General health condition (Ref: Very good)		
			Private health care	Government hospital			Good	Satisfactory	Poor
Independent variables	Odds ratio	Coeff.	Coeff.	Coeff.	Odds ratio	Coeff.	Coeff.	Coeff.	Coeff.
Summary statistics									
McFadden R^2		0.150	0.136		0.014		0.015		
McFadden (adj.) R^2		0.147	0.134		0.012		0.012		
Cox-Snell/ML		0.11	0.256		0.017		0.034		
Count		0.877	0.531		0.713		0.53		

Socioreligious groups: Ref: forward Castes; Age at Marriage: Ref: Age < 15
Source authors' calculation based on IHDS-2 data

health of women measured by both incidence of anemia and general health indicator is not significantly affected by the nature of the place of residence (Fig. 9.2).

The probability of receiving antenatal care rises gradually with an increase in per capita income. It is strikingly less for poor people in both urban as well as rural areas. At low-income levels, people in rural areas have more disadvantages than that of residents of urban areas. However, the difference reduces with income and almost phases out at the higher income levels. Therefore, the rural poor are less likely to receive antenatal care than the urban poor, whilst very rich households in both places are almost equally likely to receive antenatal care.

Socioreligious Groups: For SRGs, in the antenatal care model, odds ratios for the three categories are less than one implying, in comparison with the base category (all Hindu forward castes), if we consider the backward classes or Dalits, odds are going against access to antenatal care. In particular, compared to Hindu forward castes, OBCs/Muslims and Dalits/SCs are 2.8 percentage points and 2.31 percentage points less likely to receiving antenatal care, respectively. Similarly, log odds of the incidence of delivery at private healthcare center against at home without assistance decreases by 0.38 units, 0.87 units and 1.49 units if a woman belongs to OBCs/Muslims, Dalits/SCs and Adivasis/STs compared to the base category, all Hindu forward castes. The odds ratios are positive for the first two categories of SRGs for the dependent variable, incidence of anemia, which suggests compared to the reference category (all Hindu forward castes), for a woman of OBCs/Muslims and Dalits/SCs, the odds move in favor of suffering from anemia. In other words, the probability of getting anemic increases by 3.4 and 4 percentage points if a woman belongs to OBCs/Muslims and Dalits/SCs, respectively, instead of belonging to Hindu forward castes. If a woman is of the Adivasi community instead of the base category, the probability of being anemic during pregnancy goes

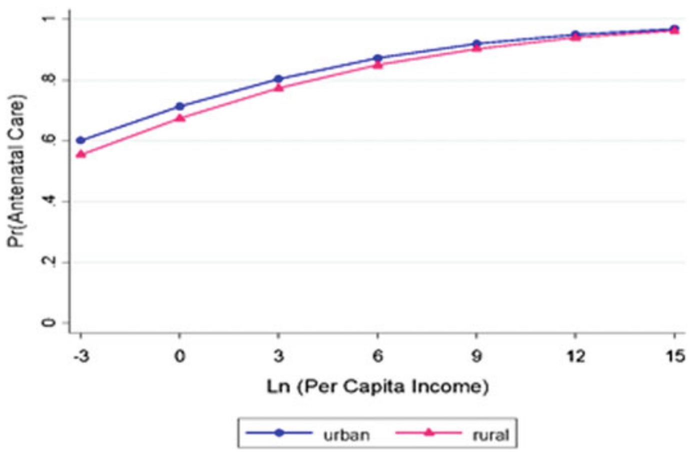

Fig. 9.2 Marginal effects of per capita income on probability of antenatal care across place of residence

down by 6.6 percentage points. Similarly, if a woman is belonging to a Dalit/SCs or OBCs/Muslims household instead of Hindu forward castes, the log odds of having good or poor health vis-à-vis very good increases significantly. However, if a woman is belonging to a tribal community instead of a Hindu forward castes, then she is less likely to have satisfactory health conditions compared to very good health. So, contrary to the popular conjecture, the health of tribal women is actually better off compared to women belonging to Hindu forward castes households both in terms of occurrence of anemia and general health condition.

Compared to the rich Dalit/SCs and OBC/Muslims, the poor Dalits/SCs and OBCs/Muslims are worse off in respect of getting antenatal care and getting anemia. Probability of getting anemia is high among them for all income levels. There is almost no difference between Dalits/SCs and OBCs/Muslims across all income levels for both the variables. Irrespective of per capita income, Adivasi/STs are better off than OBCs/Muslims in respect of access to antenatal care and probability of suffering from anemia. Hindu forward castes people are marginally better off than Adivasis/STs in terms of availability of antenatal care at low-income levels. Although, the difference mitigates at higher income levels. The probability of suffering from anemia during pregnancy is substantially less among tribals/STs at all income levels as compared to Hindu forward caste women (Fig. 9.3).

Per capita household income: The income variable has a positive and significant impact on access to antenatal care. The marginal probability tells us that one percent increase in per capita income raises the probability of getting antenatal care by 1.3 percentage points. The positive sign attached to per capita income variable for both segments of the place of delivery model indicates that log odds of selecting a private facility or government clinic relative to home increase as we move to a higher per capita income household. In other words, the log odds of going to private or public healthcare facilities relative to home rise by 0.47 units and 0.16 units, respectively, as per capita income increases. The odds ratio for the variable per capita income being greater than one in the model for prevalence of anemia says that as the level of income increases, the probability of getting anemic during pregnancy is expected to go down. As per capita income expands, the log odds of deteriorating general health from very good to good, satisfactory or poor goes down by 0.04, 0.08 and 0.24 units respectively.

Education: The odds ratios for the variables own education and spouse's education are both greater than one for the model for access to antenatal care. This is indicative of the fact that both the variables accelerate access to antenatal care. If a woman or husband is literate, the log odds of choosing private nursing home vis-à-vis home without assistance goes up by 0.82 and 0.46 units, respectively. Similarly, the log odds of receiving treatment in government clinic during the time of delivery compared to home without assistance during pregnancy also increases. Note the women's education is more effective to get access to government hospital or private hospital for delivery. In prevalence of anemia model, the odds ratios are negative for both the education variables. It implies if the woman and her husband are literate probability of suffering from anemia during pregnancy reduces. If a pregnant woman is literate,

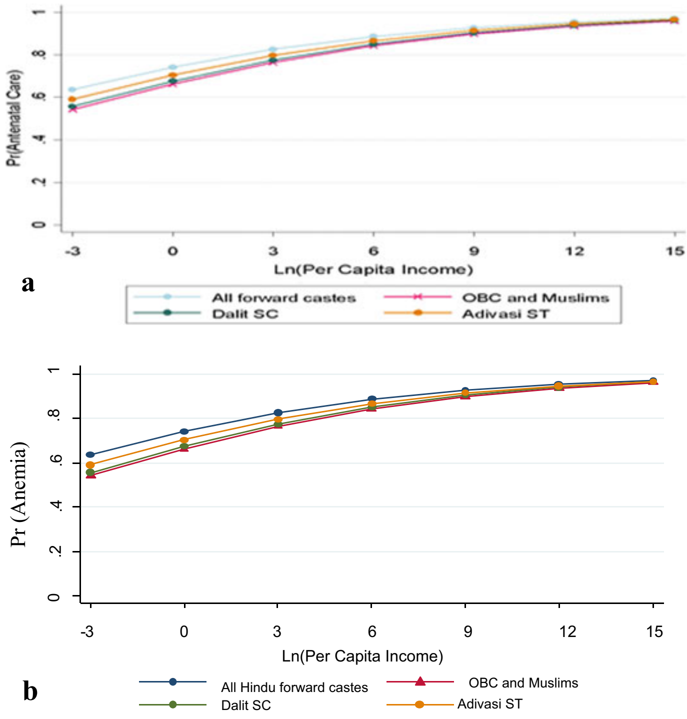

Fig. 9.3 Marginal effects of per capita income across SRGs. **a** On probability of receiving antenatal care. **b** On probability of getting anemic

she is 4.7 percentage points less likely of getting anemic, whereas if her husband is literate, there is 1.5 percentage points fall in the probability of having anemia during pregnancy. If a woman's husband is literate, then the log odds of her having good, satisfactory or poor health conditions instead of very good reduces by 0.05, 0.28 and 0.50 units, respectively. Moreover, if she is literate, then log odds of having good, satisfactory, or poor health instead of very good goes down by 0.15 units, 0.24 and 0.25 units, respectively. Therefore, women's education compared to husband's education is more effective tool to improve the health and access to healthcare facility of the Indian women (Fig. 9.4).

The marginal effect of literacy of women on the probability of receiving antenatal care and anemia is examined by Fig. 9.4a, b. Literate women are better off in respect of access to antenatal care and incidence of suffering from anemia during pregnancy for all income levels. The probability of receiving antenatal care is significantly lower among illiterate women belonging to poor households compared to literate women in similar economic conditions. However, this difference decreases with a rise in income. The illiterate women in poor households are slightly more likely to get anemic during pregnancy than their literate counterparts. This difference, however, persists for all income levels.

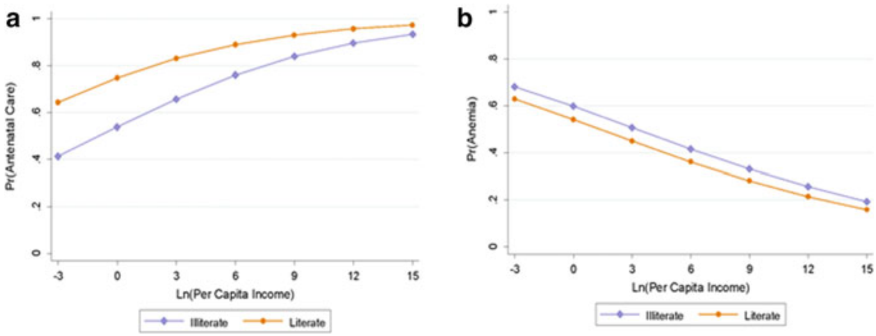

Fig. 9.4 Marginal effects of per capita income across literate and illiterate women. **a** On probability of receiving antenatal care. **b** On probability of getting anemic

Media Exposure: the probability of receiving antenatal care is 4.3 percentage points more for woman having access to media exposure, in contrast to those who do not have those privileges. If a woman has media exposure, the increase in log odds of selecting private health facilities or government facilities for delivery against home without assistance is 0.79 units and 0.12 units, respectively. When a woman has access to media exposure, the probability of getting anemic reduces by 1.8 percentage points. For women who have access to media exposure, the log odds of having good, satisfactory or poor health instead of very good health is less than that of women who do not enjoy this privilege.

Women, in low-income families, enjoying media exposure are more likely to take antenatal care compared to women not having that exposure. The difference significantly reduces at high-income levels. Women having no media exposure are more likely to get anemic at all income levels compared to those who enjoy media exposure. Refer to Fig. 9.5a, b.

Communication Services: If a woman has access to communication services like the Internet or mobile phone, she is 1.2 percentage points more likely to receive antenatal care during her pregnancy compared to a woman who does not have access to those. It also enhances the log odds of choosing a private facility for delivery relative to home without assistance by 0.15 units but does not affect the choice between government clinics over home without assistance. The women getting access to communication services compared to other women are less likely to be anemic during pregnancy by 6.4 percentage points. Similarly, a woman who has communication services enjoys a lower log odds of suffering from poor health vis-à-vis very good health conditions. These are shown in Fig. 9.6a, b, respectively.

Women, in poorer households, having access to communication services are slightly more probable to take antenatal care compared to women not having that exposure. This difference, however, vanishes at high-income bands. Women not having access to communication services have a higher chance of becoming anemic during pregnancy, at all income bands compared to those who enjoy that privilege.

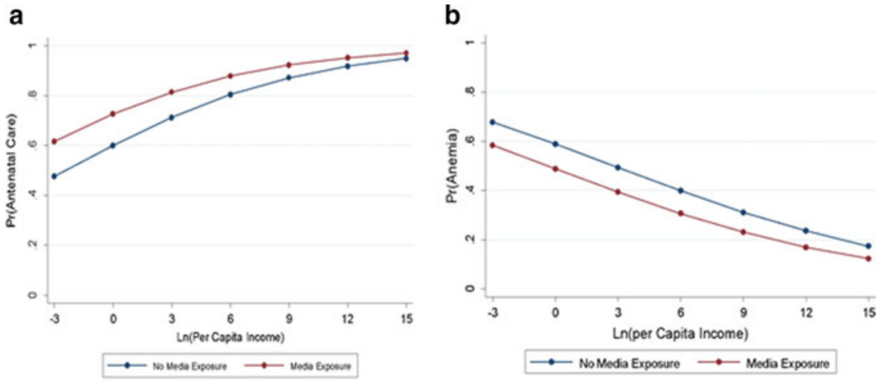

Fig. 9.5 Marginal effects of per capita income across women having media exposure. **a** On probability of receiving antenatal care. **b** On probability of getting anemic

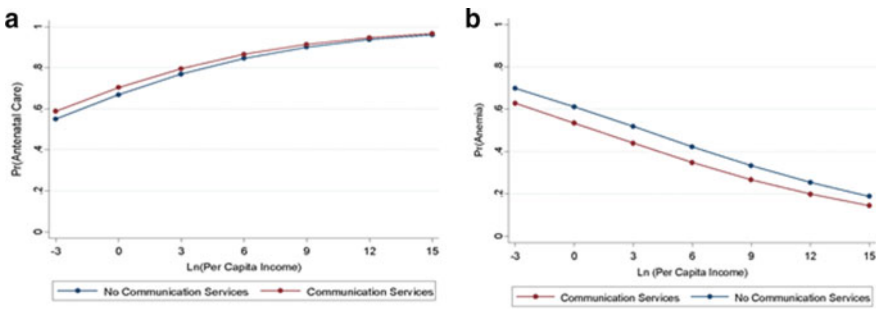

Fig. 9.6 Marginal effects of per capita income across women having communication services. **a** On probability of receiving antenatal care. **b** On probability of getting anemic

Access to maternity benefit: Monetary aids provided to women during pregnancy by the government are expected to impact healthcare utilization parameters more as compared to physical health of women. If a woman receives maternity benefits, then the probability of getting antenatal care increases by 6.2 percentage points. Similarly, the log odds of incidence of delivery at a private health center or at government hospital vis-à-vis at home without assistance improves by 0.75 units and 2.40 units, respectively, if the women received maternity benefit from government programs. Among the low-income households, women receiving maternity benefit compared to women not receiving those aids show a higher probability of taking antenatal care. At high-income bands, this difference reduces significantly.

Age at marriage: All the categories under the variable age at marriage in model for access to antenatal care model have odds ratios less than one which implies, compared to the base category (age at marriage <15), as age of the woman at marriage increases, the probability of getting antenatal care during pregnancy goes up. A woman getting

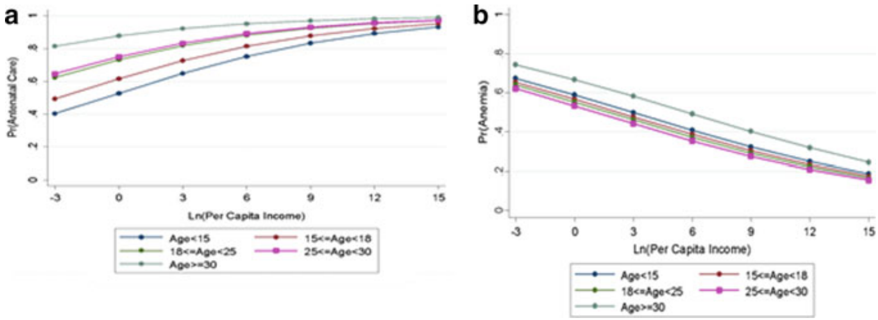

Fig. 9.7 Marginal effects of per capita income across women at age of marriage. **a** On probability of receiving antenatal care. **b** On probability of getting anemic

married after 18 years instead of <15 years has a higher possibility of choosing to deliver at a private or a government healthcare center over delivery at home without assistance. If a woman's age at marriage is between 18 and 30 years compared to being underage (<15), then the probability of becoming anemic during pregnancy increases. As the age of woman at marriage increases to greater than 18 as compared to being underage (<15 years), the probability of the woman's health deteriorating to good, satisfactory or poor from very good during pregnancy decreases.

In Fig. 9.7a, b, we find women, in poorer households, got married at an early age (<15) are significantly less likely to get access to antenatal care compared to women who got married at age greater 30 years. This difference, however, reduces as log per capita income increases. However, the probability of suffering from anemia during pregnancy is higher for the women who got married at age greater than 30 years compared to other age groups This gap remains unchanged for each level of per capita income.

Freedom of women: If the woman does not require permission from other household members to visit healthcare center, we say the woman has freedom. Freedom of woman is expected to affect the healthcare utilization factors like access to antenatal care and access to healthcare center for delivery. Women who require permission to visit healthcare centers versus women, who do not, are 1 percentage point more likely to get access to antenatal care. This may be because antenatal care is often provided by healthcare workers at the residence of pregnant women in recent times. If a woman has to take permission to visit healthcare centers, the log odds of choosing a private health center over home for delivery goes down by 0.2 units.

9.5 Conclusion and Policy Recommendations

The number of miscarriages and stillbirths in India has remained notably high in some of the states as compared to the world average. This paper aimed to understand the factors that affect pregnancy outcomes directly or indirectly as well as the nature of their relationship. We investigated the factors affecting the prevalence of wasted pregnancy in India, and it is clear that physical health and healthcare utilization of the pregnant women crucially affects the likelihood of the wasted pregnancy. Further the study has revealed that the indicators of physical health incidence of anemia among pregnant women and general health conditions as well as healthcare utilization indicators like access to antenatal care and institutional delivery are significantly impacted by the socioeconomic characteristics like place of residence, socioreligious groups, economic condition measured in per capita income, literacy and freedom of women and her households. The study has found that the percentage of wasted pregnancy is quite high among the economically and some of the socially backward classes. Although these traits could not directly affect the incidence of wasted pregnancy, we establish that they affect the incidence of wasted pregnancy through the channels of affecting physical health and utilization of healthcare facilities.

There are wide variation in healthcare utilization across the different socioeconomic and demographic traits and thereby the prevalence of wasted pregnancy. In India, the number of public health facilities and other private channels of health service in rural areas are far from adequate. Therefore, a section of women in rural areas fails to receive antenatal care, thereby increasing the chances of miscarriages. At times they are even forced to deliver at home without proper assistance which in turn leads to stillbirths, postpartum complications and even maternal deaths. The condition is perhaps worse for rural women belonging to poor Dalit or OBC households having little or no freedom in the household. The problem aggravates if both the woman as well as her spouse are illiterate and if they do not have any media exposure or communication devices at bay.

In case of physical health, however, place of residence does not play significant role as expected. Poor women in both rural and urban areas are equally likely to get anemic or suffer from poor health. A striking result is that tribal women are actually better off as they are less likely to suffer from anemia during pregnancy. This is probably indicative of the fact that matriarchal society among certain tribes paves the way for good living conditions among women. They are usually given proper care during pregnancy, thereby improving their health standards. This might be the reason behind the countrywide disparity with northeastern states having less wasted pregnancy compared to the northern and the central states.

As per capita income is usually taken to be the major cause of poor health conditions and lower healthcare utilization, most of the policies (direct cash transfer and Anganwadi scheme) are directed toward the economically poor and socially backward classes (Dalits/SCs, tribals/STs and OBCs/Muslims) in rural areas. But estimate shows that education and awareness are equally important for ensuring the proper utilization of healthcare facilities. As the literacy rate in the southern states is quite high as compared to northern or central states, they have outperformed the northern and central states in terms of maternal health. If a woman is illiterate and does not have enough knowledge, she might fail to understand the health complications during pregnancy and thereby ignore the symptoms. She might be unaware of various schemes as well and thereby refuse to take antenatal care or go for institutional delivery. It is equally important that the spouse is educated as well so as to provide her proper guidance and support. Moreover, access to communication services is important in case of health emergencies during pregnancy.

Now, we prescribe some policies in addition to the existing policies for improving maternal health that will help to lower the risk of wasted pregnancy in India. Age at marriage, media exposure and access to communication services are found as important factors improving the access to healthcare services. The door-to-door awareness campaign along with regular advertisement/discussion on importance of access to healthcare facilities through media is necessary, especially in rural areas because rural women compared to urban women are less likely to have access to healthcare facilities. The campaigns should include topics like health hazards during pregnancy, the importance of institutional health care as well as different government schemes available for pregnant women. The government has recently started an app-based service for the mothers. The pregnant women are required to register themselves, and thereby, trained auxiliary nurse midwives (ANMs) regularly visit the houses of a pregnant woman from the first trimester itself and provide basic health check-ups. The government should upgrade the service so that ANMs can also be called immediately during pregnancy-related emergencies through the app. In addition to the app-based service, more health facilities should be established in the remote areas of the country to serve the rural women more extensively and intensively. There is still a dearth of trained health workers in the country with 20.6 healthcare personnel per 10,000 people (Mehrotra & Chand, 2012). India should concentrate on increasing the number of trained nurses and midwives in the country to reduce the workload on physicians and provide care to more women in times of emergencies.

This study shows that both rural and urban women are at equal risks of getting anemic. Anganwadi scheme for mothers (providing nutritional supplements free of cost) should be extended to poor women in urban areas as well. As illiteracy remains a major issue affecting both the physical health of mothers and healthcare utilization, initiatives to increase the literacy rate among both men and women still remain relevant. Finally, it is essential to have proper motherhood experience for the women in India. When women receive reasonable education and gain media exposure, they will comprehend their problems better. In addition to this, if they receive adequate support from their partners and substantial Government aid, they can have the desirable motherhood experience. And with these initiatives, we achieve the sustainable development goal relating to maternal and child health.

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Chapter 10
Analysis of Quality of Living Data of Households of Indian Districts Using Machine Learning Approach of Fuzzy C-Means Clustering

Supratik Sekhar Bhattacharya

10.1 Introduction

Cluster analysis is an algorithmic tool for multivariate data analysis, wherein data points with multivariate attributes are assigned to clusters such that members of a cluster are as similar to each other as possible, i.e. numerical similarity measures classify data into clusters. There are a number of algorithms for clustering analysis, and they belong to a wider area of machine learning and data mining. The chief among them are K-means clustering, mean shift clustering, density-based spatial clustering of applications with noise, expectation–maximization clustering, etc., all of which are also called 'hard clustering'. The 'soft clustering', which is based on fuzzy delineation of cluster boundaries, on the other hand, assigns membership grades to data points indicating the degree to which the points belong to each cluster. In other words, in fuzzy clustering, the data points of a particular cluster have the potential of belonging to all other clusters in varying degrees. Of several variants of fuzzy clustering methods, the fuzzy C-means (FCM) method (Bezdek, 1981; Bezdek & Pal, 1992) is most popular and has been widely used where data are classified in C clusters. Compared to C-means cluster method, FCM method has better stability and can more effectively treat outlier data points.

Clustering techniques have been used in a wide variety of applications such as pattern recognition, image processing, business and marketing, computational biology, medicine research as well as in social sciences. Application to economic data had been very few, however. Some of the examples of application of cluster analysis in economics and finance are by Gokten et al. (2017) for financial health scoring of short-term investment decisions, Gupta et al. (2016) for district-level assessment of high-focus states of India regarding infant mortality, Tripathi et al. (2015) for delineation of soil management zones in a rice cultivation area in India, Shuo and JiQing (2011) for economic status of household consumption expenditure in China,

S. S. Bhattacharya (✉)
Vellore Institute of Technology, Vellore, Tamil Nadu 632014, India

S. Bagli et al. (eds.), *Persistent and Emerging Challenges to Development*, India Studies in Business and Economics, https://doi.org/10.1007/978-981-16-4181-7_10

Sun et al. (2011) for Chinese corporate social responsibility evaluation, Chen (2009) for income of rural residents of a province in China, Ahlborn and Wortmann (2018) for European business cycles, to mention a few.

This paper attempts to apply the clustering analysis, specifically the FCM method which treats and retains the granularity of data effectively, to the quality of living data of 640 districts of India (India-districts-census, 2011). The number of attributes (i.e. parameters) for each district is 26, thus making it a fairly large data set with multivariate attributes. The clustering analysis of the data with various choices of number of clusters has been carried out, and the results have been discussed.

10.2 Description of the Problem

The data set has 640 data points, each for an Indian district, and each data point has 26 attributes regarding the quality of living and educational attainment of households. The list of these attributes is given in Table 10.1 (India-districts-census, 2011). It should be noted that this 'quality of living' is not to be understood as 'standard of living', the latter being a broader idea that consists of attributes such as life expectancy, general health, access to education, health care and social services, social freedom and household income. The data attributes used for the purpose of analysis are in percentage terms, and hence, their values are between 0 and 1.

Table 10.1 Attributes of data points

No	Attribute	No	Attribute
1	Households with LPG	14	Households with TV and computer/laptop and landline/mobile and scooter/car
2	Households with electric lighting	15	Households living in dilapidated houses
3	Households with internet	16	Households with own kitchen
4	Households with computer	17	Households with bathing facility
5	Households with television	18	Households with own latrine facility
6	Households with bicycle	19	Ownership rented households
7	Households with car/jeep/van	20	Ownership owned households
8	Households with radio	21	Below primary education
9	Households with scooter/motorcycle/moped	22	Primary education
10	Households with landline only	23	Middle education
11	Households with mobile only	24	Secondary education
12	Households with landline/mobile	25	Higher education
13	Households with landline and mobile	26	Graduate education

10.3 Method of Fuzzy C-Means Clustering

Consider N data points (no of districts here) to be classified into M clusters. The data points are denoted x_i ($i = 1$ to N). The degree of membership of x_i in j-th cluster is the fuzzy membership function μ_{ij}. The sum of membership function values of all M clusters for each x_i is unity. The fuzzy partition matrix exponent that controls the degree of fuzzy overlap between clusters is denoted m (also called 'fuzzifier') with $m > 1$ (usually in the range of 1.25–2). Therefore, the cluster membership can be denoted μ_{ij}^m.

The essential steps involved in the computation are as follows:

(a) Initialize the cluster membership function values, $U = [\mu_{ij}] = U^{(0)}$ randomly.

(b) Compute the cluster centres using.

$$C_j = \frac{\sum_{i=1}^{N} \mu_{ij}^m x_i}{\sum_{i=1}^{N} \mu_{ij}^m}, (j = 1 \text{ to } M) \tag{10.1}$$

(c) Update the membership functions as

$$\mu_{ij} = \frac{1}{\sum_{l=1}^{M} \left(\frac{\|x_i - C_j\|}{\|x_i - C_l\|} \right)^{\frac{2}{m-1}}} \tag{10.2}$$

So that now $U = [\mu_{ij}],\ U^{(1)}$.

(d) Calculate the objective function

$$F_{\mathrm{m}} = \sum_{i=1}^{N} \sum_{j=1}^{M} \mu_{ij}^m \|x_i - C_j\|^2 \tag{10.3}$$

(e) Repeat the steps (b) to (d) till F_{m} is minimized with respect to a specified threshold or when the specified maximum number of iterations is reached.

The distance measures C_j establish the pair-wise similarities (or dissimilarities) between clusters so that they are both optimum and separated. The cluster is compact when its members are close to each other. This may be measured by variance of the cluster elements with respect to the cluster centre, for each cluster (denoted '*within cluster variance*'). Any two clusters are well separated if their members are distant from each other. This may be measured by variance of the cluster centres considering all clusters (denoted '*between cluster variance*'). These issues may be found in Zhao and Karypis (2001).

The partition coefficient, P_C, is defined as

$$P_C = \frac{1}{N} \sum_{i=1}^{M} \sum_{j=1}^{M} \left(\mu_{ij}^{m}\right)^2 \quad (10.4)$$

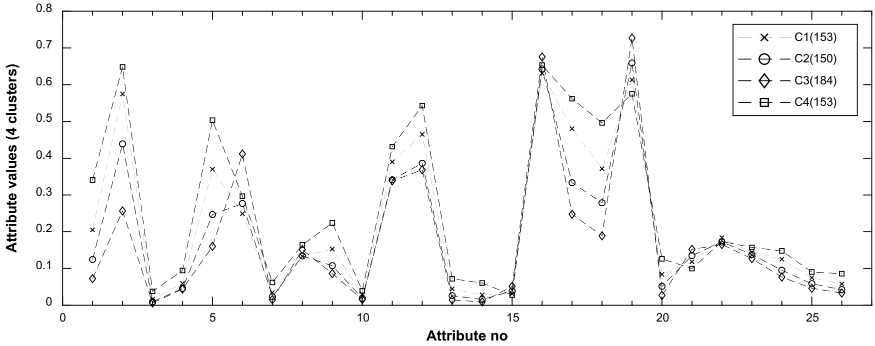
As long as this coefficient satisfies $1/M < P_C < 1$, for a given M (i.e. number of clusters), the clustering results may be deemed acceptable. There also exist other measures of partition fuzziness so that it is an index of 'cluster validity' (Rawashdeh & Ralescu, 2012). In essence, the partition coefficient is a measure of the quality of a fuzzy partition, and as a result, a higher value (between 0 and 1) indicates a better resolved fuzzy partition. As long as its value for a given number of clusters is within the range shown above, the partitions are 'meaningful'. Beyond this range, the partitions are not resolved, and this will always happen for a 'high' number of clusters.

10.4 Results and Discussion

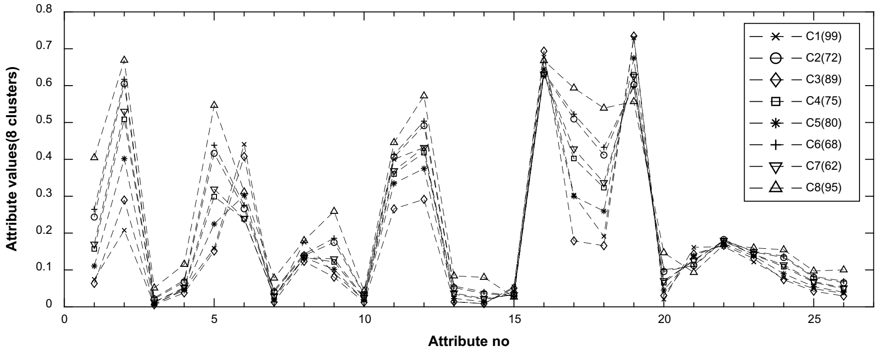
The data described in Sect. 10.2 have been analysed using the FCM clustering method described in Sect. 10.3 for 2 to 12 clusters ($M = 2, 3,\ldots, 12$), i.e. a total of 11 analyses, using the fuzzifier value of 2 ($m = 2$). In this problem, $N = 640$ (total number of districts). The number of districts in each cluster for 2 to 12 cluster problems is summarized in Table 10.2. The cluster results for 4 and 8 clusters ($M = 4$ and 8) are shown in Fig. 10.1. The partition coefficients for all 11 clusters ($M = 2$ to 12) are

Table 10.2 Number of districts in clusters

Number of clusters (M)	Number of districts											
	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$	$C7$	$C8$	$C9$	$C10$	$C11$	$C12$
2	326	314										
3	202	204	234									
4	153	150	184	153								
5	145	118	131	114	132							
6	106	118	114	118	112	72						
7	69	76	106	81	111	114	83					
8	99	72	89	75	80	68	62	95				
9	99	69	67	72	63	57	79	87	47			
10	77	66	61	60	73	30	98	20	73	82		
11	30	75	54	22	58	47	63	77	96	49	69	
12	67	13	64	33	29	63	72	48	45	71	97	38



(a) 4 Clusters



(b) 8 Clusters

Fig. 10.1 Values of 26 attributes (of Table 10.1) in each cluster (Legend shows cluster number and corresponding number of districts)

shown in Fig. 10.2. The 'within cluster variances' and 'between cluster variance', as defined in Sect. 10.3, are shown in Fig. 10.3 for all 11 cluster analyses. For $M > 12$, the clustering algorithm does not converge; i.e. it does not minimize the objective function F_{m}.

Table 10.2 shows number of districts in each cluster, marked $C1$, $C2$, etc., for each cluster analysis. The numbering of clusters ($C1,\ldots, C12$, etc.) does not show their ranking based on either a single attribute or a group of attributes. The number of districts in clusters has wide variation for larger M (e.g. 13 and 97 for $M = 12$). Figure 10.1 presents results of clusters (i.e. values of the attributes in each cluster) for $M = 4$ and 8. For brevity, the results for 9 values of M are not shown. In Fig. 10.2, the partition coefficients for $M = 2$ to 12 are shown as discrete points. The coefficients must lie between the $1/M$ line (continuous curve in this figure) and 1 (see Sect. 10.3), which they do. Therefore, all analyses ($M = 2$ to 12) pass this cluster validity test. As pointed out earlier, $M = 13$ fails this test. Figure 10.3 shows the 'within cluster variances' for each analysis (i.e. each value of M). These

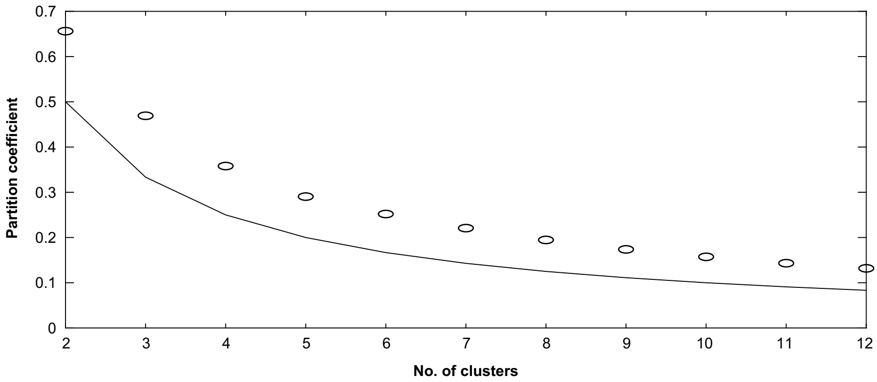


Fig. 10.2 Partition coefficients for various number of clusters

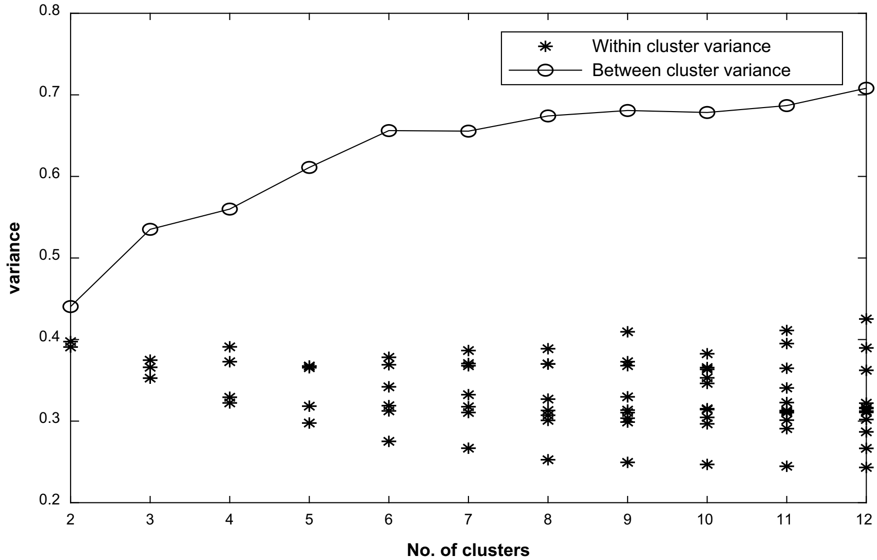


Fig. 10.3 Cluster variances for various number of clusters

variances should be 'low' for cluster compactness. The maximum value of about 0.4 is considered reasonably good for this type of problem. On the other hand, 'between cluster variance' should be 'high' for well-separated clusters. It may be seen that for $M > 5$, the cluster separation is sufficiently 'high' (i.e. it does not increase/decrease significantly). Thus, the clusters with $M = 6$ to 12 are well-separated clusters.

Consider Fig. 10.1a, the 4-cluster analysis, where the numerical values of the attributes of each cluster are marked (and joined by dotted lines to highlight the clusters though all values are discrete). The legend shows the cluster number and

Table 10.3 Cluster sequences in descending order of the attributes

4-cluster analysis ($M = 4$)		8-cluster analysis ($M = 8$)	
Sequence	Attribute numbers	Sequence	Attribute numbers
4–1–2–3	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 17, 18, 20, 23, 24, 25, 26	8–6–2–7–4–5–1–3	1, 3, 5, 7, 9, 13, 18, 24, 25, 26
3–4–2–1	6	8–6–2–7–4–5–3–1	2, 14, 20, 23
4–3–2–1	8	8–6–2–7–4–1–5–3	4, 10, 17
3–2–1–4	15, 19, 21	8–6–2–1–7–4–5–3	11, 12
3–4–2–1	16	1–3–8–5–6–2–7–4	6
1–4-2–3	22	8–1–6–2–4–5–7–3	8
		1–3–5–4–7–2-6–8	15, 21
		3–1–8–5–6–2–7–4	16
		3–1–5–4–7–2–6–8	19
		2–6–7–4–5–8–3–1	22

number of districts as per Table 10.1. It may be seen that for most attributes, the ranking of the clusters (in descending order) yields a sequence 'C4-C1-C2-C3'. The descending orders for all 26 attributes have been calculated, and it is found that there are 6 distinct sequences that cover all attributes. These are listed in Table 10.3 for both $M = 4$ analysis (6 sequences) and $M = 8$ analysis (9 sequences). The attributes (as numbered in Table 10.1) that belong to each sequence are also identified in Table 10.3.

For example, the first row of Table 10.3, for 4-cluster analysis, indicates that 19 attributes (in the second column) as numbered in Table 10.1 are largest in C4, followed by C1, C2 and C3 (4–1-2–3 in column 1). The data of this table may be interpreted in this manner. It means that all these attributes are strongly correlated, i.e. follow the same 'direct order' (descending) over the clusters. The reverse sequence of 4–1-2–3 is 3–2-1–4, and 3 attributes (numbers 15, 19 and 21) belong to this sequence. This also is a strong correlation but may be termed 'reverse order'. Looking at these 3 attributes, it is entirely logical since these are negative attributes (dilapidated house, below primary education and rented household) as against the positive list of the 4–1-2–3 sequence. The attributes 6, 8, 16 and 22 (bicycle, radio, own kitchen and primary education), each belongs to an unique sequence, signify that these do not affect the clustering problem very much and may well be excluded from the attribute list.

Now, consider the sequence list for 8-cluster analysis. The dominant sequence list 8–6–2–7–4–5–1–3 is followed by 10 attributes, all of which belong to the dominant sequence of 4-cluster analysis. These attributes, therefore, may be said to have 'strong direct correlation'. The second sequence 8–6–2–7–4–5–3–1 is slightly different from the first (1–3 interchanged by 3–1) and has 4 attributes that follow it. The third sequence 8–6–2–7–4–1–5–3 is also slightly different from the first and has 3 attributes that follow it. These 7 attributes belonging to these two slightly different sequences may be viewed as having 'weak direct correlation'. A total of 17 attributes follow almost similar sequences, and all of these belong to the first sequence of $M = 4$ analysis. Attributes 11 and 12, which are in fact repeated specification of landline and mobile ownership, share a unique sequence, and again, these do not affect the clustering problem. The reverse (and almost reverse) sequences 1–3–5–4–7–2–6–8 have attributes 15 and 21 (dilapidated house and below primary education), 3–1–5–4–7–2–6–8 has attribute 19, and these are the same attributes that belong to the reverse sequence of $M = 4$ problem.

The attributes 6, 8, 16 and 22, as in 4-cluster analysis, belong to unique sequences and again may be removed from the attribute list as they do not affect the clustering problem. In other words, the data in Table 10.3 can help identification of the attributes which have strong/weak direct/reverse correlations, lazy attributes that do not affect the analysis and over-specified (i.e. repeatedly specified in slightly different forms) attributes that also do not affect the analysis. In 8-cluster analysis, $C8$ is the best or 'winner cluster' where the desirable attributes have high values, followed by $C6$, $C2$, $C7$, $C4$, $C5$, $C1$ and $C3$.

It should be noted, however, that this discussion is based on only 4- and 8-cluster analyses. More detailed work can be done using other cluster values (i.e. $M = 4$ to 12). It has been verified, however, that the conclusions on the nature of attributes remain the same as obtained from the 8-cluster analysis.

The districts belonging to clusters are not identified by name in this work because that would require much larger space to report. Once classification by clustering algorithm is accomplished, the cluster map of districts will identify geographical spread of clusters in various states of India and help identify regional imbalances. The population belonging to each cluster can bring out the regional imbalance both in terms of geography as well as population. These results can be used to orient investment plans for various sectors such as education and housing, digital connectivity infrastructure and establish ease-of-living ranking indices for districts which, in turn, can establish a rational basis for coordinated development of Indian regional economies. However, a sample of the regional picture is presented in Table 10.4 for major Indian states using a 6-cluster analysis, wherein the number of districts in each state is reported for each cluster. This shows, for example, that similar development emphasis is required for 10 districts in West Bengal, 14 in Jharkhand, 27 in Orissa, 16 in Chhattigarh and 20 in Madhya Pradesh (all belonging to C6), depending on the attribute values of these clusters. Similarities between groups of districts of various states can easily be identified from such a regional picture.

Table 10.4 Geographical spread of districts belonging to major Indian states in a 6-cluster analysis

State	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$
Jammu and Kashmir	1	0	1	1	19	0
Himachal Pradesh	1	0	0	0	11	0
Punjab	10	0	0	10	0	0
Uttarakhand	3	0	0	1	9	0
Haryana	15	0	3	3	0	0
Rajasthan	5	3	20	0	2	3
Uttar Pradesh	7	59	2	3	0	0
Bihar	1	37	0	0	0	0
Assam	1	19	0	1	6	0
West Bengal	4	3	1	1	0	10
Jharkhand	2	5	3	0	0	14
Orissa	1	2	0	0	0	27
Chhattisgarh	0	0	2	0	0	16
Madhya Pradesh	4	2	22	2	0	20
Gujarat	12	0	10	2	1	1
Maharashtra	14	0	13	5	2	1
Andhra Pradesh	16	0	4	3	0	0
Karnataka	15	0	14	1	0	0
Kerala	7	0	0	7	0	0
Tamil Nadu	22	0	1	9	0	0

10.5 Conclusion

Machine learning approach is used to analyse census data of physical amenities and educational levels of Indian households to classify Indian districts based on living standards and educational attainment. The FCM clustering algorithm is used in this study. The numerical features of the problem are discussed. The cluster sequence is shown to yield the quality of the attributes such as their correlation and significance. Such classification exercise can lead to identification of regional variations and hence help formulation of economic/investment policies.

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Chapter 11
Multidimensional Poverty in Rural India: An Exploratory Study of Purulia District

Supravat Bagli and Goutam Tewari

11.1 Introduction

Until the third quarter of the last century, economists measured the incidence and intensity of poverty in terms of per capita income, a single dimension of poverty, with a single cut-off value. This cut-off value of income is called 'poverty line income' which distinguishes the poor from the non-poor. In the nineteenth century and before, some did die directly from consumption poverty through starvation, but in general, the situation is less dramatic in present world. Still as a crude measure, we define poverty as a lack of income or extreme starvation. However, this alone doesn't reveal the broader picture of what life is really like for the poor. Sen (1979) has powerfully argued that poverty must be viewed as the deficiency of basic capabilities rather than merely as lowness of income. The set of capabilities of a household or a person is the set of functionings that the person/household values and chooses to perform with freedom. According to Sen (1982), to remove the capability deprivation people have to have access to education and a long healthy life in addition to get access to subsistence level of income. He has formulated a framework to analyse the poverty or achievement of a society encompassing multidimensional perspectives of life and living of the people. This approach is known as capability approach to development where poverty/achievement is viewed as a multidimensional phenomenon beyond income deprivation. With the same line of thought, Human Development Index (HDI) has appeared in UNDP Human Development Report since 1990.

Since 1980s, social science researchers have started to analyse poverty considering several non-income aspects of deprivation, like illiteracy, mortality, malnourishment, autonomy, empowerment along with the income or consumption deprivation. In

S. Bagli (✉)
Department of Economics, Presidency University, Kolkata 70073, India
e-mail: supravat.econ@presiuniv.ac.in

G. Tewari
The AG Church School, Purulia, India

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appearance of the Senian concept of development, different measures of poverty have also been emerged in the literature during the last four decades. The literature on the measurement of multidimensional poverty is developing radically in the recent times. The important contributors in the development of theoretical foundation of multidimensional poverty are Anand and Sen (1997), Tsui (2002), Atkinson (2003), Bourguignon and Charkravarty (2003), Alkire and Foster (2011). The measurement and analysis of multidimensional poverty is an ongoing research project of different national and international bodies like UNDP, World Bank, Oxford University Poverty and Human Development Initiatives (OPHI) with a long history.

Most of the measures have been developed to explore the intensity of multidimensional poverty based on quantitative data set at the aggregate level. They have developed a composite index of several dimensions or indicators. Usually to construct multidimensional poverty index, economists encompass dimensions such as education, health and hunger and living conditions. The paradigm shift to the measure of poverty gives rise to a number of questions such as:

- *Which dimensions and indicators to be included?*
- *What would be the cut-off value for the indicators?*
- *How do we determine the relative weight of the indicators?*

Moreover, the expert group of the World Bank (2015) has raised some questions regarding the relevancy of the measure of multidimensional poverty index.

- *Why do we combine different dimensions/indicators of poverty into a single index?*
- *Is it possible to do in a more logical and meaningful way? And even if possible,*
- *Does the composite index or its decomposition give fruitful message to the policy makers?*

The seminal work of Alkire and Foster (2011), the counting approach to measure multidimensional poverty, has addressed most of the issues. Moreover, it is applicable to the quantitative data and qualitative (ordinal) data regarding deprivation. This methodology follows all the properties of the standard measure of income poverty like Foster et al. (1984) (FGT) measure discussed in Sect. 11.3. It can be applied to explore the incidence, intensity and inequality of multidimensional poverty for a society and for a household. UNDP has adopted the counting approach to report the multidimensional poverty index (MPI) of the countries in Human Development Reports since 2010.

In 2018, the value of multidimensional poverty index (MPI) of India places it as a multidimensionally poor country just below the overall value of MPI for all the developing countries in the world. However, this index is not sufficient to understand the depth and disparity of multidimensional poverty across the regions of India. The study of multidimensional poverty at the regional level is also important to formulate/reformulate the regional planning for development in a sustainable manner. With this end in view, the study has been organized into four more sections. Section 11.2 has cited some selected literature review and specified the objectives of this study.

We have explained the methodology of measuring income poverty and multidimensional poverty in Sect. 11.3. Section 11.4 interprets and discusses the findings. Finally, Sect. 11.5 concludes the chapter with some policy prescriptions.

11.2 Literature Review and Profile of Purulia District

There is a vast empirical literature regarding the incidence of multidimensional poverty across the globe and the factors affecting the multidimensional poverty. This section presents some selected studies in India. Jayaraj et al. (2010) have developed a class of multidimensional poverty headcount indices based on individual deprivation functions. Their indices are analogous to the FGT measure of income poverty and MPI. Applying NFHS data set 1992–93 and 2005–06, this study encompasses eight indicators of deprivations—failure of access to; drinking water within premises, electricity, improved fuel for cooking, improved sanitation, decent shelter, education, even a bicycle for mobility and even a radio for entertainment. They have reported that among the indicators, the highest deprivation has been experienced in access to improved fuel for cooking followed by access to decent shelter and access to improved sanitation for the Indian households. The incidence of severe deprivation reduces while incidence of vulnerability and marginal deprivation increases during 1992–93 to 2005–06. They have identified West Bengal as an element of the set of poorest Indian states in 2005–06 although West Bengal was not in that set in1992–93. Alkire and Seth (2013) have examined the reduction of multidimensional poverty in India during 1999 to 2006. This study, an exercise of Alkire and Foster (2011) methodology of MPI, has used the NFHS data from round 2 (1998–99) and round 3(2005–06). Initially, they have found that the incidence of multidimensional poverty has fallen 8.3% points (from 56.8% to 48.4%) while the value of MPI in India reduces from 0.3 in 1998–99 to 0.251 in 2005–06. Decomposition of MPI among the indicators shows the relative rate of reduction in the censored headcount ratios of the living standard indicators like 'electricity', 'water', 'housing' and 'sanitation' are greater than the reduction of deprivation in any health and education indicators. This result is consistent with the finding of Jayaraj et al. (2010). Moreover, multidimensional poverty reduces invariably across the social castes, but the rate of reduction was lowest for the tribals. Banerjee et al. (2014) have compared the ranks of the Indian states in respect of head count ratio of income poverty and MPI. Using the NFHS data 1992–93, 1998–99 and 2005–06, the study has reported that income poverty has decreased in all states in India during the period under study. However, the incidence of multidimensional poverty has increased in the states of Arunachal, Manipur and Tripura during the same period. The study reveals that poverty has no noticeable spatial pattern in India, but the extent of poverty in rural area compared to urban areas is high and the rural–urban disparity is increasing over time. Actually, the human development across the states exhibits an unbalanced pattern. Poor states are continuing with poverty and non-poor states continuously develop themselves. For example, the state of Bihar stays in extreme poverty during the period of three rounds of NFHS in India. They have found that Indian women are most deprived section and their deprivation varies significantly in accordance with their social and ethnic identity. The study also explains how the male child favouritism causes higher degree of deprivation of women compared to men in India. Seth and Alkire (2014) describe a separate measure of inequality among the poor and across population subgroups. They also report that the value of MPI and its components decrease for each social caste, but the inequality increases among the poor in scheduled tribes during 1999–2006. Dehury and Mohanty (2015) have included some economic variables under the dimension of employment and indoor environment and some of the key environmental dimensions in addition to the dimensions of health, education and living condition for estimating multidimensional poverty for the 84 regions in India. They have used unit-level data from the Indian Human Development Survey (IHDS), 2004–05, and household consumption expenditure has been considered to determine the status of the living dimension. The study finds that about half of India's population is multidimensionally poor with wide regional disparities. West Bengal appears where share of poverty is higher than its share of population in India. Decomposition analysis explores that in most of the regions, one-third contribution to MPI comes from the economic dimension. They have suggested target-wise interventions of the government for eradicating multidimensional poverty and inequality in India.

Using a primary survey data, Bagli (2015) has reported the MPI for two CD blocks, Kotulpur, agriculturally developed, and Chhatna agriculturally backward, in Bankura district, an adjacent district of Purulia, in West Bengal. This study has revealed that the agriculturally developed block is better in position compared to the backward block in respect of multiple economic deprivations. He has found that scheduled caste households compared to scheduled tribes are more likely to fall in extreme multidimensional poverty. However, scheduled castes compared to tribal are less marginally poor and vulnerable. Roy et al. (2018) have reported multidimensional poverty for the rural households in West Bengal on the basis of primary survey from 384 households of four districts. They have applied Alkire and Foster (2011) methodology along with the indicators and found the health dimension with highest contribution to MPI. The inequality among the multidimensionally poor is highest among the upper caste poor followed by the poor belonging to OBC, scheduled castes and scheduled tribe. Inequality among the poor also varies across the occupational groups and districts. It is highest among the farmer households among the occupational groups. However, they did not consider any district from the western part of West Bengal where our study district belongs to.

Debnath and Shah (2020) have analysed the intertemporal changes in multidimensional poverty in Tripura, a north-eastern state in India during 2000–2015. Applying NFHS data of second, third and fourth rounds, they have reported that the value of the MPI for Tripura reduces by 4.6% during the study period and the incidence of multidimensional poverty by 1.7% per annum. They have observed that greater degree of reduction in the living condition indicators primarily cause the reduction of MPI. The reduction in the intensity and the incidence of poverty was significantly higher in the rural areas compared to urban part of Tripura. Among the social castes, the largest reduction in the intensity of the multidimensional poverty is observed among the SCs, and the highest MPI and the incidence of poverty (H) are found among the STs. Poverty reduction is higher among male-headed households and households with smaller family than their counterparts.

Based on the NFHS data, Alkire et al. (2018) show that MPI including incidence and intensity of multidimensional poverty has been reduced remarkably from 2005–06 to 2015–16 for India. However, the proportion of population at risk of multidimensional poverty has been increased. There is a wide disparity in poverty across districts and regions. In 2015–16, the number of rural residents living in poverty is roughly four times those of the urban areas. Further, the study finds Bihar to be the poorest state with more than half its population in poverty. Over half of India's multidimensionally poor live in Bihar, Jharkhand, Uttar Pradesh and Madhya Pradesh. High deprivations are concentrated in districts along the Indo-Gangetic Plain including pockets from Uttar Pradesh, western Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh and Odisha. In respect of the value of MPI among the districts in West Bengal, Purulia (0.262) is the worst in position preceded by Uttar Dinajpur, Birbhum, Malda, Bankura. Again the incidence of multidimensional poverty is highest in Purulia district among the districts in West Bengal. The intensity of multidimensional poverty is highest in Uttar Dinajpur, followed by Purulia district.

Therefore, the value of MPI for India has reduced while the vulnerability of multidimensional poverty in India increases during the last two decades. The incidence of multidimensional poverty did not reduce uniformly across the Indian states, even in some of the north-eastern states it is increasing. In India, the incidence, intensity and inequality of multidimensional poverty are unevenly distributed across the regions, rural–urbans, gender, castes and occupational groups. In West Bengal, there is wide variation across the districts in respect of the incidence and intensity of multidimensional poverty. The position of the district of Purulia is at the bottom line among the districts of West Bengal, in 2015. Now the right time to examine whether the incidence and intensity of multidimensional poverty in the poorest of the multidimensionally poor districts in 2015 is reducing or not. If it is reducing, what is the rate and what factors are significantly contributing to current value of MPI? Moreover, in literature there is no systematic case study of a district in India for exploring the incidence and intensity of multidimensional poverty which is relevant to examine the effectiveness of existing public policies and for formulating district development planning. It provides immense inspiration to study the depth and distribution of multidimensional poverty for a district in India. Let us now introduce the district of Purulia before mentioning the objectives of the study.

Purulia was a district of erstwhile state of Bihar at the time of independence of India. It was recognized as a district of West Bengal on 1 November 1956, after a long movement for Bengali language. It is the westernmost border district of West Bengal in eastern India. The district is identified as the juncture of table-top land of Chota Nagpur and delta of lower Bengal. The western and north-western parts of the district are dominated by forests and hills of Ajodhya range. Remaining part is relatively plain land dominated by non-irrigated agriculture and mines and minerals. 'Kansai', 'Subarnarekha' are the major river streams of the district. The three sides, namely north, west and south of the district, are ended with the state of Jharkhand. The district of Purulia belongs to the Red Corridor, a zone of eastern India experiencing frequent Naxalite–Maoist insurgency.

Compared to West Bengal as a whole, Purulia district is sparsely populated while the district is denser than India as a whole. The district is divided into 20 Community Development (C.D.) blocks and 3 municipalities. The district of Purulia is primarily rural in nature. 87.26% of the population lives at villages. Majority of the people (about 83.42%) believe in Hinduism. In this district, scheduled castes and scheduled tribes constitute 19.4% and 18.5% of the total population respectively. In respect of the share of tribal population, Purulia district ranks second (next to Jalpaiguri) among the districts in West Bengal. Majority of the working population in this district is engaged in traditional agricultural or informal traditional arts and crafts. Moreover, a large section of children and elderly in Purulia district is compelled to participate in workforce. Seasonal migration of the poor people of this district to the adjacent districts as agricultural labourer is a common phenomenon (Government of West Bengal, 2014).

Population census 2011 (Government of India, 2011) reports that literacy rate in Purulia is 64.48% which was 55% in 2001. The gender wise, female and male literacy as per the census report 2011 were 50.52% and 77.86%, respectively. Thus, in respect of literacy rate this district lies far behind the state average. As per 2011 census, the sex ratio in Purulia district is 957 which is much better than that in West Bengal (934) and India (933) as a whole. The infant mortality rate for Purulia district is 10.5 per thousand which is surprisingly lower compared to the infant mortality rate for West Bengal (27 per thousand) in 2015–16. The rate of institutional birth in Purulia is 73% of the pregnant women in 2015–16 which is close to the figure for West Bengal as a whole. However, the problem of malnutrition is prominent in this district relative to the state. In this district, BMI of 47.5% (24.5%) of eligible women (men) are below normal level. Not only that, 80% (44.9%) of eligible women (men) in Purulia district are found as anaemic in 2015–16, which is much higher than the figures for West Bengal. The rate of child immunization in Purulia district catches up the state average.

We now look into the picture of living conditions of the households of Purulia district with the lens of census data 2011. In respect of the housing condition of the households (7% live in dilapidated house), the position of this district is better than West Bengal as a whole. It is disappointing to note that two-thirds of the households in this district have no electricity. Most of the households in Purulia district cook their food using dirty fuel like cow dung cake, crop residue, forest residue, etc. In respect of access to safe source of drinking water, the district lies far behind the state average. It is shocking that 88.2% of the households in Purulia district don't use improved sanitation facility. At least one member in 43% households in this district has bank account. However, compared to the state, this district is not poor in respect of holding assets for mobility, entertainment, etc.

The socio-economic profile indicates the backwardness of Purulia district in West Bengal. Hence, the study of multidimensional poverty of Purulia district is badly relevant to examine the progress and for planning in more decentralized way for sustainable development of different community and county of the district. This study is initially devoted to analyse the incidence, severity and intensity of income poverty for the households in Purulia district. Secondly, we explore the incidence and intensity of multidimensional (a non-income measure) poverty in Purulia district.

11.3 Methodology and Data

Traditionally, poverty refers to income or consumption deprivation. So in the first step, we measure income poverty. There is a strong theoretical literature on measuring income poverty given the poverty line income. Poverty line income is a threshold level of income used to identify the poor people in a given population. Poverty line income is defined as the income which is minimal necessary to avail the basic needs of life in a given society. Poverty line income varies from region to region and time to time.

11.3.1 Measure of the Incidence and Intensity of Income Poverty

In India, different group of experts provided different values of poverty line income in the country as a whole and for the states individually and for the rural and urban part of the country and for the states. It was Rs. 972 for India in 2011–12 (Planning Commission, 2014). In 2011–12, poverty line income for rural West Bengal was Rs. 934 per month per person. As the district of Purulia is a remote and rural district where life and living standard of the people are not so advanced, we have assumed that modest inflation rate is 3% per annum for the basic goods and services during the six years since 2011–12. Then adding the modest 3% inflation rate with the Planning Commission poverty line income in 2011–12, we have found Rs. 1115 as poverty line income per head per month for the households living in Purulia district for the year 2017–18. In order to explore the incidence, intensity and distributional sensitivity index of poverty, Foster et al. (1984) (FGT) have developed a general family of poverty measure. The working formula for the FGT family of poverty index can be written as follows:

$$P_\alpha = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{y_p - y_i}{y_p}\right)^\alpha \tag{11.1}$$

where n stands for the total population and q is the number of households having below poverty line income.

y_i measures volume of welfare, e.g. consumption or income per capita,

y_p is specified poverty line monthly per capita income and the parameter $\alpha \geq 0$ denotes the measure of poverty aversion. The greater values of α means the greater weightage on the poverty gaps of the poorer households.

For very large value of α, P_α converge to a 'Rawlsian' measure of poverty which considers only the position of the poorest household. Setting $\alpha = 0$, FGT index reduces to head count ratio (P_0) which explore the incidence of income poverty. Putting $\alpha = 1$, it gives Poverty Gap Index which explores the depth or intensity of poverty. Alternatively, P_1 can be viewed as a $P_0 \times$Income Gap Ratio. In other words, P_1 is a renormalization of the income gap ratio. We find squared poverty gap index if $\alpha = 2$, which captures the effect of inequality in income. P_2 measure is known as the Severity Index of Poverty. P_α satisfies monotonicity axiom, the transfer axiom and transfer sensitivity axiom for $\alpha > 2$. Therefore, FGT is a more general measure of intensity of poverty. Moreover, the FGT index is decomposable, i.e. the poverty index of a society can be expressed as a weighted average of the poverty indices of the mutually exclusive and exhaustive sections of the society. This study considers $\alpha = 0$, 1, 2 and 3 for revealing the incidence and intensity of income poverty for the sample households.

11.3.2 Measure of the Incidence and Intensity of Multidimensional Poverty

The foundation work for measuring MPI is the selection of dimensions. Then the justification of indicators under the selected dimensions is a very much important and serious job to the researcher. With the great legacy of UNDP, we have encompassed three common dimensions, namely health and hunger, literacy and knowledge and living condition for measuring the overlapping deprivations of the households in Purulia district. Across the selected dimensions, 12 indicators in total have been considered; three for health dimension, three for education and six for living condition. The selected dimensions and indicators of multidimensional poverty for Purulia district have been displayed in Table 11.1.

We have considered all the indicators used by UNDP in the measure of MPI of the countries except infant mortality. We have added two extra indicators under health and hunger dimension and one under education dimension. The incidence of hunger is not uncommon in several parts of our study district. Due to lack of improved communication and lack of awareness and often due to income poverty in Purulia district, the households usually depend on informal health service. That is why this study includes incidence of hunger and access to formal health service as indicator of health dimension of poverty. Financial exclusion is another important indicator of human poverty under the knowledge dimension. A right financial plan of the household often reduces the pangs of poverty. We have a bitter experience of chit-fund scam in our state. This chit-fund scam gives a lesson that financial illiteracy makes people financially vulnerable. Thus, financial literacy is necessary for poverty

Table 11.1 Dimension, indicators with weights of MPI in Purulia district

Dimension	Deprivation criteria for the selected indicator (d_j)	Weight (w_j)
Health and hunger	Don't have access to formal health clinic during illness	1/6
	At least one member suffers from malnourishment	1/6
	At least one member suffers from hunger at least one day	1/6
Literacy and knowledge	No one adult has passed primary level of education	1/6
	No one school-aged children attend school	1/6
	No one member has a bank account	1/6
Living condition	Mud flooring of the residence	1/12
	No electric connection at the residence	1/12
	Use unsafe source of drinking water	1/12
	Don't use improved sanitation	1/12
	Don't use improved cooking fuel	1/12
	Household owns at most one of: bicycle, motorcycle, refrigerator, cell phone or television	1/12

Source Authors' justification

alleviation. With this end in view, we consider financial illiteracy as an indicator of multidimensional poverty.

The indicators are stated in view of the deprivation. We assign value '1' if the statement (d_j) is true and '0' otherwise. Following UNDP, this study has awarded equal weight to each dimension, and further equal weight has been awarded for each indicator within a dimension. Table 11.1 depicts the deprivation criteria for the corresponding indicators and their weights.

Now to measure the incidence and intensity of multidimensional poverty of the households, we compute the sum of the weighted deprivation score (S) over the dimensions and indicators for each household. Symbolically,

$$S_i = \sum_{j=1}^{12} w_j d_j \tag{11.2}$$

where w_j denotes the relative weight attached with jth indicator such $\sum_{j=1}^{12} w_j = 1$. Note that S_i lies in between 0 and 1 such that as deprivation increases the value of S_i increases and vice versa. In order to identify the multidimensional poor, we now have to choose a cut-off value for the weighted score. Following UNDP, we have identified a household (or all members of the household) as multidimensionally poor, if the sum of weighted deprivation scores (S) for the household is at least 1/3. The head count ratio in case of multidimensional poverty (H) is the ratio of the number of multidimensionally poor people and the size of total population. Thus, technically the formula for head count ratio can be written as,

$$H = \frac{q}{n} \tag{11.3}$$

where q is the number of households with weighted deprivation score 1/3 and above. In other words, 'q' is the size of multidimensionally poor households. 'n' is the size of sample size. H measures the incidence of multidimensional poverty of the households. Head count ratio is a simple and basic measure, but it ignores the differences between different poor households in respect of deprivation score. That encourages us to measure the intensity of multidimensional poverty.

The intensity of multidimensional poverty (A) is the ratio of the sum of weighted deprivation scores of the multidimensionally poor and size of multidimensionally poor population. This measure is known as the breadth of multidimensional poverty. Technically,

$$A = \sum_{1}^{q} \frac{S_i}{q} \tag{11.4}$$

Here S_i denotes the total weighted deprivations score of ith multidimensionally poor household in respect of all the dimensions of deprivation. Finally, the multidimensional poverty index (MPI) is the product of the multidimensionally poverty head count ratio (H) and the intensity of multidimensional poverty (A). Therefore,

$$\text{MPI} = H \times A \tag{11.5}$$

The measure is called adjusted headcount ratio, M_0, for multidimensional poverty. This measure of multidimensional poverty has some important properties which are useful to analyse multidimensional poverty of a region or for a country. MPI has some important properties which place the methodology in an advantageous position compared to the position of the other available measures of multidimensional poverty.

1. MPI methodology is applicable and robust when indicators are response variables, as it creates binary variable for each information regarding the access to a specific facility into 'deprived' and 'non-deprived'.
2. It is also applicable when one or more indicators are cardinal. Moreover, it can be extended to measure squared poverty gap which reflects inequality among the multidimensionally poor.
3. MPI satisfies the property of dimensional monotonicity. Thus, if a poor household becomes deprived in an additional indicator, the value MPI increases.
4. Finally, this measure is decomposable by mutually exclusive and exhaustive population subgroups. This measure enables comparing poverty across the subgroups. Further, this measure is decomposable by indicator and dimension.

The formula of MPI for the district can be decomposed across the residential region (for example) of the households as follows.

$$\text{MPI}_{\text{Dist}} = \frac{n1}{n}\text{MPI}_{\text{rural}} + \frac{n2}{n}\text{MPI}_{\text{urban}} \tag{11.6}$$

Symbols have their standard meanings. This formula can be used for any number of exhaustive strata like social castes, occupational classes, etc. The percentage contribution of each strata to overall poverty can be measured applying the following formula developed by Alkire et al. (2011).

$$\text{Contribution of the households to district MPI} = \frac{\frac{n1}{n}\text{MPI}_{\text{rural}}}{\text{MPI}_{\text{Dist}}} * 100 \tag{11.7}$$

If the contribution of a subgroup to the overall poverty is greater than its population share, we conclude that poverty disproportionately distributed across the study strata.

MPI can also be decomposed across the indicators under consideration. In order to decompose the MPI by indicators, first we compute the censored head count ratio for each indicator. The censored head count ratio for an indicator is the ratio of the number of multidimensional poor who are deprived of the particular indicator to total sample size. The censored head count ratio (CH) for a particular indicator is as follows.

$$CH_j = \frac{1}{n}\sum_{i}^{q} d_{ji} \tag{11.8}$$

Such that, d_{ji} takes value '1' when the ith multidimensionally poor household is deprived of jth indicator and '0' otherwise. Then, according to Alkire et al. (2011), decomposition formula of MPI across the indicators can be written as follows,

$$\text{MPI}_{\text{Dist}} = \sum_{j=1}^{12} w_j CH_j \tag{11.9}$$

Here w_j denotes the relative weight attached with jth indicator. The percentage contribution of each indicator to overall poverty can be measured with the following formula.

$$\text{Contribution of } j\text{th indicator to MPI} = \frac{w_j CH_j}{\text{MPI}_{\text{Dist}}} * 100 \tag{11.10}$$

Whenever the contribution of a particular indicator to the overall poverty is widely greater than its relative weight, the deprivation is relatively high in this indicator. In other words, the multidimensionally poor households are more deprived in this indicator than in others.

11.3.3 Data Sources

This study is based on a set of primary data of 700 households surveyed in 2018–19. In order to make the data set representative of Purulia district, this study covers all the three subdivisions, namely Purulia East (Sadar), Purulia West and Raghunathpur. Data have been collected following multistage random sampling technique. In the first stage, we have selected one block randomly from each subdivision. The selected three blocks are namely Raghunathpur-1, Purulia-1 and Jhalda-1. We have also covered Purulia Municipality, the major municipality in this district. In the second stage, two Gram Panchayats have been selected randomly from the blocks. In stage three, we have randomly selected two residential villages from each selected Gram Panchayat. Finally, we have collected data from randomly selected 600 households from the selected villages considering a suitable number of households from each selected village depending on its socio-demographic features. We have also surveyed randomly selected 100 households from two wards of Purulia municipality. Therefore, our study follows a multistage sampling technique. But it is ultimately a random sample where households from selected villages/municipality are chosen following random number table method. The required data from 700 households in Purulia district covering have been collected during August 2018-February 2019.

11.4 Empirical Findings and Discussion

Table 11.2 displays that average family size of the surveyed households is 4.2, which is consistent with the census data of population in Purulia district. In our sample, the average age of household head is of 47.04 years which varies from 21 to 82 years.

Table 11.2 Descriptive statistics of the sample households ($N = 700$)

Variable	Mean	Median	Mode	SD	Max	Min
Family size	4.2	4	4	1.5	11	1
Age of the head (year)	47.04	47	48	13.35	82	21
Education of the head (year)	4.84	0	0	5.65	22	0
Dependency ratio (%)	63.23	66.66	75	19.73	100	0
Highest male education (year)	8.17	9	0	5.42	22	0
Highest feale education (year)	6.38	7	0	5.57	22	0
Agricultural land (bigha)	0.86	0	0	2.02	35	0
Per capita monthly income (Rs. 000)	3.58	1.3	1.3	6.04	48.7	0.39
Per capita gross savings (Rs. 000)	8.22	0.3	0	40.90	750	0
Formal loan outstanding (Rs. 000)	28.86	0	0	14.27	1500	0
Informal loan outstanding (Rs. 000)	2.66	0	0	22.88	500	0

Source Authors' computation based on household survey 2019

Majority of the household heads are illiterate. However, the average of maximum education among the male (female) members is 9 (7) years. Therefore, there is huge exclusion in Purulia district in respect of education. Average dependency ratio in the surveyed household is 63per cent. In an average sample, households hold one bigha (0.4 acre) of land although majority of the households has no agricultural land. Average monthly per capita household income is Rs 3.5 thousand in 2017–18 which varies from rupees four hundred to forty-eight thousand. The descriptive statistics of gross savings and outstanding loan there is huge inequality among the sample households.

Table 11.3 shows the percentage distribution of the sample households in respect of the socio-economic and demographic attributes like residential place, structure, social castes, occupational status and economic status. Still, eight per cent of the households in Purulia district send their children for earning livelihood. In Purulia district, seven per cent of the households seasonally migrate for smoothing the livelihood throughout the year. Therefore, the problem of child labour and seasonal rural-to-rural migration are not negligible social problems. Only 10% of the sample households are the recipient of benefit from social security scheme like old age pension, health insurance.

Table 11.3 Socio-economic and demographic traits of the sample households ($N = 700$)

Attributes	Number	Percentage
Residential place		
Rural	600	85.71
Urban	100	14.29
Nuclear family	532	76.00
Major household occupation		
Cultivation	164	23.42
Self-employment	129	18.42
Service	97	13.85
Wage labour	310	44.28
Social castes		
General castes households	315	45.0
Households belonging to OBCs	75	10.71
Households belonging to Scheduled castes (SCs)	180	25.71
Households belonging to Scheduled tribe (STs)	130	18.57
Agricultural landless households	418	59.71
Economic condition (holding BPL card) of the households	256	36.57
Prevalence of child labour	56	8.00
At least one member migrates for earning livelihood	51	7.28
Households obtained social security benefit	75	10.71

Source Authors' computation based on household survey 2019

Let us now give an explanation of income poverty for the sample households. The primary money metric measure of poverty is the head count ratio, which is found to be 0.39 for the district of Purulia. The incidence of income poverty is higher than the average incidence of income poverty for rural India which was 30.9% (Government of India, 2017). In West Bengal, the incidence of income poverty was 29.7% in 2011–12 while it was 30.1% for the rural households in West Bengal as per methodology of Planning Commission. The position of West Bengal is 20th in respect of incidence of poverty when we rank the states from the least poor to the poorest one (World Bank, 2017). Further, the share of West Bengal in Indian population and in India's poor population is almost equal. Therefore, incidence of income poverty in the district of Purulia is higher than average in rural West Bengal. The report of World Bank (2017) displays that incidence of income poverty of Purulia district lies in range of 31–38%. Thus, our findings are very much compatible with the report of World Bank. However, our study explores that in respect of income poverty the district of Purulia is much better than that in rural Jharkhand (45.9%), the neighbour state of West Bengal adjacent to Purulia district.

Table 11.4 shows the incidence, depth, severity and intensity of income poverty for households belonging to different social castes. The incidence of poverty is highest among households belonging to tribal community followed by scheduled castes, OBCs than general castes. More than half of the tribal households are income poor in our sample. The head count ratio for the tribal households is far higher than average head count ratio in the district. So, tribals in Purulia district are relatively poorer than other social castes. On the other hand, households belonging to forward castes are relatively better in position in respect of head count ratio. Households of OBCs and SCs in Purulia district are close to each other in respect of incidence of income poverty. Moreover, in respect of depth, severity and intensity of income poverty, scheduled tribes uniquely come first, then SCs then OBCs and finally general castes.

Table 11.5 shows the nature of deprivation of households on the basis of some selected non-income indicator. Five per cent of the sample households in Purulia

Table 11.4 Income poverty for the households of different castes in Purulia district

Measures	District $N = 700$	General castes ($n = 315$)	OBCs ($n = 75$)	SCs ($n = 180$)	STs ($n = 130$)
Head count ratio	0.391	0.311	0.41	0.422	0.530
Poverty gap index	0.097	0.075	0.092	0.109	0.137
Squared poverty gap index	0.033	0.026	0.027	0.038	0.048
FGT measure ($\alpha = 3$)	0.014	0.011	0.010	0.015	0.019

Source Authors' computation based on household survey 2019

Table 11.5 Indicator-wise deprivation of the households in Purulia district

			Community development blocks			
Dimension	Deprivation criteria for the selected indicator (d_j)	Purulia district (N = 700)	Purulia−1 (N = 200)	Jhalda-1 (N = 200)	RN Pur-1 (N = 200)	Municipalities (N = 100)
Health and Hunger	Don't have access to formal health clinic during illness	0.051	0.005	0.170	0.005	0
	At least one member suffers from malnourishment	0.288	0.43	0.350	0.22	0.02
	At least one member suffers from hunger at least one day	0.335	0.305	0.435	0.43	0.01
Literacy and Knowledge	No one adult has passed primary level of education	0.194	0.145	0.365	0.17	0
	No one school-aged children attend school	0.064	0.06	0.065	0.09	0.02
	No one member has a bank account	0.077	0.035	0.365	0.13	0.08
Living condition	Mud flooring of the residence	0.702	0.66	0.965	0.80	0.07
	No electric connection at the residence	0.224	0.145	0.415	0.22	0.01
	Use unsafe source of drinking water	0.071	0.07	0.170	0.01	0

(continued)

Table 11.5 (continued)

			Community development blocks			
Dimension	Deprivation criteria for the selected indicator (d_j)	Purulia district (N = 700)	Purulia−1 (N = 200)	Jhalda-1 (N = 200)	RN Pur-1 (N = 200)	Municipalities (N = 100)
	Don't use improved sanitation	0.707	0.78	0.925	0.77	0
	Don't use improved cooking fuel	0.711	0.725	0.935	0.825	0.01
	Household owns at most one of: bicycle, motorcycle, refrigerator, cell phone or television	0.061	0.035	0.075	0.105	0

Source Authors' computation based on household survey 2019

don’t have access to formal clinic during illness. It is 17% in Jhalda block. They report the use of self-made herbal, call the informal practitioners, Ojhas, etc. It is not only lack of money, rather often it happens due to lack of awareness of health services. At least one member in twenty-eight per cent of the households suffers from malnutrition. The prevalence of malnutrition is the highest in Purulia-1 block followed by Jhalda-1 block and Raghunath pur-1 block. It is not surprising that one-third of the households in Purulia district suffered from shortage of square meal during the last year. The figure is much higher in western part of the district. Thus, food insecurity is a prominent economic problem to the households in Purulia district. This information indicates the shortage of food during several periods of a year which causes malnutrition and health hazard of the households. In spite of wide expansion of educational infrastructure in India including West Bengal during last two decades, still 19% of the households have reported that no single adult member passed primary level of education. At least one child (up to 14 years) of six per cent sample households is not enrolled in school. Further, during the last six-seven years, there is commendable extension of banking service across the corners of India. Yet, it fails to bring seven per cent of the sample households in Purulia district under the purview of banking services. This figure is five times (double) of the district average for the westernmost block Jhalda-1 of the district (easternmost block, Raghunath pur-1). So, a large percentage of the rural households in the district are financially excluded. Taking the opportunity of this unfortunate illiteracy, several corrupted chit-fund organizations like Sarada, Rose-Valley, Alchemist, etc. have stimulated financial shocks to the poor people in the district. This kind of monetary shock often makes the poor poorer.

We now explore the deprivation of the households in respect of living conditions. Seventy per cent of the households live in clay-house. It is shocking that 22% of the households have no electric connection for lighting. Seven per cent of the surveyed households collect drinking water from unsafe sources. Majority of these households drink water with iron contamination and face shortage of drinking water during every summer. Only thirty per cent of the sample households have access to improved sanitation and access to modern fuel and energy for cooking. Thus, the households in the district are not conscious of health and hygiene. Only six per cent of the sample households are poor in terms of asset holding like cycle/motor cycles, television and mobile hand-set. We have observed that in respect of each indicator in living standard dimension, the block of Jhalda-1 is the worst off preceded by Raghunathpur-1 and Purulia-1.

Tables 11.6, 11.7 and 11.8 illustrate the empirical findings of the incidence and intensity of multidimensional poverty computed based on the selected indicators for the district of Purulia and its decomposition across the regions, social castes and occupational groups. It is estimated that 37% of the sample households are multi-dimensionally poor in Purulia district, while 27% of Indian households are multi-dimensionally poor (UNDP, 2020). The incidence of multidimensional poverty of Purulia district in 2015–16 was 59% as reported by Alkire et al. (2018). Therefore, the incidence of multidimensional poverty remarkably reduces during the last three years. The incidence of multidimensional poverty of Purulia district is similar to

Table 11.6 Rural–urban decomposition of multidimensional poverty in Purulia district

Measures	Purulia district (N = 700)	Rural area (N = 600)	Urban area (N = 100)
HCR of multidimensional poverty (H)	0.367	0.426	0.01
Intensity of multidimensional poverty (A)	0.438	0.439	0.333
Multidimensional poverty index (MPI)	0.161	0.187	0.0003
Share in sample (%)	100	85.7	14.3
Contribution of the castes to MPI (%)	100	99.6	0.04

Source Authors' computation based on household survey 2019

Table 11.7 Decomposition of multidimensional poverty across the social castes

Measures	General castes (n = 315)	OBCs (n = 75)	SCs (n = 180)	STs (n = 130)
HCR multidimensional poverty (H)	0.234	0.360	0.488	0.530
Intensity of multidimensional poverty (A)	0.447	0.430	0.439	0.436
Multidimensional poverty index (MPI)	0.105	0.155	0.214	0.231
Share in sample (%)	45	10.71	25.71	18.57
Contribution of the social caste to MPI (%)	29.34	10.31	34.17	26.64

Source Authors' computation based on household survey 2019

Pakistan in 2017 (38.3%), but it is poorer than Bangladesh (24%) in 2019 and Nepal (34%) in 2016 (UNDP, 2020). Although the incidence of multidimensional poverty helps the policy maker to identify the multidimensionally poor households or individuals, it has little policy implications. The policy makers, who plan for poverty alleviation, would get an incentive to reduce only the deprivation of marginally poor households deliberately ignoring the poverty of severely poor households. In this situation, policy practitioners often get incentive to be corrupted by spending less than the allotted money for reducing poverty. That is why we should consider intensity of multidimensional poverty and adjusted HCR.

Table 11.8 Decomposition of multidimensional poverty across the occupation groups

Measures	Cultivation (n = 164)	Self-employment (n = 129)	Service (n = 97)	Casual labour (n = 310)
HCR of multidimensional poverty (H)	0.390	0.077	0.041	0.581
Intensity of multidimensional poverty (A)	0.397	0.483	0.361	0.454
Multidimensional poverty index (MPI)	0.155	0.037	0.015	0.264
Share in sample (%)	23.42	18.43	13.86	44.28
Contribution of the social caste to MPI (%)	22.55	4.24	1.29	72.61

Source Authors' computation based on household survey 2019

The value of intensity of multidimensional poverty of the poor for Purulia district is 0.438 which is actually the average deprivation of the multidimensionally poor households. This finding is very close to the intensity of multidimensional poverty for India (43.9%) and the intensity of multidimensional poverty for Purulia district (44.3%) based on DHS 2015–16 by Alkire et al. (2018). This result closely matches with the intensity of multidimensional poverty of Nepal in 2016 and Bangladesh (42.2%). In respect of the intensity of multidimensional poverty, Purulia district as well as India has done better compared to Pakistan (51.7%) in 2017. The estimated MPI for Purulia district is 0.161 which is nothing but the adjusted incidence of multidimensional poverty. It can be viewed as the proportion of deprivation experienced by the multidimensionally poor out of maximum possible deprivation within the district. Our finding shows that the value of MPI for Purulia district is remarkably higher than that for India as a whole in 2018 (0.121) (UNDP, 2020). The figure of MPI of Purulia district is mildly better than that of Pakistan (0.198) in 2017–18 and mildly worse than that of Bangladesh (0.104) in 2019 (UNDP, 2020). The MPI for Purulia district was 0.262 in 2015–16 (Alkire et al., 2018). It establishes that the adjusted headcount ratio of multidimensional poverty has reduced remarkably during the last three or four years in the district of Purulia. However, the average deprivation of the poor remains unchanged.

The subgroup decomposability of the multidimensional poverty index is its salient feature. It has good implication in formulation of regional planning. The decomposition of the MPI across the regions shows that incidence and adjusted incidence of multidimensional are more serious in rural areas compared to urban counterpart. The rural areas contribute 99.5% in the district MPI, while the district share of population of the rural region is 85.7%. It is seen that incidence intensity and adjusted incidence of multidimensional poverty are higher among the scheduled tribes compared to the other social castes. In all respects, households belonging to forward castes are least deprived compared to the deprivation of other social castes. This analysis shows that the order of the castes in accordance with their multidimensional poverty is same as we find in income poverty analysis. Tribal folks are relatively more deprived followed by SCs, OBCs and general castes. Moreover, contribution of the SCs to the district MPI is 34% which is the highest among the contribution of social castes. The contributions of SCs and STs are greater than their population shares. Thus, the distribution of multidimensional poverty is skewed towards lower social castes in Purulia district. The cumulative contribution of SCs and STs is 60%, while they account for 43% of the total sample.

The decomposition of MPI across the occupational groups shows 58% (39%) of casual labour (cultivator) households as multidimensionally poor. The MPI for the casual labour is 0.26 which is 0.39 for cultivators. In terms of incidence, the degree of deprivation is the highest among casual labour force followed by cultivators, self-employed and service holders. However, intensity of multiple deprivation is the highest among the self-employed group. The contribution of casual labour force in district MPI is significantly higher than their population share. So, the multidimensional poverty highly concentrated among the casual labour households.

The report of the contribution of individual indicators is very much relevant to current policy makers to assess their existing project, and it is equally important to the future planners to formulate appropriate regional plan for alleviating multidimensional poverty. Table 11.9 displays the contribution of individual indicators and its dimensions to overall multidimensional poverty index in Purulia district. Only the contribution of prevalence of hunger is greater than its weight under the health and hunger dimension. It says that deprivation is relatively high in this indicator. Among the indicators in living standard deprivation regarding the flooring of residence, access to improved cooking fuel and access to improved sanitation are significant contributors to district MPI. Each of them contributes 12% to overall MPI which is greater than their individual weight in MPI. It says that multidimensionally poor households are more deprived in these indicators. Finally, the contribution of living standard is widely higher than its weight in MPI. Therefore, relative to other dimensions, higher portion of multidimensional poverty is due to deprivation of the dimension of living condition.

Cross-tabulation in Table 11.10 depicts the association between incidence of income poverty and multidimensional poverty in Purulia district. We find that 24% of the non-poor in respect of income is multidimensionally poor and among the multidimensionally poor 60% is income poor. The chi-square test infers a positive and significant association between the incidence of income poverty and multidimensional poverty.

Table 11.9 Decomposition of MPI across the indicators in Purulia district ($N = 700$)

Dimension	Deprivation criteria for the selected indicator (d_i)	Censored head count ratio	Weight	Contribution of the indicator to district MPI
Health and hunger	Don't have access to formal health clinic during illness	0.029	0.166	0.020
	At least one member suffers from malnourishment	0.213	0.166	0.147
	At least one member suffers from hunger at least one day	0.256	0.166	0.176
	Dimension of Health and Hunger		0.333	0.343
Literacy and knowledge	No one adult has passed primary level of education	0.174	0.166	0.120
	No one school-aged children attend school	0.053	0.166	0.036
	No one member has a bank account	0.050	0.166	0.034
	Dimension of Literacy and Knowledge		0.333	0.190
Living condition	Mud flooring of the residence	0.346	0.083	0.119
	No electric connection at the residence	0.194	0.083	0.067
	Use unsafe source of drinking water	0.043	0.083	0.015
	Don't use improved sanitation	0.349	0.083	0.120
	Don't use improved cooking fuel	0.360	0.083	0.124
	Household owns at most one of: bicycle, motorcycle, refrigerator, cell phone or television	0.059	0.083	0.020
	Dimension of living condition		0.083	0.465

Source Authors' computation based on household survey 2019

Table 11.10 Cross-tabulation of incidence of income poverty and multidimensional poverty

		Incidence of Income poverty		
		Poor	Non-poor	Total
Incidence of multidimensional poverty	Poor	155	102	257
	Non-poor	119	324	443
	Total	274	426	700
Value of chi-square statistic with df 1				76.39* (0.001)

Source Authors' computation based on household survey 2019

11.5 Conclusion with Policy Prescriptions

This study explores that the incidence and extent of income poverty and multidimensional poverty in the district of Purulia have been reducing since 2015–16 but is still higher than that in national level. However, the intensity of multidimensional poverty of this district remains unchanged as it was in 2015–16. The sectoral decomposition reveals that multidimensional poverty is concentrated in rural areas and among the SCs and STs households. Although the self-employed and service holders are least poor, casual labour and cultivators are contributing a significant part of MPI in the district. Among the dimensions living, standard dimension has higher contribution relative to its weight in MPI. Particularly poor are more deprived in respect of the access to improved sanitation and access to improved fuel for cooking and flooring condition of the residence. Moreover, among the indicators under the health and hunger, the incidence of hunger has significant contribution to the MPI. Therefore, the district has to emphasize on the improvement of housing infrastructure and food security for the people in Purulia district. Moreover, there is a positive association between the incidence of income poverty and multidimensional poverty.

Therefore, this study suggests taking more intensive programmes for generation of off-farm occupation like tourism, small scale/cottage industrial development like pottery, lakh culture, sericulture, etc. through group centric microfinance and financial inclusion schemes which have great prospect in Purulia district. These programmes helps to increase income of the households changing the occupational status and consciousness regarding standard of living for reducing the extent of multidimensional poverty. This study concludes that the total sanitation programme is not properly functioning in the district. In order to improve the figure of multidimensional poverty, outreach of the total sanitation programme should be accelerated. The use of dirty/environment adversary fuel for cooking is a common feature of the district. The households are not aware that they are increasing the indoor and outdoor pollution through the use of dirty fuel for cooking. Recently, the central government of India has taken a flagship programme for providing subsidized LPG to women of poor households. The more important thing that we have observed is the unawareness of people regarding evil consequences of this deprivation. Moreover, in order to reduce hunger in Purulia district, government has to invest on agriculture more extensively in addition to extension of food security system to alleviate multidimensional poverty for reaching Sustainable Development Goals (SDGs).

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Part III
Education, Human Capital and Evolution of the Employment Quality in India

Chapter 12
Input-Oriented Technical Efficiency and Its Determinants of Primary Education in West Bengal: A District-Level Analysis

Amrita Bhanja and Arpita Ghose

12.1 Introduction

Among the different levels of education crucial is the development of primary level of education. Different programmes were launched by the Government of India as well as by different states of India to improve the overall performance of primary education system. Performance of West Bengal as represented by literacy rate during the Five Year Plans is also quite satisfactory. For West Bengal economy, literacy rate has increased steadily from 24.61 in 1951 to 68.64 in 2011, and also, the enrolment corresponding to primary level has increased from 7,221,398 in 2005–06 to 8,131,797 in 2015–16 (District Information System for Education (DISE), National University of Educational Planning and Administration, (NUEPA)). In this context whether educational system is functioning efficiently or not is major question.

For attainment of equalization of education facilities across different districts of any particular state, an analysis of efficiency at the district level is needed. The problems should be addressed at the school level. Are schools using minimum input given the quantity of outputs produced? The question is whether performance of any district of a particular state can be considered as efficient, if one takes into account different schools of that particular district and what the factors that determine the level of efficiency are. Policy formulation to boost up efficiency level of a particular district necessitates determination of such factors. The present paper addresses this issue considering primary education sector in West Bengal economy as a case study. There are two component of efficiency: technical efficiency (TE) and allocative efficiency (AE). TE shows the ability of a decision-making unit (DMU) to obtain

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A. Bhanja · A. Ghose (✉)
Department of Economics, Jadavpur University, Kolkata 700032, India

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maximum output from a given set of inputs and technology. Alternatively, it shows whether the DMU is using minimum level of input, given the level of output produced. On the other hand, allocative efficiency reflects the ability of a DMU to use the inputs in optimal proportions, given their respective prices. **The present research is concerned only with the measurement of TE**. Technical efficiency of a DMU can be measured either by (i) output oriented (OUTTE) or by (ii) input-oriented (INPTE) approach. The measure of **input-oriented technical efficiency** shows the maximum amount of input quantities, which can be proportionately reduced without changing quantities produced as output and *can be measured by comparing its actual input in use with the minimum input that would produce the given output level, i.e. by how much input quantities can be proportionally reduced without changing the actual output bundle.* On the other hand, **output-oriented technical efficiency** (OUTTE) *represents the maximum output quantities that can be proportionately increased without altering input quantities and can be computed by comparing its actual output with the maximum producible output from its observed inputs.* The present study is concerned with the measurement of **input-oriented TE (INPTE) and** investigates whether primary level of education in different districts of West Bengal is technically efficient in the sense that they are using the minimum level of input given the output produced and what are the factors responsible for the variation of such INPTE measure? A related question is whether the districts with high literacy rate and or high educational development index (EDI) are also the districts with high technical efficiency.

In efficiency analysis, it is not assumed that the production unit always behaves optimally and hence they can operate inefficiently. Efficiency measurement is a two-stage problem. In order to judge the performance of the production units, a benchmark production function has to be constructed which is called as frontier and is supposed to be perfectly efficient. The method of comparing the observed performance of production unit with the postulated standard of perfect efficiency is the basic problem of measuring efficiency.

Review of literature suggests that there are mainly two approaches to conduct efficiency analysis—parametric approach or stochastic frontier analysis and nonparametric approach, widely known as data envelopment analysis (DEA). Data envelopment analysis (DEA) is basically a programming method. Charnes et al. (1978, 1981) introduced the method of DEA to address the problem of efficiency measurement for decision-making units (DMU) with multiple inputs and multiple outputs under constant returns to scale. Among the DMU, they include non-market agencies like schools, hospitals and courts which produce identifiable and measurable output from measurable inputs but generally lack of market prices of outputs (and often some inputs as well) and constructed a benchmark production function as mentioned above, using programming approach under the assumption of constant returns to scale globally. Later, Banker et al. (1984) extended the Charnes et al. (1978, 1981) model to variable returns to scale. **The advantage of DEA analysis is that it is not dependent on the prior specification of functional form or the criterion function**.

Several studies have applied data envelopment analysis (DEA) in measuring the efficiency and productivity in education sector around the globe. In particular, the technical efficiency of schools was estimated by Bessent and Bessent (1980), Jesson et al. (1987), Fare et al. (1989), Ray (1991) and Bonesrqnning and Rattsq (1994) among others. In the Indian context, Tyagi et al. (2009) assessed the technical efficiency and efficiency differences among 348 elementary schools of Uttar Pradesh state. Sengupta and Pal (2010, 2012) measured and find out determinants of the output-oriented efficiency for only primary education sector in India and Burdwan District of West Bengal, respectively, corresponding to a single-year 2005–2006 and hence cannot provide inter-district comparison of efficiency for West Bengal. Ghose (2017) assesses the level of efficiency for primary and upper primary levels of education considering group frontier and meta-frontier analysis in Indian context using state-level data classifying the states into General Category State and Special Category State and also finds out that the significant factors in explaining the efficiency scores, however, did not consider district-level analysis.

In the literature, estimation of TE of a school rests on assumed production relationship between input and outputs. This necessitates identification of inputs and outputs. In tune with the literature, educational production function can be defined as: $Y = A(X_1, \ldots, Xm)$, where Y is some measure of school output, $X_1, \ldots, Xm$ are the variables measuring the school infrastructure. The variables here would typically include the amount and quality of teaching services, the physical infrastructure or facilities of the school that are directly related to the promotion of TE (Ray 1991). Relevantly, it will be useful to highlight the following difference between this educational production function and the standard production function used in micro-theory: The first difference is that the output produced in case of education is not the tangible output. Thus, one needs to represent the output using some suitable measures. For example, the present study considers two outputs for the measurement of efficiency score: (i) net enrolment ratio (NER) and (ii) percentage of students passed having greater than 60% in the examination. The second output represents the attainment of quality. However, there can be other measures of output as well. Similarly, following input variables are considered: (i) number of schools per lakh population, (ii) teacher–pupil ratio in the school, (iii) classroom–student ratio in the school and (iv) percentage of teachers with qualification graduate and above in the school, measuring the quality of the teacher input. The second difference is that both the output and the inputs in the production process do not have prices. Thus, one needs to obtain their shadow prices for further analysis.

Given these backdrop, **the contributions of this study to the literature are the following**: **First of all**, the perusals of the literature suggest that there is dearth in analysis of measurement and determinants of input-oriented technical efficiency (INPTE) for primary level of education in the Indian context using district-level data. In particular, there is a lack of studies on measuring INPTE for different districts of the state over time assuming variable returns to scale, inter-district variation in efficiency scores and also the variables explaining INPTE. The present paper adds the literature in this direction by considering the case of primary education sector in West Bengal considering the study period from 2005–06 to 2013–14. The analysis will help us to identify the districts that are lagging behind the West Bengal average INPTE score and to formulate policies for enhancing educational efficiency of less efficient districts. As mentioned above to estimate technical efficiency, we need to use some measure of outputs and inputs. Since the current research is a district-level study based on secondary data sources, the districts are taken as a unit of account. Thus, the average value of each of the above-mentioned input and output variables of all the schools in any particular district taken together is considered, from District Information System for Education (DISE), India data sources, and this average value is taken to be a value of the corresponding variable for that district. **Secondly**, for estimation of INPTE, it considers both quantities as well as quality aspects of the outputs and inputs; there is scarcity of such approach in the existing literature. **Thirdly**, the present paper also measures whether there is more usage of different inputs over the minimum requirement, given the output bundle at district level, for primary level of education of West Bengal and identified the input for which there is maximum extra usage; studies for which are lacking in the literature. **Finally**, while explaining the significant factors influencing INPTE score, obtained from the first stage estimation and used as dependent variable, using second stage panel regression, considering the effect of district school specific both favourable and unfavourable or poor infrastructures, policy variables and also some district specific macro-indicators representing its general environment, instead of using composite index, the study captures the individual effect of the different explanatory variables. This is because for successful implementation of the policies one needs to identify the individual effect of different variables. The problem with the use of composite index is that it cannot differentiate between the factors which are significant and which are not. Relevantly, it may be mentioned that Sengupta and Pal (2012) used composite index for policy variables and did not find out its positive effect. However, it does not rule out the possibility that some of the individual policy variables may be significant, while the others are not. Based on the results of estimation, the present research also prescribes some appropriate policies to enhance INPTE for primary level of education in West Bengal (Aigner et al. 1977).

The present study unfolds as follows. Section 12.2 discusses the methodology and the data sources. The estimated results are presented in Sect. 12.3. The Sect. 12.4 presents summary and conclusions, and it recommends some policy suggestions to improve the efficiency score of primary level of education in West Bengal.

12.2 Methodology and Data

The input-oriented measure represents the maximum amount of input quantities, which can be proportionately reduced without changing quantities produced as output. In input-oriented measure, the TE of a DMU can be measured by comparing its actual input in use with the minimum input that would produce the targeted output level, i.e. by how much input quantities can be proportionally reduced without changing the actual output bundle. Figure 12.1 represents these measures in case of single input and output.

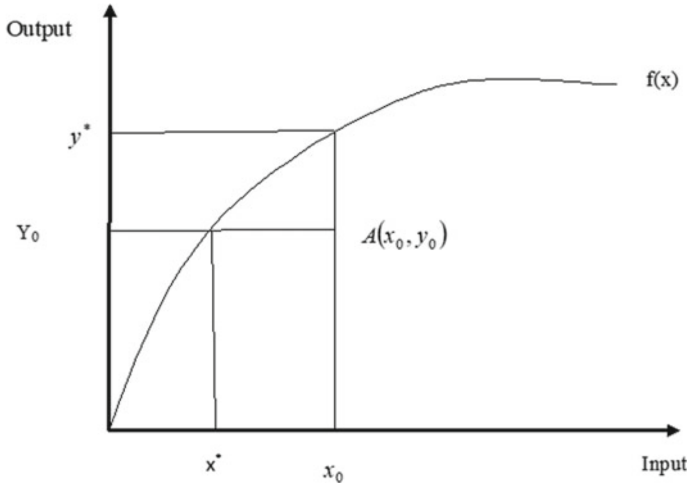

Fig. 12.1 Output- and input-oriented measure of technical efficiency

In Fig. 12.1, input x is measured along the horizontal axis, and output y is measured along the vertical axis. Point $A(x_0, y_0)$ represents the actual input–output bundle of a DMU at a point $A.y^* = f(x_0)$, where y^* is the maximum output producible from input x_0.The **output-oriented** measure of TE of DMU at point A is given by $\frac{y_0}{y^*}$,which is the comparison of actual output with the maximum producible quantity from the observed input.

Now, for the same output bundle y_0, the input quantity can be reduced proportionately till the frontier is reached. So, y_0 can be produced from input x^*. Thus, the **input-oriented** TE measure for DMU at a point A is $\frac{x^*}{x_0}$. The TE score of a DMU takes a value between 0 and 1. A value of 1 indicates that the production unit is fully technically efficient.

In this context, let us note that the TE of the DMU depends also on the assumption of returns to scale. Two different assumptions can be made, i.e. constant return to scale (CRS) and variable returns to scale (VRS). The CRS describes the fact that output will change by the same proportion as inputs are changed (e.g. a doubling of all inputs will double output). On the other hand, VRS reflects the fact that production technology may exhibit increasing, constant and decreasing returns to scale. If there are economies of scale, then doubling all inputs should lead to more than a doubling of output.

Figure 12.2 illustrates the basic ideas behind DEA and returns to scale. Four data points (A, C, B’ and D) are used here to describe the efficient frontier under VRS. In a simple one output case, only B is inefficient, lies below the frontier, i.e. shows capacity underutilization. So, unit B can produce more output at point B’ on the frontier (which is equal to theoretical maximum) utilizing same level of input at X_1. Under CRS, the frontier is defined by point C for all points along the frontier, with all other points falling below the frontier (hence indicating capacity underutilization). So, capacity

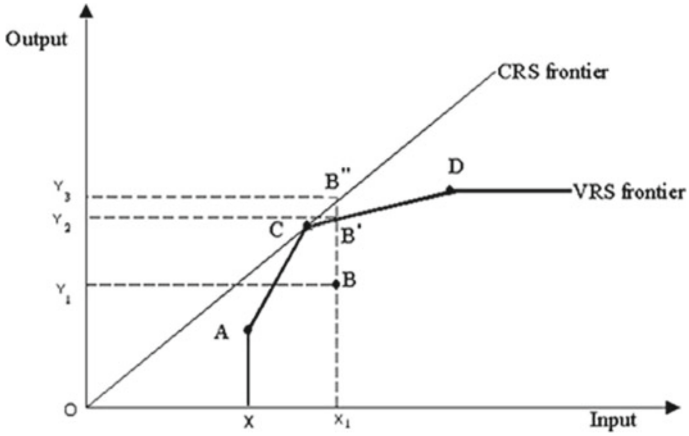

Fig. 12.2 Production Frontier and returns to scale

output corresponding to VRS is smaller than the capacity output corresponding to CRS.

The assumption of CRS is restrictive; it did not allow us to conceptualize economies of scale. A more generalized case will be the assumption of VRS. **Given the actual input–output bundle, the present research estimates input-oriented TE score by constructing the frontier under variable returns to scale (VRS) using nonparametric data envelopment analysis as formulated by** Banker et al. (1984). Using a sample of actually observed input–output data and a number of fairly general assumptions about the nature of the underlying production technology, namely (i) all actually observed input–output combinations are feasible, (ii) the production possibility set is convex, (iii) inputs are freely disposable, and (iv) outputs are freely disposable, and Banker et al. (1984) **derives a benchmark output quantity without any prior specification of the production frontier** applying a linear programming (LP) problem, with which the actual output of a DMU can be compared for efficiency measurement.

12.2.1 Methodology for Finding Input-Oriented TE Score

It is supposed that there are N DMUs. Each of them is producing 'g' outputs using 'h' inputs. The DMU t uses input bundle $x^t = (x_{1t}, x_{2t}, \ldots\ x_{ht})$ and produces the output bundle $y^t = \left(y_{1t}, y_{2t}, \ldots\ y_{gt}\right)$. This paper assumes VRS technology.

The specific production possibility set under VRS is given by

$$T^{VRS} = \left\{ (x, y) : x \geq \sum_{j=1}^{N} \lambda_j x^t ; y \leq \sum_{j=1}^{N} \lambda_j y^t ; \right.$$
$$\left. \sum_{j=1}^{N} \lambda_j = 1; \lambda_j \geq 0; (j = 1, 2, \ldots, N) \right\} \tag{12.1}$$

The input-oriented measure of TE of any DMU *t* under VRS technology requires the solution of the following LP problem

$$\begin{aligned} &\min \theta \\ &\text{s. t.} \sum_{j=1}^{N} \lambda_j x_{ij} \leq \theta x_{it}; \\ &\sum_{j=1}^{N} \lambda_j y_{rj} \geq y_{rt}; \\ &\sum_{j=1}^{N} \lambda_j = 1; \\ &\lambda_j \geq 0 (j = 1, 2, ..., N). \\ &\theta \text{ free,} \end{aligned} \tag{12.2}$$

Input-oriented TE of DMU t can be determined by using Eq. (12.2).

$$\mathrm{TE}_I^V (x^t, y^t) = \theta^* . \tag{12.3}$$

where θ^* is the solution of Eq. (12.3). The minimum input required to produce the targeted level of output y is $x_*^t = \theta^* x^t$.

12.2.2 Description of Radial and Slack Movements

In LP models, radial measures of efficiency are obtained. Here, efficiencies are measured along a ray from the origin to the observed production point. In such a radial projection of an observed input–output bundle onto the frontier, sometimes all the inputs used are not potentially reduced. The horizontal or vertical portion of an isoquant accounts for inefficiency in usage of inputs. As a result, there may be the possibility of the existence of input slack for the case of multiple input–output production process. Among the output produced by firm t, the largest output bundle

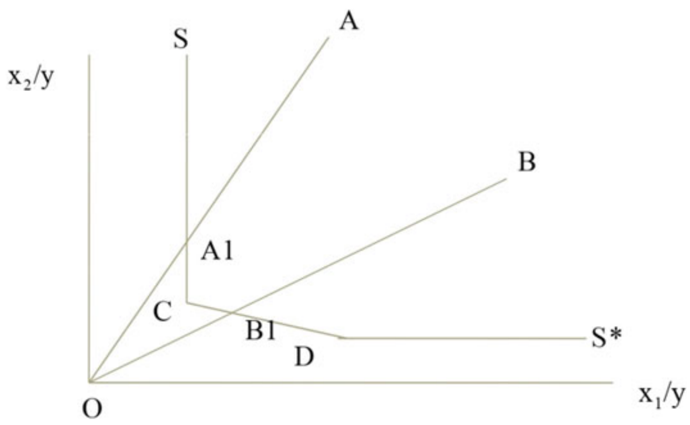

Fig. 12.3 Measurement of input slack and radial movement

with the same output mix as (y_1^t, y_2^t) that can be produced from the input bundle $(x_1*, x_2*)\, is\, (\phi * y_1*, \phi * y_2*)$.

It is sometimes possible to expand individual outputs by a factor larger than $\phi*$. It is also possible that firm t may not entirely use up all the individual components of the input bundle to produce the expanded output bundle. Hence, all the inputs used are not potentially reduced.

The input slack variable can be defined as

$$Si^{-} = x_{it} - x*_{it},\ (i = 1, 2, \ldots, h)$$

The existence of inefficiency in input utilization basically implies existence of radial and or slack movement. The extent of inefficiency of input can be measured by the sum of radial and slack movement.

The input slack can be explained graphically as depicted in Fig. 12.3.

In Fig. 12.3, C and D are two efficient DMUs which are on the frontier. DMU A and B are inefficient. Point A1 is on the frontier, but here also, the DMU is inefficient as one can reduce the amount of x_2 input by CA1 and still produce the same output. So, CA1 is the input slack movement of input x_2, while AA1 is the input radial movement. Thus, the extent of inefficiency of input is the sum of this radial and slack movement.

12.2.3 *The Variables Used for the Determinants of Input-Oriented Technical Efficiency*

It may be noted that not too many studies are found relating to INPTE of education sector. Ghose (2017) estimated input-oriented technical efficiency of primary and upper primary level of education separately for General Category State and Special Category State in India, using state-level data. While selecting the explanatory variables for the present study, Ghose (2017) has been made use of subject to the availability of the data at the district level of West Bengal. Some of the explanatory variables used in this paper were also used to explain total factor productivity growth of elementary education for different states of India in Ghose (2019). The variables used to explain the variation of INPTE score are the following:

(i) **Unfavourable or poor infrastructure** to **investigate whether poor infrastructure negatively affects efficiency score**, considering the effects of the following variables namely (i) percentage of schools without building (SWBP), (ii) percentage of schools having no pucca building (NPBP), (iii) percentage of classroom in 'bad' condition in the schools (CBCP), (iv) percentage of single-teacher schools at primary (SNTSP), (v) percentage of para teacher in the schools (PTCP). The variable percentage of para teachers are included because due to lack of sufficient number of full time teachers many schools employ a significant number of para teachers and the basic question is whether the para teachers play any significant role in promoting TE or not.

(ii) **Favourable infrastructure** to see **whether the existence of favourable infrastructure positively affects INPTE** comprising the variables namely (i) percentage of schools with drinking water facility (DWFP), (ii) percentage of schools with common toilet (CTFP) and (iii) percentage of schools with girls' toilet (GTFP).

(iii) **Policy variables** to **investigate whether provision of more public facilities increase efficiency score** including the effects of the following variables like (i) percentage of students getting free textbooks in the schools (SFTBP), (ii) percentage of girls getting free textbooks to boys in the schools (GFTBBP), (iii) percentage of girls getting free stationary to boys in the schools (GFSTBP), (iv) percentage of primary schools received School Development Grant (SDGP), (v) percentage of primary schools received Teaching Learning Material Grant (TLMGP).

(iv) **Macro-indicators** to find out **whether general economic environment of the district has something to with its efficiency score** considering the impacts of inequality in distribution of income, i.e. Gini coefficient (GINI), density of population (POPDEN) and the per capita net district development product of the districts (PCNDDP) (measured at constant 2004–05 prices).

Since the basic interest is to find out the impact of the individual explanatory variables, the panel regression with composite index representing the above five broad indicators has not been tried out in the second stage panel regression for the determinant analysis.

12.2.4 Data Sources

The sample consists of 20 districts (as per DISE) in West Bengal, namely Bankura, Burdwan, Birbhum, Dakshin Dinajpur, Darjeeling, Howrah, Hooghly, Jalpaiguri, Cooch Bihar, Kolkata, Malda, Murshidabad, Nadia, North 24 Parganas, Paschim Midnapore, Purba Midnapore, Purulia, Siliguri, South 24 Parganas and Uttar Dinajpur, over the nine consecutive years from 2005–06 to 2013–14. The secondary data for two-output–four-input framework of the present study as mentioned above in Sect. 12.1 above and also for the variables used in the determinant analysis are obtained from DISE, Office of the Registrar General and Census Commissioner (2011), India, NSSO, Bureau of Applied Economics and Statistics, Government of West Bengal.

12.3 Empirical Findings

12.3.1 Results of Estimation of Technical Efficiency Score

Window measure of technical efficiency is incorporated here to address the degree of freedom problem of the data envelopment analysis (DEA) applied with only 20 district levels per year. Basically, the method of window analysis pools observations from multiple years for solving each DEA problem. A two-year window is selected for the present analysis. Normally, the initial and the terminal years were based on the optimal solution of a single window. For intermediate years, optimal solutions from consecutive windows were averaged to measure these efficiencies. In order to get the estimate of technical efficiency score, DEAP Version 2.1 of Coelli (1996) is used.

The estimated average value of INPTE score under the assumption of variable returns to scale for different districts of West Bengal over the sample year from 2005–06 to 2013–14 for primary level of education is presented in Table 12.1.

The results suggest that not all the districts are perfectly efficient. Inter-district variations in INPTE score are evident for primary education. Figures in Table 12.1 provide the following information:

(i) Among the 20 districts (as per DISE) considered, none of the districts are perfectly efficient under each of the sample year.
(ii) Some of the districts like Bankura, Burdwan, Birbhum, Kolkata, Malda, North 24 Parganas, Paschim Midnapore and Purulia, Jalpaiguri and Purba Midnapore were not fully technically efficient in the initial year, but subsequently, their efficiency level (INPTE) has increased to one. However, they are unable to maintain this higher efficiency level, and accordingly, the efficiency level declined. Among these districts for Bankura, Burdwan, Birbhum, Kolkata, Malda, North 24 Parganas, Paschim Midnapore and Purulia, the levels of

Table 12.1 District-wise INPTE score over the sample period at primary level of education

District	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	Average
Bankura	0.749	0.677	0.610	0.662	0.708	0.888	1.000	0.774	0.743	0.757
Burdwan	0.764	0.767	0.848	0.990	0.962	0.925	1.000	1.000	1.000	0.917
Birbhum	0.732	0.705	0.747	0.861	0.969	0.949	1.000	1.000	1.000	0.885
DakshinDinajpur	1.000	0.975	0.762	0.965	1.000	1.000	1.000	0.960	1.000	0.962
Darjeeling	1.000	0.955	1.000	0.999	0.921	0.924	1.000	0.965	0.958	0.969
Howrah	0.893	1.000	0.866	0.994	0.904	0.903	1.000	0.913	1.000	0.941
Hooghly	0.878	0.783	0.845	0.933	0.946	0.929	1.000	0.879	0.981	0.908
Jalpaiguri	0.931	1.000	0.777	0.786	0.801	0.905	1.000	0.911	0.884	0.888
Cooch Bihar	0.862	1.000	0.761	0.820	0.681	1.000	1.000	0.871	1.000	0.888
Kolkata	0.901	0.823	1.000	1.000	0.962	0.959	0.884	0.894	1.000	0.936
Malda	1.000	1.000	1.000	1.000	0.844	1.000	0.884	1.000	1.000	0.970
Murshidabad	1.000	0.855	0.925	0.992	0.876	1.000	1.000	1.000	1.000	0.961
Nadia	1.000	0.895	0.914	0.947	0.863	1.000	1.000	0.886	0.913	0.935
North 24 Parganas	0.918	1.000	0.856	0.995	0.929	1.000	1.000	0.881	1.000	0.953
PaschimMidnapore	0.939	0.921	0.864	1.000	0.933	1.000	1.000	1.000	1.000	0.962
PurbaMidnapore	0.932	0.922	0.874	1.000	0.770	0.979	1.000	0.884	0.790	0.906
Purulia	0.773	1.000	0.782	0.770	0.894	1.000	1.000	1.000	0.789	0.890
Siliguri	1.000	1.000	1.000	1.000	0.957	0.841	1.000	0.772	0.857	0.936
South 24 Pargans	1.000	0.799	0.815	0.975	0.919	1.000	1.000	1.000	0.973	0.942
Uttar Dinajpur	1.000	1.000	1.000	1.000	0.929	1.000	1.000	1.000	1.000	0.992
Average	0.913	0.904	0.862	0.934	0.888	0.960	0.988	0.930	0.944	0.925

Source Author's calculation

INPTE at the terminal year of the study period are higher as compared to the initial year, suggesting an increase of efficiency level as compared to the initial level. But for Jalpaiguri and Purba Midnapore, the level of INPTE at the terminal point is lower as compared to the initial situation, implying a decrease in efficiency level as compared to the initial position.

(iii) Some of the districts were technically fully efficient in the initial year, but their efficiency level has declined over the years, and they are unable to achieve full efficiency level again. These districts are Dakshin Dinajpur, Darjeeling, Murshidabad, Nadia, Siliguri and South 24 Parganas.

Thus, the above information suggests that estimation of INPTE for any particular year does not always show complete information. Therefore, the mean value of INPTE over the sample years and for all the districts is computed to visualize the complete clear picture and is presented in Table 12.1.

The grand average level of technical efficiency for all the districts and all the years taken together turned out to be 0.925. The districts having greater than average level of INPTE are the following: Dakshin Dinajpur, Darjeeling, Howrah, Kolkata, Malda, Murshidabad, Nadia, North 24 Parganas, Paschim Midnapore, Siliguri, South 24 Parganas and Uttar Dinajpur, showing relatively better performance on INPTE as compared to grand average. The performances of the other districts are not good as they belong to the group having below grand average INPTE.

12.3.2 Comparison of Technical Efficiency Score and Literacy Rate and Educational Development Index

The comparisons are carried out for average level of INPTE, the literacy rate (LIT) and the educational development index (EDI), corresponding to different districts in West Bengal. The figure of literacy rate, year-wise average level of TEINP and the EDI for different districts are given in Table 12.2.

Since the figures on LIT, EDI and INPTE vary over time, for comparisons of the performances, a grand average spanning over all the districts and all time points **(GAV)** of each of these indicators are calculated and are presented in Table 12.2. The figures of Table 12.2 suggest that

(i) There are some districts like Darjeeling, Howrah, Kolkata, North 24 pargaas, Siliguri and South 24 Parganas, and the performances of those are good in terms of all the three indicators, namely literacy rate, INPTE and EDI, as these districts belong to group having higher **GAV** for all the three indicators.

(ii) For the districts, namely Bankura, Cooch Bihar and Purulia, the figures for the three indicators, literacy rate, TEINP and EDI, are below the **GAV**, and hence, the performances of those districts are bad in terms of all the three indicators.

Table 12.2 Comparison of literacy rate, education development index (EDI) and INPTE at primary level of education

Districts	Literacy rates (%; as per 2011 census)	EDI based on West Bengal development report (2010)	INPTE
Bankura	63.44	0.472	0.757
Burdwan	70.18	0.665	0.917
Birbhum	61.48	0.361	0.885
DakshinDinajpur	63.59	0.338	0.962
Darjeeling	71.79	0.696	0.969
Howrah	77.01	0.814	0.941
Hooghly	75.11	0.786	0.908
Jalpaiguri	62.85	0.461	0.888
Cooch Bihar	66.3	0.452	0.888
Kolkata	80.86	1	0.936
Malda	50.28	0.042	0.970
Murshidabad	54.35	0.148	0.961
Nadia	66.14	0.472	0.935
North 24 Parganas	78.07	0.824	0.953
PaschimMidnapore	70.41	0.797	0.962
PurbaMidnapore	80.16	0.797	0.906
Purulia	55.57	0.247	0.890
Siliguri	85.46	0.523	0.936
South 24 Parganas	69.45	0.561	0.942
Uttar Dinajpur	47.89	0.015	0.992
Average	68.64	0.510	0.925

Source Author's calculation

(iii) The performance of the districts like Burdwan and Jalpaiguri is good in terms of the LIT, as the literacy rates for these two districts are higher than **GAV**, but are bad in terms of EDI and INPTE, as the corresponding figures of INPTE and EDI are below for these two indicators.

(iv) The performance of the districts Hooghly and Paschim Midnapore is good in terms of LIT and EDI, as the figures of EDI and Literacy rate are higher than **GAV**. But the figures on INPTE are below the **GAV,** and hence, the performances of these two districts are poor in terms of INPTE.

(v) Interesting case happens to be the districts for Birbhum, Dakshin Dinajpur, Malda, Murshidabad, Nadia and Uttar Dinajpur, and performance of which is bad in terms of LIT and EDI, as the figures of EDI and literacy rate are lower than average level, but are good in terms of INPTE, as the corresponding figures of INPTE are higher than the average level.

Thus, the higher level of EDI and literacy rate does not imply higher level of INPTE. On the other hand, higher level of INPTE can be associated with low level of EDI or literacy rare. Further, higher level of literacy rate may not lead to higher level of EDI.

12.3.3 Analysis of Radial and Slack Movements of Different Inputs

The extent of inefficiency of inputs of the production process is captured by radial **(R)** and slack movements **(S)**. Basically, INPTE is the radial measure. For the districts having INPTE score 1 in most of the years or on average of the nine successive years, the radial values are zero or very close to zero. But there may be slack movement which reflects the extent of inefficiency of the inputs. For example, INPTE of the district Uttar Dinajpur (0.992) is close to 1 on average, and thus, **R** and **S** measures are zero. The districts for which, the mean value of INPTE is less than one , there may also exist both **S** and **R** movements, i.e. one can further reduce the input level and still can produce the same level of output. The computed percentage of the ratios of the slack and radial movements to that of actual figure of the four inputs used by the different districts over the time period from 2005–06 to 2013–14, using input-oriented DEA measure for primary level of education, as well as their average values for all the districts taken together are presented in Table 12.3.

For the input **number of schools per lakh population**, considering **radial movement, it** is found that the value is lowest for the districts Siliguri (0%) and Uttar Dinajpur (0%). The mean value of radial movement for this input turned out to be 5.73%. The districts having lower than mean value of radial movement are the following: Dakshin Dinajpur, Darjeeling, Howrah, Malda, Murshidabad, Nadia, North 24 Parganas, Paschim Midnapore, Purba Midnapore, Siliguri and Uttar Dinajpur. Considering **slack movement**, the districts such as Burdwan, Birbhum, Dakshin Dinajpur, Darjeeling, Hooghly, Kolkata, Paschim Midnapore, Purba Midnapore, Siliguri, South 24 Parganas and Uttar Dinajpur have experienced the lowest score which corresponds to zero value. For slack movement, it is evident that the mean value of slack movement for this input is 2.58%. The districts having slack movement lower than this average are Burdwan, Birbhum, Dakshin Dinajpur, Darjeeling, Howrah, Hooghly, Jalpaiguri, Kolkata, Murshidabad, Paschim Midnapore, Purba Midnapore, Siliguri, South 24 Parganas and Uttar Dinajpur.

For **the input teacher–pupil ratio**, taking into account **radial movement**, it is observed that the radial movement is lowest for the districts North 24 Parganas, Siliguri and Uttar Dinajpur and the value is equal to zero. The mean value for the radial movement is found to be 5.86%. The districts which are below the mean level are Dakshin Dinajpur, Darjeeling, Howrah, Malda, Murshidabad, Nadia, North 24 Parganas, Paschim Midnapore, Purba Midnapore, Siliguri, South 24 Parganas and Uttar Dinajpur. Considering **slack movement of this input**, it is found that lowest

Table 12.3 Radial (R) and slack (S) movements for different inputs computed under INPTE measure for different districts at primary level of education in West Bengal

Districts	Number of primary schools per lakh population		Teacher–pupil ratio at primary		Classroom–student ratio at primary		% of teachers with qualification graduate and above at primary	
	R	S	R	S	R	S	R	S
Bankura	−25.70	−3.37	−25.85	−3.34	−25.21	−7.08	−25.71	0.00
Burdwan	−8.72	0.00	−10.46	−8.42	−9.02	−5.09	−8.77	0.00
Birbhum	−13.99	0.00	−15.83	−13.89	−13.32	−3.22	−13.95	−1.54
DakshinDinajpur	−3.45	0.00	−3.80	0.00	−2.87	−1.43	−3.47	0.00
Darjeeling	−0.80	0.00	−0.68	−6.14	−0.62	−2.80	−0.79	0.00
Howrah	−0.68	−2.34	−0.66	−9.18	−0.85	0.00	−0.68	−2.33
Hooghly	−6.99	0.00	−7.34	−4.17	−7.53	−6.25	−6.99	0.00
Jalpaiguri	−10.12	−0.14	−9.48	−2.84	−10.13	−9.93	−10.11	−3.36
Cooch Bihar	−11.55	−8.74	−10.50	0.00	−10.87	−4.27	−11.51	−3.57
Kolkata	−5.89	0.00	−6.14	0.00	−5.46	0.00	−5.90	−2.28
Malda	−0.43	−5.12	−0.58	−3.78	−0.69	0.00	−0.43	−7.61
Murshidabad	−3.23	−0.07	−2.97	−8.80	−3.77	−8.07	−3.22	−0.07
Nadia	−3.31	−2.87	−4.09	−22.32	−3.71	−18.10	−3.31	−4.07
North 24Parganas	−0.05	−4.04	0.00	−8.31	0.00	−3.07	−0.05	−4.00
PaschimMidnapore	−1.11	0.00	−1.07	−5.91	−1.14	−6.26	−1.11	0.00
PurbaMidnapore	−3.47	0.00	−3.44	−0.76	−3.61	−8.75	−3.46	0.00
Purulia	−9.30	−24.81	−8.57	−2.27	−9.53	−10.31	−9.28	−3.90
Siliguri	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South 24Pargans	−5.74	0.00	−5.71	−0.80	−7.10	0.00	−5.73	0.00
Uttar Dinajpur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Average	−5.73	−2.58	−5.86	−5.05	−5.77	−4.73	−5.72	−1.64

Source Author's calculation

slack movement is zero and this value happens for the districts namely Dakshin Dinajpur, Cooch Bihar, Kolkata, Siliguri and Uttar Dinajpur. The average value of slack movement turned out to be 5.05%. The districts having lower level of slack movements as compared to the average score are Bankura, Dakshin Dinajpur, Hooghly, Jalpaiguri, Cooch Bihar, Kolkata, Malda, Purba Midnapore, Purulia, Siliguri, South 24 Parganas and Uttar Dinajpur.

Considering **the input classroom–student ratio** and **its radial movement**, it is found that the mean value of the radial movement is 5.77%. The districts having below average radial movement are Dakshin Dinajpur, Darjeeling, Howrah, Kolkata, Howrah, Murshidabad, Nadia, North 24 Parganas, Paschim Midnapore, Purba Midnapore, Siliguri and Uttar Dinajpur. The lowest radial movement (0%)

exists for the districts like North 24 Parganas, Siliguri and Uttar Dinajpur. In case of **slack movement of this input**, the districts such as Howrah, Kolkata, Malda, Siliguri, South 24 Parganas and Uttar Dinajpur have experienced lowest measure which corresponds to zero value. The districts Birbhum, Dakshin Dinajpur, Darjeeling, Howrah, Cooch Bihar, Kolkata, Malda, North 24 Parganas, Siliguri and South 24 Parganas have below average slack movement (4.73%) for this input.

For the **input percentage of teachers with qualification graduate and above considering radial movement**, it is found that the radial movement is lowest for the districts, namely Siliguri and Uttar Dinajpur. The mean radial movement turned out to be 5.72%. The following districts have lower radial movement as compared to the mean value: Dakshin Dinajpur, Darjeeling, Howrah, Malda, Murshidabad, Nadia, North 24 Parganas, Paschim Midnapore, Purba Midnapore, Siliguri and Uttar Dinajpur. On the other hand, considering the **slack movement**, it is found that the slack movement is equal to zero for the districts such as Bankura, Burdwan, Dakshin Dinajpur, Darjeeling, Hooghly, Paschim Midnapore, Purba Midnapore, Siliguri, South 24 Parganas and Uttar Dinajpur. The mean value of slack measure for this input is 1.64%. The districts Bankura, Burdwan, Birbhum, Dakshin Dinajpur, Darjeeling, Hooghly, Murshidabad, Paschim Midnapore, Purba Midnapore, Siliguri, South 24 Parganas and Uttar Dinajpur have lower value of slack movement than state average.

The estimation of radial and slack movement is crucial as it depicts the clear picture regarding the extent of inefficiency of the different inputs employed in the production process. What ultimately is important is the extent of the inefficiency of any input, which can be measured by the sum of slack and radial movement taken together for that input. The estimation of these radial and slack movements has been used to derive the extent of inefficiency of different inputs used in the production process and to rank the inputs depending on the degree of inefficiency. The combined radial and slack for different inputs as well as the grand average of radial and slack taken together are presented in Table 12.4.

Combined radial (R) and slack (S) movements as presented in Table 12.4 reveal the following:

For **the input number of schools per lakh population**, the average magnitude of **R and S** is 8.30% corresponding to primary level of education. The districts having **R and S** measures lower than the average value are Dakshin Dinajpur, Darjeeling, Howrah, Hooghly, Kolkata, Malda, Murshidabad, Nadia, North 24 Parganas, Paschim Midnapore, Purba Midnapore, Siliguri, South 24 Parganas and Uttar Dinajpur. The extent of combined movement is highest for the district Purulia.

In case of **the input teacher–pupil ratio in the school**, the mean value of combined movement **R and S** is 10.90%. The districts having **R and S** lower than this average value are Dakshin Dinajpur, Darjeeling, Howrah, Kolkata, Malda, North 24 Parganas, Paschim Midnapore, Purba Midnapore, Siliguri, South 24 Parganas and Uttar Dinajpur. The extent of combined inefficiency is highest for the district Birbhum.

For **the input classroom–student ratio in the school**, the mean value of **R and S** turned out to be 10.50%. The districts which are lower than the average value of combined movement are Dakshin Dinajpur, Darjeeling, Howrah, Kolkata,

Table 12.4 Combined movements for different inputs computed under INPTE measure for different districts at primary level of education in West Bengal

Districts	No of primary schools per lakh population	Teacher–pupil ratio at primary	Classroom–student ratio at primary	% of teachers with qualification graduate and above at primary
Bankura	−29.07	−29.19	−32.29	−25.71
Burdwan	−8.72	−18.88	−14.11	−8.77
Birbhum	−13.99	−29.72	−16.53	−15.49
Dakshin Dinajpur	−3.45	−3.80	−4.30	−3.47
Darjeeling	−0.80	−6.82	−3.43	−0.79
Howrah	−3.02	−9.83	−0.85	−3.01
Hooghly	−6.99	−11.51	−13.78	−6.99
Jalpaiguri	−10.25	−12.32	−20.06	−13.47
Cooch Bihar	−20.29	−10.50	−15.14	−15.08
Kolkata	−5.89	−6.14	−5.46	−8.17
Malda	−5.56	−4.36	−0.69	−8.04
Murshidabad	−3.30	−11.76	−11.84	−3.29
Nadia	−6.18	−26.41	−21.81	−7.37
North 24 Parganas	−4.09	−8.31	−3.07	−4.06
Paschim Midnapore	−1.11	−6.98	−7.40	−1.11
Purba Midnapore	−3.47	−4.20	−12.35	−3.46
Purulia	−34.11	−10.83	−19.84	−13.18
Siliguri	0.00	0.00	0.00	0.00
South 24 Pargans	−5.74	−6.51	−7.10	−5.73
Uttar Dinajpur	0.00	0.00	0.00	0.00
Grand average	−8.30	−10.90	−10.50	−7.36

Source Author's calculation

Malda, North 24 Parganas, Paschim Midnapore, Siliguri, South 24 Parganas and Uttar Dinajpur. The combined measure for this input is highest for the district Bankura.

Considering **the input percentage of teachers with qualification graduate and above**, the mean value of combined **R and S** movements turned out to be 7.36%. The districts such as Dakshin Dinajpur, Darjeeling, Howrah, Hooghly, Murshidabad, North 24 Parganas, Paschim Midnapore, Purba Midnapore, Siliguri, South 24 Parganas and Uttar Dinajpur have R and S movements lower than the state average. The combined movement for this input is highest for the district Bankura. It is evident from the empirical analysis that among all these four inputs the lowest value of combined **R and S** movements occurs for the districts Siliguri and Uttar Dinajpur.

Thus, the above analysis gives an idea about the extent or inefficiency of different inputs used in the production process, or in other words, it finds out whether there is any extra usage of inputs to produce a given level of output.

The combined estimates of R and S movements together suggest that:

(i) Performances of the districts like Dakshin Dinajpur, Howrah, Malda, North 24 Parganas are good with respect to input utilization as for each of the inputs considered in this model, these districts contain lower aggregate combined value of R and S movements as compared to the grand mean value of combined R and S movements of all the districts.
(ii) Performances of the districts, namely Bankura, Birbhum, Jalpaiguri, Cooch Bihar and Purulia, are bad with respect to input utilization, and as for each of the considered inputs, these districts contain higher aggregate combined value of R and S movements as compared to the grand mean value of combined R and S movements of all the districts. In particular, the district Bankura contains highest value of combined radial and slack movements for classroom–student ratio and the proportion of the teachers graduate and above, whereas the highest value of combined radial and slack movements for the input number of schools per lakh of population and teacher–student ratio is obtained for the districts Purulia and Birbhum, respectively.

Comparing the performance level of different inputs by using the combined measure of R and S movements, it can be found that **the extent of average inefficiency is highest for the input teacher–pupil ratio (10.90%) in the school, followed by classroom–student ratio (10.50%) in the school, number of schools per lakh population (8.30%) and least for the input percentage of the teachers with qualification graduate and above. Hence, better utilization of these inputs can produce more of output with the help of same level of input**.

12.3.4 Factors Influencing Technical Efficiency Score

This section narrates the significant determinants of INPTE score at primary level of education. The panel regression has been carried out considering the nine consecutive years from 2005–06 to 2013–14. While carrying out the determinant analysis using panel regression, to test for appropriateness of the assumption of fixed affect vis. a vis. the random effect panel model, Hausman's specification test is performed, which strongly rejects the assumption of fixed effect model in favour of random effect model for primary level of education. Different specifications are tried out, and the best fitted results with significant explanatory variables are reported in Table 12.5

Considering the determinants of INPTE, the results of the panel regression suggest that not all the considered explanatory variables are significant. The poor as well as favourable infrastructure, policy variables and the district specific macro-indicator

Table 12.5 Significant variables explaining INPTE at primary level of education of West Bengal

Variables	Coefficients	$P > \|z\|$
Percentage of single-teacher schools	−0.0037318	0.040
Percentage of primary schools having girls' toilet	0.0012626	0.008
Percentage of girls getting free textbooks to boys	0.0158465	0.000
Per capita net district domestic product	0.004509	0.000
Constant	1.092015	0.000
Goodness of fit	Wald $\text{Chi}^2 = 77.15$, $P > \text{Chi}^2 =$ 0.0000	

Source Author's calculation

like per capita district domestic product is important in explaining INPTE. For favourable infrastructural variables, one can find that percentage of primary schools having girls' toilet facility (GTFP) plays significant role in promoting efficiency level. The variable percentage of primary schools with girls' toilet facility may also be considered as social indicator variable.

Among the poor infrastructural variable percentage of schools with single teacher (SNTSP) is important showing that prevalence of schools with single-teacher negatively affects utilization of existing resources and hence attainment of input-oriented technical efficiency. Taking into account the policy variables, it is found that percentage of girls getting free textbooks to boys (GFTBBP) is important and positively influences INPTE score highlighting the role of policy variable in explaining INPTE. The district specific variable like per capita net district development product (PCNDDP) has significant role to play in explaining input-oriented TE.

12.4 Summary and Policy Suggestions

The basic motive of this study is to find out whether primary education in West Bengal is functioning efficiently or not. In particular, the study estimates input-oriented technical efficiency (INPTE), i.e. whether there is any provision of contracting educational input keeping the output level unchanged.

The extent of inefficiency in different input utilization and the factors determining INPTE are determined. Further, whether higher level of literacy rate and or educational developmental index implies higher level of INPTE is also investigated.

Given the fact that estimation of INPTE score for each of the year over a certain time horizon always gives more information than the estimation of INPTE score for any particular year, this paper estimates INPTE for each of the year over the period 2005–06 to 2013–14 of primary education sector for different districts in West Bengal using nonparametric data envelopment analysis in a two output, four input framework, assuming variable returns to scale, and taking into account both quantities as well as quality aspects of outputs and inputs. It considers two outputs, viz. (i) net enrolment ratio and (ii) percentage of students passed with 60% in the examination, measuring achievement of quality output. The inputs used are (i) number of schools per lakh population, (ii) teacher–pupil ratio in the primary school, (iii) classroom–student ratio in the primary school and (iv) percentage of teachers with qualification graduate and above in the primary schools, measuring quality of the teacher input. Since the current research is a district-level study based on secondary data sources, the districts are taken as a unit of account. Thus, the average value of each of the above-mentioned input and output variables of all the schools in any particular district taken together is considered, and this average value is taken to be a value of the corresponding variable for that district. After obtaining INPTE score, a second stage panel regression is carried out for finding out its determinants considering variables from **(a) Favourable Infrastructure** to see whether favourable infrastructure positively affects INPTE, **(b) Poor Infrastructure** to test whether poor infrastructure negatively affects INPTE, **(c) Policy Indicators** to determine whether provision of more public facilities promotes INPTE and **(d) Macro-indicators** to find out whether general economic environment of the district has something to do with its INPTE score.

Since the basic interest is to find out the impact of the individual explanatory variable, the panel regression by forming a composite index for each of the above four broad indicators after taking into account individual variables prevailing within it and taking that composite index as an explanatory variable has not been tried out. This is because successful implementation of policies for promoting technical efficiency necessitates identification of individual effect. The problem with the use of composite index is that it is possible that some of the individual variables may be significant while the others are not and the use of a composite index cannot differentiate between these possibilities.

The sample consists of 20 districts (as per DISE) in West Bengal, namely Bankura, Burdwan, Birbhum, Dakshin Dinajpur, Darjeeling, Howrah, Hooghly, Jalpaiguri, Cooch Bihar, Kolkata, Malda, Murshidabad, Nadia, North 24 Parganas, Paschim Midnapore, Purba Midnapore, Purulia, Siliguri, South 24 Parganas and Uttar Dinajpur over the nine consecutive years from 2005–06 to 2013–14.

The results of the analysis suggest that not all the districts are perfectly technically efficient. Inter-district variation in efficiency score is prominent. Among the 20 districts considered, no district is perfectly efficient under each of the sample year. The districts having greater than grand average level of INPTE for all the districts, and all the years taken together are Dakshin Dinapur, Darjeeling, Howrah, Kolkata, Malda, Murshidabad, Nadia, North 24 Parganas, Paschim Midnapore, Siliguri, South 24 Parganas and Uttar Dinajpur corresponding to primary level of education. The performances of the other districts are not good with respect to INPTE as these districts belong to the group having INPTE score lower than grand average INPTE.

A comparison of literacy rate, INPTE score and educational development index (EDI) reveals that there are some districts which lie above average literacy rate and EDI but below average INPTE scores. It implies that high level of literacy rate and EDI may not be associated with high level of INPTE score. For example, although EDI and the level of literacy rate for Burdwan, Hooghly and Purba Midnapore are higher than the corresponding average level of both, INPTE score for these districts is below the average INPTE corresponding to the primary level, implying that there can be the possibility of contracting educational input given the output produced for these districts. On the other hand, the districts, namely Darjeeling, Howrah, Kolkata, North 24 Parganas, Paschim Midnapore, Siliguri and South 24 Parganas, have experienced the higher value than the district average score for all three types of indicators. There are some districts such as Dakshin Dinajpur, Malda, Murshidabad, Nadia and Uttar Dinajpur with higher score of INPTE than average but below average value for the literacy rate and EDI. The other sample districts Bankura, Birbhum, Jalpaiguri, Cooch Bihar and Purulia have experienced lower value in terms of INPTE and literacy rate. Hence, there may not necessarily be one to one correspondence between these three performance indicators, namely INPTE, EDI and the literacy rate.

The study also finds the extent of inefficiency in utilization of different inputs used in the production process. Regarding inefficiency of different inputs, it can be said that for primary level, the average combined level of radial and slack movements of input is highest for the input teacher–pupil ratio (10.90%) in the school, followed by classroom–student ratio in the school (10.50%), number of schools per lakh population (8.30%) and least for the input percentage of the teachers with qualification graduate and above. Therefore, it can be concluded that the extent of inefficiency at primary level of education is highest for the input teacher–pupil ratio and lowest for percentage of teachers with qualification graduate and above. Hence, an increase in the efficiency of input utilization of each of these inputs can increase the output level without an extra usage of the inputs.

Considering the determinants of INPTE, the results of the panel regression suggest that infrastructural both poor as well as favourable along with policy and the district specific factors are important in explaining INPTE. For example, poor infrastructural variable like percentage of single-teacher schools is important and negatively influence INPTE. Similarly, the favourable infrastructural variable like percentage of primary schools with girls' toilet facility plays significant role in improving efficiency level. Among the policy variables, percentage of girls getting free textbook to boys positively influence INPTE score suggesting the significant role of policy variable in explaining INPTE. The increase in INPTE as also happened through the rise in per capita net district domestic product (PCNDDP).

For determinant analysis, the paper uses static panel model. The generalization of the model by using dynamic panel requires determination of optimum lag. However, this is not an appropriate and good approach of estimation having yearly data with only nine period time points and can be attempted in future with much more larger time span.

An analysis of the determinants of INPTE suggests the positive role of policy variables in promoting input-oriented technical efficiency for primary education level in West Bengal. For example, it is found that the percentage of girls getting free textbook to boys positively affects INPTE. Therefore, government should provide more textbook to girls as compared to boys to boost up INPTE. Similarly, percentage of schools with girls' toilet in the district enhances input-oriented technical efficiency. This result in turn suggests that government should provide girls' toilet in the schools at the district level, so that number of schools with girls' toilet in the district actually increases. The analysis also confirms that percentage of single-teacher schools negatively influences INPTE. Thus, government should recruit more number of teachers on the schools at the district level so that number of single-teacher school eventually decreases and it improves the level of INPTE. Further, INPTE actually increases with increase in per capita net district domestic product. Thus, any policy measure that actually increases per capita net district domestic product will also imply an increase in INPTE.

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Chapter 13
Public Expenditure on Pre-tertiary and Tertiary Education: Effects on Skilled–Unskilled Wage Inequality

Ujjaini Mukhopadhyay

13.1 Introduction

Education is considered to be the best tool for skill formation and lowering the existing and increasing inequality in income (Ashenfelter & Rouse, 2000; Johnson, 1997). In developing countries, public investment in education plays a catalytic role. The rationale for such government intervention lies in the suboptimal private investment in human capital, since education is associated with spillover effects resulting in positive externality so that private returns diverge from social returns. Moreover, in developing countries, there is considerable inequality in educational access due to low income and limited opportunity for credit (Chevalier et al., 2005; Najeeb, 2007). Although private players have been gaining importance in the education sector in the recent years, government-funded education system still remains a panacea for individual benefits of a vast majority of the population as well as social benefits in developing countries. During 1960–2010, there has been remarkable surge in the share of government expenditure on education in GDP in low and middle income countries, particularly the Latin American ones like Argentina, Columbia, Mexico; in fact, the share in Brazil has exceeded that in the high income countries (Szirmai, 2015). In India, about 80% of the schools are government owned or aided (MHRD, 2018), and out of 903 universities, only 343 are managed privately (All India Survey on Higher Education, 2017–18).

Public policies that promote equal distribution in educational attainment are found to significantly reduce inequalities in education and income (Lee & Lee, 2018). The educational expansion policies might take the form of incentivization of education through education subsidy, conditional cash transfer (CCT) or provision of scholarship. While subsidies aim to raise the participation and retention of economically weaker sections in education by reducing the costs of education, CCT addresses the

U. Mukhopadhyay (✉)
Department of Economics, Behala College, Parnashree Pally, Behala, Kolkata, West Bengal 700060, India

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inequality of educational opportunity and complements the equity enhancing policies; however, scholarships, though cater to the financial needs, are performance based (IOM, 2011; Ham, 2014).

Subsidies are the most widespread and popular among the human capital expansion policies. Public subsidies on education are justified in the literature on the grounds of equity of opportunity, static and dynamic externalities contributing to economic growth and technological progress, imperfection in capital market and increasing returns to scale in education (Tilak, 2004). On the other hand, several arguments are forwarded in opposition to public subsidies on education, like lower social return to education than private returns, adverse effects on distribution and vulnerability to governmental control (Psacharopoulos 1994; World Bank, 2000).

Public subsidies on education can have important implications on the labour market. The cheap subsidized education cost is likely to result in greater private demand for education, raise unskilled wages and thereby compress the skill premium. However, though education subsidy is believed to be instrumental in skill formation in the economy, there is considerable debate in the literature regarding its effects on the skilled–unskilled wage inequality. Blankenau (1999) shows that education subsidies may be preferred to direct transfers as a means of decreasing wage inequality. Dur and Teulings (2003) assert that when workers of different skill levels are imperfect substitutes in production, an increase in the mean level of human capital in the economy due to education subsidy may reduce wage inequality. However, Kiley (1999) concludes that subsidy policies that raise the supply of skilled labour bring about an increase in the demand for skilled labour by stimulating technological progress and innovation geared towards skilled workers and educated consumers. This results in the rise in the relative wages of skilled workers and widening of wage inequality. Shepard and Sidibe (2019) show that education subsidies lead to additional mismatch for low-educated workers, while college and advanced graduates are less exposed to mismatch. The combination of these two effects results in increased inequalities. Penalosa and Walde (2000) show that a subsidy rate that allows the optimal number of workers to study results in a greater lifetime income for the skilled than for the unskilled and that a higher subsidy rate increases the number of students and equalizes lifetime incomes.

A number of studies have been undertaken to find the impact of education subsidies on wage inequality in the general equilibrium framework. Pan (2014) shows in terms of a general equilibrium model that increased government led investment on education reduces skilled–unskilled wage inequality. Mukhopadhyay (2017) asserts that education subsidy, if accompanied by increase in capital inflow, may have favourable effects on skilled–unskilled wage inequality. Ojha et al. (2013) show in a CGE framework that expansionary educational investment policy is substantially disequalizing since the resulting growth biases the structure of production towards skill-intensive sectors and benefits the skilled and semi-skilled workers at the cost of the unskilled majority. Gupta and Dutta (2014) find no effect of education subsidy on wage gap. This is because in the competitive equilibrium of the education sector, skilled wage rate varies positively with the unskilled wage rate and education subsidy does not affect the unskilled wage. Violante (2007) shows that long-term general equilibrium results of education subsidies may drastically differ from those of short-term partial equilibrium. While in partial equilibrium, subsidization increases education levels among the less able and reduces earnings inequality; in general equilibrium, the more able but liquidity constrained individuals get more education, while the education levels of the less able can decrease, leading to a rise in earnings inequality. The dynamic effects of public education subsidy policy on wage inequality have been examined by Chaudhuri et al. (2018); they find that when there is full employment, the result depends solely on distributive shares of the intersectorally mobile factor, while in the presence of Harris–Todaro type unemployment, the results crucially also depend on the degree of imperfection prevailing in the unskilled labour market.

A pertinent issue regarding public education subsidy is that it can be disaggregated into expenditure on primary, secondary and tertiary education. There is some unanimity regarding subsidization of primary and secondary education, but the case for subsidies in higher education is controversial since basic education is considered a pure public good, while higher education is deemed a quasi or semi-public good (Tilak, 2004).

Earlier, empirical studies showed greater rates of return to investments in education at lower levels of education, which prompted allocation of more funds to pre-tertiary levels of education (Heckman et al., 2008). However, the recent trend shows that there is a bias towards investments in higher education programmes in many developing countries, mainly in order to benefit from the post liberalization surge in demand for skilled workers. Studies have demonstrated the crucial role of tertiary education in fostering economic growth, human capital development and technological diffusion (Bloom et al., 2006; Chatterji, 1998). Also, the economic returns for higher education graduates are the highest in the entire educational system—an estimated 17% increase in earnings as compared with 10% for primary and 7% for secondary education (World Bank, 2018). According to the World Bank data, in India, the government expenditure on primary, secondary and tertiary education (as % of GDP) increased by 20%, 10% and 62% during 1999 to 2012. In low-income countries, higher education is almost completely subsidized by the government (Roser & Ortiz-Ospina, 2016).

Evidence suggests that unequal investments in higher education are important determinants of increasing inequalities in developing countries (Barro, 1999). Since governments often undertake policies for promoting higher education at the expense of primary and secondary education, it is imperative to examine the impact of such asymmetrical policy on the earnings disparities of the workers. However, the existing literature does not deal with the role of preferential emphasis of public expenditure towards higher or tertiary education on wage inequality. A notable exception, though, is the study by Mukhopadhyay (2021), which considers the effects of subsidies on primary, secondary and higher education on wage inequalities between unskilled, semi-skilled and skilled labour in a two-sector Harris–Todaro model.

The objectives of the paper are twofold: first, to determine whether budgetary funds meant for pre-tertiary (primary to secondary) and tertiary (higher) education sectors should be asymmetric or go hand in hand and second, to investigate the implications of differential education expenditure of the government on skilled–unskilled wage gap in a developing economy. We consider a three-sector full-employment general equilibrium model with endogenous skill formation, where the composition of skilled and unskilled labour is determined by intertemporal utility maximizing behaviour of the households. The results show that the effects of government expenditure on pre-tertiary and tertiary education on skilled–unskilled wage inequality depend on the factor intensity condition and level of skill formation of the economy.

The paper contributes to the literature in the sense that given the fiscal stringencies in developing countries, resulting in asymmetries in public expenditure on school education and higher education; it disaggregates education subsidies into the two types to analyse their effects on skilled and unskilled wages and the inequality thereof, in order to provide a direction towards government policies.

13.2 Endogenous Skill Formation and Determination of Skilled and Unskilled Labour Supply

To derive the endogenous skill formation, we follow Mukhopadhyay (2021). It is assumed that initially, there are $\overline{L}$ unskilled and $\overline{S}$ skilled households in the economy. However, the supply of unskilled and skilled labour is determined by the intertemporal utility maximizing behaviour of the households over three periods.

Period 1: Let $\bar{l}$ be the number of members in an unskilled household. In period 1, the household takes a decision on the number of members who are to obtain pre-tertiary education and to join the labour force respectively. The family members with no education can still earn W_L by working as unskilled labour. However, those with primary or secondary education possess higher efficiency/productivity which enables them to earn higher effective income. But poverty and lack of educational credit facilities disallow the households to send all its member for acquiring education. In this circumstances, pre-tertiary education subsidy induces greater participation in education resulting in higher efficiency. The positive correlation between education subsidy and productivity/efficiency of workers has been confirmed in empirical studies (Kampelmann et al., 2018; Rycx et al., 2015). Hence, efficiency of the representative unskilled worker, h, depends on the magnitude of pre-tertiary education subsidy, e, and is given by

$$h = h(e);\ \ h' > 0 \tag{13.1}$$

Let l_P proportion of members in the household are sent for pre-tertiary education and the rest join the unskilled labour force; hence, the supply of unskilled labour in period 1 is $(l - l_P)$, and they earn W_L, the competitive wage rate (per efficiency unit). The unit cost of pre-tertiary education is C_e out of which the government spends proportion e in the form of subsidy. So, the net cost of pre-tertiary education for the household is $l_p C_e(1 - e)$. The effective income of the unskilled household net of education expenditure is given by $W_L(l - l_p) - l_p C_e(l - e)$.

Period 2: Among the l_P proportion of workers who had obtained primary education in the period 1, l_s proportion go for tertiary (higher) education. The unit cost of higher education is C_E, and the government contributes proportion E as higher education subsidy. Hence, the education cost for l_s members is $l_s C_E(1-E)$. Now, the rest $(l_p - l_s)$ join the unskilled labour force, but due to higher efficiency, they earn higher wages, $W_L h(e)$. The effective income of the household consists of the incomes of the unskilled workers without education and those with pre-tertiary education net of higher education cost and is given by $W_L(l-l_p) + W_L h(e)(l_p - l_s) - l_s C_E(1-E)$.

Period 3: In this period, l_s number of persons who had obtained higher education in the previous period earn skilled wage W_s per efficiency unit. The efficiency of skilled wage is fixed at 1. Hence, the household now consists of unskilled labour with no education, unskilled labour with pre-tertiary education and higher efficiency, and skilled labour. So the effective income of the household is $W_L(l-l_p)+W_L h(e)(l_p - l_s) + l_s W_s$.

The household maximizes its intertemporal utility over the three periods and determines the number of members to be sent for pre-tertiary and tertiary education, l_p and l_s, respectively. The utility of the household depends on its consumption level in the three periods: C_1, C_2 and C_3. Hence, the household's problem can be expressed as

$$\max U(C_1) + \beta U(C_2) + \gamma U(C_3) \tag{13.2}$$

where

$$C_1 = W_L(\bar{l} - l_p) - l_p C_e(1-e) \tag{13.3}$$

$$C_2 = W_L(\bar{l} - l_p) + W_L h(e)(l_p - l_s) - l_s C_E(1-E) \tag{13.4}$$

$$C_3 = W_L(\bar{l} - l_p) + W_L h(e)(l_p - l_s) - l_s W_s \tag{13.5}$$

Maximization of Eq. (13.2) with respect to l_p and l_s yields the following first order conditions:

$$U_1'\{W_L + C_e(1-e)\} = \{\beta U_2' + \gamma U_3'\} W_L(h(e) - 1) \tag{13.6}$$

$$\beta U_2'\{W_L(h(e) - C_E(1-E)\} = \gamma U_3'\{W_s - W_L h(e)\} \tag{13.7}$$

From (13.6) and (13.7), the demand for primary and higher education for each household can be obtained respectively as

$$l_p = l_p(W_L, e);\ l_{p1}' = (\partial l_p/\partial W_L) < 0;\ l_{p2}' = (\partial l_p/\partial e) > 0 \tag{13.8}$$

$$l_s = l_s(W_S, E);\ l'_{s1} = (\partial l_s/\partial W_s) > 0;\ l'_{s2} = (\partial l_s/\partial E) > 0 \tag{13.9}$$

Hence, the total demand for pre-tertiary and tertiary education in the economy is given respectively by

$$L_P = L_P(W_L, e) \tag{13.8.1}$$

$$L_S = L_S(W_S, E) \tag{13.9.1}$$

13.3 The General Equilibrium Model

It is assumed that a small open economy consists of three sectors. Sector 1 produces an agricultural good, X_1 using unskilled labour and land. Sector 2 produces a manufacturing good, X_2 using both skilled and unskilled labour, and capital. Sector 3 produces skill-intensive manufacturing good using skilled labour and capital. Unskilled labour is mobile between sectors 1 and 2, while skilled labour and capital are mobile between sectors 2 and 3. Land is assumed to be specific to sector 1. Unskilled labour earns competitive wage W_L (per efficiency unit), while skilled labour earns a higher wage W_S per efficiency unit. Although the total labour force in the economy is given, the stocks of skilled ($\overline{S}$) and unskilled labour ($\overline{L}$) in physical units can change because of endogenous skill formation through education. The government subsidizes both primary education and higher education, and the subsidies are financed by tax on return to capital. Due to the assumption of small open economy, prices of all the goods are assumed to be internationally given. Production functions exhibit constant returns to scale with diminishing marginal productivity to each factor. It is assumed that sector 3 is more skill intensive vis-à-vis sector 2.

It is assumed that (i) sector 1 is more labour intensive than sector 2, and (ii) sector 3 is more skilled labour intensive (with respect to capital) than sector 2. These factor intensity conditions are appropriate to developing countries with the presence of a considerably skill-intensive sector, so that they are faced with the policy choice of subsidization of pre-tertiary or tertiary education.

The general equilibrium is represented by the following set of equations.

$$W_L a_{L1} + R a_{K1} = P_1 \tag{13.10}$$

$$W_L a_{L2} + W_S a_{S2} + r a_{K2} = P_2 \tag{13.11}$$

$$W_S a_{S3} + r a_{K3} = P_3 \tag{13.12}$$

Equations (13.10), (13.11) and (13.12) depict the price-unit cost equality conditions of the competitive industry equilibrium in sectors 1, 2 and 3, respectively. Here, a_{K1} is the land-output ratio in sector 1; a_{Ki} denotes the capital-output ratio in the ith sector, $i = 2, 3$; a_{Li} is the unskilled labour-output ratio in the ith sector, $i = 1, 2$; a_{Si} represents the skilled labour-output ratio in sector i, $i = 2,3$; R and r denote return to land and capital respectively, while P_i is the world price of the ith good, $i = 1, 2, 3$.

$$a_{K1}X_1 = K_1 \tag{13.13}$$

Equation (13.13) indicates that the entire stock of land (K_1) is used up in sector 1.

$$a_{K1}X_1 + a_{K2}X_2 = K_2 \tag{13.14}$$

Equation (13.14) implies that total capital endowment in the economy is completely utilized.

The full employment of unskilled and skilled labour in efficiency units (before any decision on education is made) respectively gives

$$a_{L1}X_1 + a_{L2}X_2 = \overline{L} \tag{13.15}$$

$$a_{S2}X_2 + a_{S3}X_3 = \overline{S} \tag{13.16}$$

In the above equations, X_i denotes the output level of the ith sector, $i = 1, 2, 3$; K_1 and K_2 represent the aggregate stocks of land and capital in the economy; $\overline{L}$ is the initial endowment of unskilled persons in the economy in physical unit; and $\overline{S} =$ initial endowment of skilled labour in the economy in physical unit.

There are ten endogenous variables in the system: $h, L_P, L_S, W_L, W_S, R, r, X_1, X_2$ and X_3 that can be solved from the ten equations—(13.1), (13.8.1), (13.9.1), (13.10)–(13.16). This is an indecomposable production system where any change in factor endowment affects factor coefficients and factor prices.

13.4 Effects of Government Subsidy on Pre-tertiary and Tertiary Education

Now, we examine the effect of government subsidy on pre-tertiary and tertiary education on skilled–unskilled wage inequality in three periods.

Since the pre-tertiary education subsidy affects the productivity of unskilled labour, the appropriate measure of wage inequality between skilled and unskilled labour W_I is given *by*[1]

$$W_I = W_S - W_L h(e) \tag{13.17}$$

Period 1:

In this period, those members of the household who do not want to get educated join the labour force so that the supply of unskilled labour is $\overline{L} - L_p(W_L, e)$. The supply of skilled labour remains unchanged at $\overline{S}$. Hence, Eq. (13.15) can now be written as

$$a_{L1}X_1 + a_{L2}X_2 = \overline{L} - L_p(W_L, e) \tag{13.15.1}$$

An increase in the government expenditure on basic education induces participation in pre-tertiary education and hence reduces the supply of unskilled worker. Given its demand, the unskilled labour wage W_L rises. Lower unskilled labour supply leads to contraction of both sectors 1 and 2. The demand for land and capital declines so that both R and r fall. To maintain zero profitability conditions in sector 3, W_S goes up. Since this period entails skill formation, the unskilled labour consists of only those without education. The effect on wage inequality depends on the relative strengths of the changes in the skilled and unskilled wages. The sufficient condition (13.33) shows that the skilled–unskilled wage inequality hinges on the factor intensity conditions.

The supply of unskilled labour is influenced by government expenditure on pre-tertiary education in period 1, but any increase in public expenditure on higher education has no effect on wage inequality.

This leads to the following proposition.[2]

Proposition 1: *A rise in government expenditure on pre-tertiary education (i) raises both skilled and unskilled wages; and (ii) lowers (accentuates) the wage gap if the skilled labour intensity of sector 3 is more (less) than the unskilled labour intensity of sector 2 (with respect to capital).*

Period 2:

In this period, the members who had obtained pre-tertiary education experience improvement in their efficiency. Hence, the skilled–unskilled wage inequality depends not only on the relative changes in their respective wages but also on the rise in efficiency of the unskilled workers.

Hence, the following proposition is proposed.[3]

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[1] Similar treatment of wage inequality, though in a different context, is found in Mukhopadhyay (2018).

[2] Detailed derivations are shown in the "Appendix".

[3] See the Appendix for detailed derivations.

Proposition 2: *An increase in government expenditure on pre-tertiary education narrows the skilled–unskilled wage inequality irrespective of factor intensity condition if the returns to education are sufficiently high.*

Now, some of the members with pre-tertiary education are sent for higher education in this period while the rest of the members with only basic education join the unskilled worker labour force. The supply of unskilled labour becomes $\overline{L} - L_s(W_s, E)$, but the supply of skilled labour remains $\overline{S}$. Hence, Eq. (13.15) can now be written as

$$a_{L1}X_1 + a_{L2}X_2 = \overline{L} - L_s(W_s, E) \tag{13.15.2}$$

Due to the rise in government expenditure on tertiary education, more people opt for higher education. The supply of unskilled labour falls and W_L increases. The rest of the effects are analogous to that in the previous period.

Hence, the following proposition follows.

Proposition 3: *Rise in government expenditure on higher education (i) increases skilled and unskilled wages; and (ii) reduces (intensifies) the wage gap if the skilled labour intensity of sector 3 is more (less) than the unskilled labour intensity of sector 2 (with respect to capital).*

Period 3:

The unskilled labour supply remains the same as in the previous period. However, those who obtained higher education in period 2 now join the skilled labour force. Hence, the supply of skilled workers becomes $\overline{S} + L_s(W_s, E)$. Hence, Eq. (13.16) can be rewritten as

$$a_{S2}X_2 + a_{S3}X_3 = \overline{S} + L_s(W_s, E) \tag{13.16.1}$$

While in all the periods, the total population in the economy remains the same, the supply of unskilled and skilled workers changes due to endogenously determined skill formation.

The increase in the supply of skilled labour produces a Rybczynski type effect and leads to expansion of sector 3 since it is more skilled labour intensive than sector 2. The additional demand for capital in sector 3 is met by contraction in sector 2. Now, the impact on factor prices will be different for the alternative factor intensity conditions:

Case (i): If the capital intensity of sector 2 (with respect to unskilled labour) is more vis-à-vis sector 3 (with respect to skilled labour), that is, $a_{K3}a_{L2} < a_{K2}a_{S3}$, sector 2 releases more capital than that absorbed by sector 3, so that r falls. As a consequence W_S rises to maintain zero profitability condition in sector 3. On the other hand, the unskilled labour released leads to expansion in sector 1; the latter being more unskilled labour intensive than sector 1 raises W_L. Skilled–unskilled wage inequality reduces under the sufficient condition (13.39).

Case (ii): If the capital intensity of sector 3 (with respect to skilled labour) is more vis-à-vis sector 2 (with respect to unskilled labour), that is, $a_{K3}a_{L2} > a_{K2}a_{S3}$, the demand for capital by sector 3 shots up and raises r. To maintain zero profitability condition in sector 3, W_S falls. The unskilled labour released leads to expansion in sector 1; the demand for land goes up so that R also increases. As a result, W_L declines to maintain zero profitability condition in sector 1. Skilled–unskilled wage inequality reduces in this case as well under the sufficient condition (13.39). Hence, the following proposition can be established.

Proposition 4: *At higher levels of stock of skilled labour, a rise in government expenditure on higher education (i) reduces skilled and unskilled wages; (ii) narrows the wage gap irrespective of factor intensity conditions*

13.5 Conclusion

The paper endeavours to investigate the effects of differential education expenditure of the government on pre-tertiary (primary and secondary) and tertiary (higher) education on the skilled–unskilled wage gap in the economy. A three-sector full-employment general equilibrium model is set up. There is endogenous skill formation where unskilled and skilled labour supply are determined by intertemporal utility maximizing behaviour of the households. The results show that the impact of the two types of education subsidies hinges on the relative factor intensity conditions and the level of skill formation of the economy. At initial stages of skill formation, subsidies on both school (pre-tertiary) education and higher education have favourable effects on the absolute wages of skilled as well as unskilled labour. But higher education subsidies at higher skill levels of the economy lower the wages of both types of labour.

While the effect of a rise in pre-tertiary education subsidy on wage inequality in the initial period of skill formation depends on the relative factor intensity condition, it may have favourable effects irrespective of factor intensity conditions when there is sufficient rise in effective wages of unskilled labour due to skill formation. On the other hand, the effect of enhancement of tertiary education subsidies on skilled–unskilled wage inequality depends on the factor intensity conditions at lower skill levels of the economy; however, it ameliorates the wage inequality irrespective of factor intensity conditions at higher levels of skilled labour supply.

The policy implications are twofold: first, the government aiming at uplifting the overall wage income of workers at initial levels of skill formation might opt for either pre-tertiary or tertiary education subsidies, since both raise the wages; however, at higher skill level of the economy, higher education subsidy can be detrimental. Secondly, if the low-skill sector is more capital intensive vis-à-vis the high-skill sector, both subsidies on pre-tertiary and tertiary education are beneficial for wage inequality irrespective of the level of skill formation. On the other hand, if the high-skill sector is more capital intensive vis-à-vis the low-skill sector, a rise in subsidy on tertiary education subsidy may reduce the skilled–unskilled wage inequality when the skilled labour stock is higher, while pre-tertiary education is likely to be favourable during the period of skill formation only if the returns to education are sufficiently high; otherwise, it can be detrimental. Hence, it might be rational to prioritize pre-tertiary or school education for a low-skill economy because it not only promotes skill formation but also has favourable effects on skilled and unskilled wages and the inequality thereof. However, after enhanced skilled labour supply is available due to skill formation, public expenditure on higher education may be sought since it ameliorates wage inequality. The government policies pertaining to public expenditure on education should take into account the level of skill formation in the economy and the prioritized objectives of ensuring absolute increases in wages or addressing inequality.

Appendix

Total differentials of (13.10), (13.11) and (13.12) and the use of envelope conditions give

$$\theta_{L1}\hat{W}_L + \theta_{K1}\hat{R} = 0 \tag{13.18}$$

$$\theta_{L2}\hat{W}_L + \theta_{S2}\hat{W}_S + \theta_{K2}\hat{r} = 0 \tag{13.19}$$

$$\theta_{S3}\hat{W}_S + \theta_{K3}\hat{r} = 0 \tag{13.20}$$

Here, θ_{ji} is the distributive share of the jth input in the ith sector, $i = 1, 2, 3; j = L, K, S$; λ_{ji} denotes the proportion of the jth input employed in the ith sector, $i = 1, 2, 3; j = L, K, S$; while ^ depicts proportionate change.

It may be noted that producers in each industry choose techniques of production so as to minimize unit costs. This leads to the condition that the distributive-share weighted average of changes in input–output coefficients along the unit isoquant in each industry must vanish near the cost-minimization point. This states that an isocost line is tangent to the unit isoquant. In mathematical terms, for example, cost-minimization condition in sector 1 may be written as: $\theta_{L1}\hat{a}_{L1} + \theta_{K1}\hat{a}_{K1} = 0$. These are called the envelope conditions. See Caves et al. (1990) and/or Chaudhuri and Mukhopadhyay (2009).

Solving (13.18), (13.19) and (13.20) by Cramer's rule, we get

$$\hat{W}_L = -(\hat{R}/|\theta|)[\theta_{K1}(\theta_{K2}\theta_{S3} - \theta_{K3}\theta_{S2})] \tag{13.21}$$

$$\hat{W}_S = -(\hat{R}/|\theta|)[\theta_{K1}\theta_{L2}\theta_{K3}] \tag{13.22}$$

$$\hat{r} = (\hat{R}/|\theta|)[\theta_{K1}\theta_{L2}\theta_{S3}] \quad (13.23)$$

where $|\theta| = \theta_{L1}(\theta_{K2}\theta_{S3} - \theta_{K3}\theta_{S2}) > 0$ since it is assumed that sector 3 is more skill intensive than sector 2.

Period 1:

Total differentiation of (13.13), (13.14), (13.15.1) and (13.16) yields, respectively

$$\hat{X}_1 + A_1\hat{R} = 0 \quad (13.24)$$

$$\lambda_{K2}\hat{X}_2 + \lambda_{K3}\hat{X}_3 + A_2\hat{R} = 0 \quad (13.25)$$

$$\lambda_{L1}\hat{X}_1 + \lambda_{L2}\hat{X}_2 + A_3\hat{R} = (-)L'_{p2}e\hat{e} \quad (13.26)$$

$$\lambda_{S2}\hat{X}_2 + \lambda_{S3}\hat{X}_3 + A_4\hat{R} = 0 \quad (13.27)$$

Solving (13.24), (13.25), (13.26) and (13.27) by Cramer's rule yields

$$\hat{R} = (L'_{p2}e\hat{e}/\Delta)[\lambda_{K2}\lambda_{S3} - \lambda_{K3}\lambda_{S2}] \quad (13.28)$$

where

$$\left.\begin{aligned}
A_1 =& (1/|\theta|)[\lambda_{K1}(\theta_{K2}\theta_{S3} - \theta_{K3}\theta_{S2})(\theta_{L1}S^1_{KK} - \theta_{K1}S^1_{KL})] < 0\\
A_2 =& (1/|\theta|)\theta_{K1}[\theta_{L2}\theta_{S3}(\lambda_{K2}S^2_{KK} + \lambda_{K3}S^3_{KK}) - \lambda_{K2}S^2_{KL}(\theta_{K2}\theta_{S3} - \theta_{K3}\theta_{S2})\\
&- (\lambda_{K2}S^2_{KS} + \lambda_{K3}S^3_{KS})\theta_{L2}\theta_{K3}] < 0\\
A_3 =& (1/|\theta|)[(\theta_{K2}\theta_{S3} - \theta_{K3}\theta_{S2})\{\lambda_{L1}S^1_{LK}\theta_{L1} - (\lambda_{L1}S^1_{LL} + \lambda_{L2}S^2_{LL} + L'_{p1}W_L)\theta_{K1}\\
&+ \lambda_{L2}\theta_{K1}\theta_{L2}(S^2_{LK}\theta_{S3} - S^2_{LS}\theta_{K3})]\\
A_4 =& (1/|\theta|)\theta_{K1}[(\lambda_{S2}S^2_{SK} + \lambda_{S3}S^3_{SK})\theta_{L2}\theta_{S3} - \lambda_{S2}S^2_{SL}(\theta_{K2}\theta_{S3} - \theta_{K3}\theta_{S2})\\
&- (\lambda_{S2}S^2_{SS} + \lambda_{S3}S^3_{SS})\theta_{L2}\theta_{K3}]
\end{aligned}\right\} \quad (13.29)$$

$$\text{and } \Delta = [A_3(\lambda_{K3}\lambda_{S2} - \lambda_{K2}\lambda_{S3}) - \lambda_{K3}\lambda_{L2}A_4 + A_2\lambda_{L2}\lambda_{S3} - A_1(\lambda_{K3}\lambda_{S2} - \lambda_{K2}\lambda_{S3})\lambda_{L1}] \quad (13.30)$$

From (13.30), it follows that $\Delta < 0$ under the sufficient conditions

$$\text{(i) } S^2_{LK}\theta_{S3} > S^2_{LS}\theta_{K3} \text{ and (ii) } S^2_{SL}\theta_{K2} > S^2_{SK}\theta_{L2} \quad (13.31)$$

Here, S^i_{jk} is the degree of substitution between factors in the i th sector, $i = 1, 2, 3$, for example, in sector 1, $S^1_{LL} = (da_{L1}/dW_L)(W_L/a_{L1})$, $S^1_{LK} = (da_{K1}/dR)(R/a_{K1})$. $S^i_{jk} > 0$ for $j \neq k$ and $S^i_{jj} < 0$. It should be noted that as the production functions are homogeneous of degree one, the factor coefficients, a_{ji} s are homogeneous of degree zero in the factor prices. Hence, the sum of elasticities for any factor of production in any sector with respect to factor prices must be zero. For example, in sector 1, with respect to labour, we have $(S^1_{LL} + S^1_{LK}) = 0$ while with respect to capital, $(S^1_{KL} + S^1_{KK}) = 0$.

From (13.28), it is evident that $\hat{R} < 0$ when $\hat{e} > 0$ if $\Delta < 0$.

From (13.21), (13.22) and (13.23) one gets $\hat{W}_L > 0$, $\hat{W}_S > 0$ and $\hat{r} < 0$ if $\Delta < 0$.

Since in period 1, people are in the process of getting education, skilled–unskilled wage inequality is given by

$$W_I = W_S - W_L \tag{13.17.1}$$

Totally differentiating (13.17.1) and use of (13.21), (13.22) and (13.28), one gets.

$W_I\hat{W}_I = W_S\hat{W}_S - W_L\hat{W}_L$.

Hence,

$$\begin{aligned} W_I\hat{W}_I = &- (1/(\Delta|\theta|P_2P_3))\theta_{K1}rW_LW_Se\hat{e}[L'_{p2}\{\lambda_{K2}\lambda_{S3} - \lambda_{K3}\lambda_{S2}\}\{a_{K3}(a_{L2} + a_{S2}) \\ &- a_{K2}a_{S3}\}] \end{aligned} \tag{13.32}$$

From (13.32) it follows that when $\hat{e} > 0$,

$$\hat{W}_I < (>)0 \text{ if } a_{K3}a_{L2} < (>)a_{K2}a_{S3} \text{ and } \Delta < 0 \tag{13.33}$$

Period 2:

Due to increase in primary education subsidy in period 1, the efficiency of those with education rises and the skilled–unskilled wage inequality is given by Eq. (13.17).

Differentiating (13.17) and use of (13.21), (13.22) and (13.28) yields

$$\begin{aligned} W_I\hat{W}_I = &- (h(e)/(\Delta|\theta|P_2P_3))[\theta_{K1}rW_LW_Se\hat{e}\{L'_{p2}(\lambda_{K2}\lambda_{S3} \\ &- \lambda_{K3}\lambda_{S2})\{a_{K3}(a_{L2} + a_{S2}) - a_{K2}a_{S3}\}\} - W_Lh'(e)|\theta|P_2P_3] \end{aligned} \tag{13.34}$$

We consider the two alternative factor intensity conditions when $\hat{e} > 0$. From (13.34), it follows that

$$\left.\begin{aligned} &\text{Case I}: \hat{W}_I < 0 \text{ if } a_{K3}a_{L2} < a_{K2}a_{S3} \text{ and } \Delta < 0 \\ &\text{Case II}: \hat{W}_I < 0 \text{ if } a_{K3}a_{L2} > a_{K2}a_{S3},\ \Delta < 0 \text{ and } W_Lh'(e) \text{ is sufficiently high} \end{aligned}\right\} \tag{13.35}$$

Now, differentiation of (13.15.2) yields

$$a_{L1}\hat{X}_1 + a_{L2}\hat{X}_2 - A_5\hat{R} = (-)L^{'}_{s2}E\hat{E} \tag{13.26.1}$$

Solving (13.24), (13.25), (13.26.1) and (13.27) by Cramer's rule yields

$$\hat{R} = (L^{'}_{S2}E\hat{E}/\Delta)[\lambda_{K2}\lambda_{S3} - \lambda_{K3}\lambda_{S2}] \tag{13.28.1}$$

From (13.28.1), it follows that $\hat{R} < 0$ when $\hat{E} > 0$ if $\Delta < 0$.
From (13.21), (13.22) and (13.23), we get $\hat{W}_L > 0$, $\hat{W}_S > 0$ and $\hat{r} < 0$ if $\Delta < 0$.
Differentiating (13.17) and use of (13.21), (13.22) and (13.28.1) yields

$$\begin{aligned} W_I\hat{W}_I =& - 1/(\Delta|\theta|P_2P_3))[\theta_{K1}rW_LW_SE\hat{E}\{L^{'}_{S2}(\lambda_{K2}\lambda_{S3} \\ &- \lambda_{K3}\lambda_{S2})\{a_{K3}(a_{L2} + a_{S2}) - a_{K2}a_{S3}\}\} \end{aligned} \tag{13.36}$$

From (13.36), it follows that when $\hat{E} > 0$

$$\hat{W}_I < (>)0 \text{ if } a_{K3}a_{L2} < (>)a_{K2}a_{S3} \text{ and } \Delta < 0. \tag{13.37}$$

Period 3:
Differentiation of (13.16.1) gives

$$\lambda_{S2}\hat{X}_2 + \lambda_{S3}\hat{X}_3 + A_6\hat{R} = L^{'}_{s2}E\hat{E} \tag{13.27.1}$$

Solving (13.24), (13.25), (13.26.1) and (13.27.1) by Cramer's rule yields

$$\hat{R} = (L^{'}_{S2}E\hat{E}/\Delta)[\lambda_{K2}\lambda_{S3} - \lambda_{K3}(\lambda_{L2} + \lambda_{S2})] \tag{13.28.2}$$

From (13.28.2), it follows that when $\hat{E} > 0$.
Case I: $\hat{R} < 0$ when $a_{K3}a_{L2} < a_{K2}a_{S3}$ if $\Delta < 0$.
Case II: $\hat{R} > 0$ when $a_{K3}a_{L2} > a_{K2}a_{S3}$ if $\Delta < 0$.
Differentiating (13.17) and use of (13.21), (13.22) and (13.28.1) yields

$$\begin{aligned} W_I\hat{W}_I =& - 1/(\Delta|\theta|P_2P_3))[\theta_{K1}rW_LW_SE\hat{E}\{L^{'}_{S2}(\lambda_{K2}\lambda_{S3} \\ &- \lambda_{K3}(\lambda_{L2} + \lambda_{S2}))\{a_{K3}(a_{L2} + a_{S2}) - a_{K2}a_{S3}\}\}] \end{aligned} \tag{13.38}$$

We consider the effects on factor prices and skilled–unskilled wage inequality under two alternative factor intensity conditions.

From (13.21), (13.22), (13.23) and (13.38), one gets

$$\left.\begin{aligned} &\text{Case I: when } a_{K3}a_{L2} < a_{K2}a_{S3}, \hat{W}_L > 0,\ \hat{W}_S > 0, \hat{r} < 0 \text{ and } \hat{W}_I < 0 \text{ if } \Delta < 0 \\ &\text{Case II: when } a_{K3}a_{L2} > a_{K2}a_{S3},\ \hat{W}_L < 0,\ \hat{W}_S < 0, \hat{r} > 0 \text{ and } \hat{W}_I < 0 \text{ if } \Delta < 0 \end{aligned}\right\} \tag{13.39}$$

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Chapter 14
Not in Education, Employment or Training: Incidence, Determinants and Costs in India

Somtirtha Sinha and Zakir Husain

14.1 Introduction

The International Labour Organization defines NEET as the section of the youth population, which is not engaged in education, employment or training. In this context, education includes any form of it as long as it is intentional, planned and most importantly institutionalized. Anything which might be planned/deliberate but not institutionalized is not considered to be education. Employment here refers to any sort of paid employment and excludes the unpaid domestic care workers. Persons are considered to be in training if they are in a non-academic learning activity through which they acquire specific skills intended for vocational or technical jobs. Finally, ILO defines the youth as anyone aged between 15 and 24 years. However, not all people complete their education by 24 years of age (ILO, 2015), and hence, the upper limit for defining the youth is not set in stone.

Pre-1980s, the focus of policymakers in UK and Europe in general was to target the youth unemployment rate, which included all persons aged 15–25 who were currently unemployed, but they were actively seeking jobs. However, following the 1988 Social Security Act (Furlong, 2006), official recognition to the youth unemployment rate was withdrawn. This left most under 18-year-olds without access to unemployment benefits and limited the entitlements of those under the age of 25. As a consequence of this, both researchers and Government Officials started to adopt new ways of estimating the prevalence of labor market vulnerability among young people. The concept of NEET emerged at this juncture, which was a heterogeneous category combining groups with very different experiences, characteristics and needs. Its all-encompassing nature helped maintain the focus of policymakers and researchers on patterns of vulnerability at a time when youth unemployment, the traditional measure of vulnerability, was declining.

S. Sinha · Z. Husain (✉)
Economics Department, Presidency University, Kolkata, India
e-mail: zakir.econ@presiuniv.ac.in

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A glance at the NEET percentages of the 28 SWTS countries and the EU for 2012/13 reveals that it ranges from a low of about 5% in Madagascar to a high of about 45% in Samoa. Cambodia and Madagascar are doing well in terms of youth inclusion with NEET rates of less than 10%, whereas Bangladesh and Occupied Palestinian Territory have rates as high as 45%. The EU average lies somewhere in between with a rate of 15.4%. The NEET rates of the lower and high-income countries are almost on par, but there exists a sharp rise in the rates for the middle-income countries. Geographical inspection reveals that NEET is predominantly a North African and Middle Eastern phenomenon with a NEET percentage of about 30% (Elder, 2015).

The growing concern regarding NEET stems partly from the fact that it reflects a detachment of young people from the labor market. The group consists of some distinct states of unemployment like unemployment, inactivity. Inactivity occurs as a result of discouragement and marginalization which may reflect the accumulation of multiple disadvantages such as the lack of qualifications, health issues, poverty and other forms of social exclusion. Studies have shown that being NEET at 16–18 years of age is the single most powerful predictor of unemployment at age 21 (Bäckman & Nilsson, 2016). This happens because the NEET is neither improving their future employability through investment in skills or education. Additionally, there exists evidence to suggest that the NEET experiences 1.5–2 times higher risks of poor mental and physical health as compared to their non-NEET counterpart (Goverment of Scotland, 2015, Gutiérrez-García et al., 2018). Lastly, there exists various individual and public finance costs associated with the NEET. At the individual level, the NEET suffers huge losses in current income and potential future income. At the government level, for example, it has been found that the NEET is more likely to be engaged in criminal activities. This leads to higher costs to the public exchequer in terms of maintaining a stronger law enforcement system (Godfrey et al., 2002; Bălan, 2016).

However, despite India's economic growth in the last two decades, unemployment has risen to a 42 year high of 6.1% (GoI, 2017). This rings the alarm bells indicating the possibility of the existence of a severe NEET problem in India. Almost all the major studies concluded that the major proportion of the NEET population were the females attending domestic duties (Gutiérrez-García et al., 2018). Given the huge gender bias present in India and the severe consequences of being a NEET, it is surprising to say the least that there has been no study on NEET in India till date.

14.2 Literature Review

NEET as a topic of research first emerged in the UK and still gains most attention in the UK and other European nations. However, a rich strand of literature has also emerged from Japan in more recent times. NEET as a group is very heterogeneous in nature consisting of people who are inactive maybe because of disability, or it might also be a conscious choice. This was captured by Raffe (2003). If NEET is defined narrowly to include only those who were unemployed, sick or disabled, or looking after a child or the home, 20% of the Scottish youth fall in the NEET category. A gender gap in NEET also exists. For instance, women tend to remain NEET longer than men. The reason is that females provide child care services at home, or seek part-time jobs—even though fewer women are actually unemployed. He concludes that different NEET statuses require different policy solutions.

Another strand of literature explores the effectiveness of some of the policies which have been implemented to tackle the NEET problem. Maguire and Thompson (2017) explored the most recent policy initiative termed as activity agreements (AAs) being piloted in Australia. These agreements offer financial incentives in a flexible and responsive manner addressing the needs of the youth who will be part of NEET for a long time. Mawn et al. (2017) found that high-intensity multi-component interventions, featuring classroom and job-based training had a positive impact by reducing the NEET group.

In the UK, the focus has been on identifying the factors which act as major determinants of being a NEET. Duckworth and Schoon (2012) identified several socio-economic risk factors such as low parent education, lone parent family, whether the individual is living in a social housing which affected the odds of being a NEET across two cohorts, namely 1980 and 2008, which are both periods of recession. They also identified several protective factors like prior attainments, educational aspirations which helped the individuals to avoid being NEET even after getting exposed to severe socio-economic risks. They concluded that the earlier cohort had a lower risk of being NEET than the 2008 cohort. Shinozaki (2012) finds that apart from the respondents' educational backgrounds, their parents' employment status when the respondents were adolescents and past household income are significant determinants of young adults' employment outcomes. Leaving the workforce is particularly correlated with previously having a high standard of living and not attaining the same level of education as one's same sex parent. A comparative study between Australia and Japan by Wong (2016) finds that, in general, young people who were unemployed in Japan were the most disadvantaged group, while young people without home duties were the most disadvantaged in Australia.

Finally, Godfrey et al. (2002) provided an estimate of the costs associated in sustaining the NEET population. The short-term costs included the income loss to the individuals, the medium-term costs included the costs of supporting the NEET individual to the families, finally, the NEET is more likely to be involved in criminal activities, and hence, this involves costs to the government in terms of maintaining a larger and stricter criminal justice system and law enforcement. The total estimated additional lifetime costs of being NEET at age 16–18 at present values (2000/01 prices) are estimated as £7 billion resource costs and £8.1 billion public finance costs at a conservative estimate.

Our study differs from the studies mentioned above primarily because of the fact that there has been no study concerning NEET in India before. Our study builds on some of the methodologies adopted in the literature to provide a comprehensive overview of the NEET situation in India.

14.3 Research Objective

Our study aims to find the incidence that is the proportion and the absolute number of NEET in India. Secondly, we aim to find some of the important socio-economic factors affecting the odds of being a NEET. Finally, we provide an estimate of the potential earning loss to the NEET population.

14.4 Database and Methodology

14.4.1 Database

We have used the sixty-first and sixty-eighth rounds of the “Employment and Unemployment Survey” of the National Sample Survey Organization of India. The sixty-first round was conducted in 2004–05, and the sixty-eighth round was conducted in 2011–12.

A stratified sampling technique was used in both the rounds. Sample size allocated to each state and union territory was according to the population weights of Census 2001 for the sixty-first round and Census 2011 for the sixty-eighth round. Min of 8 FSUs was allocated to each state/UT. For the rural sector, from each stratum/sub-stratum, the required number of sample villages was selected by probability proportional to size with replacement (PPSWR), size being the population of the village as per Census 2001. For the selection of required number of cities in the urban sector, FSUs were selected by using simple random sampling without replacement (SRSWOR).

In our study, we have used a sub-sample of this consisting of age groups of 15–30 and the urban sector (Table 14.1). We consider this particular age group because NEET is a measure of vulnerability among the youth. In India, especially, the age of 30 is a good upper bound by which people complete their education and move into employment. Further, in the rural sector, there exists a lot of disguised unemployment. People might be engaged in some odd job or the other, but in reality, they contribute

Table 14.1 Sample profile for 2004–05 and 2011–12

	2004–05	2011–12
Total households	124,680	101,724
Urban households	45,374	42,024
Respondents	602,814	456,999
Urban respondents	204,808	176,236
Male (%)	51.2	51.1
Female (%)	48.8	48.9

Source Estimated from data

nothing of substance in any productive work. In this situation, the NEET rates are likely to be biased downward. Hence, we drop the rural sector for our study.

14.4.2 Operational Definition of NEET

14.4.2.1 Definitions Adopted

The NEET category essentially consists of the people who are currently not engaged in any work, but they are searching for jobs (i.e., the unemployed) and the individuals who are considered to be outside the labor force. However, by definition, the students and the individuals engaged in some sort of skill enhancing training are excluded from being NEET, even if they might be a part of the non-labor force.

In this context, there exists a conundrum regarding the status of the individuals engaged in unpaid domestic care work. In our study, we adopt two definitions of NEET. In the first definition, the domestic workers are considered to be outside the labor force and, hence, NEET. This we call Type 1 NEET or simply NEET 1. In the second definition, we consider the domestic care workers to be engaged in productive work and, hence, non-NEET. This definition is labeled as NEET 2. However, it should be kept in mind that the actual number of NEET is likely to lie in between the two values of NEET 1 and NEET 2, since not all individuals who reported that they were engaged in household work might have been contributing something productive toward the household. In the subsequent analysis, we report all the results using both these definitions.

14.4.2.2 NSSO Categories

Table 14.2 lists the occupational categories of the NSS survey and which of these categories are NEET 1.

Anyone who is engaged in some sort of "outside" work is treated as employed in the first definition. Even the unpaid workers who were engaged in household enterprise are classified as productive workers and, hence, by extension as non-NEET.

The bone of contention is the two categories which include the domestic workers, namely "engaged in domestic duties only" and "attended domestic duties and was also engaged in tailoring, etc. for domestic use." These two categories are treated as NEET in the first definition but as workers in the NEET 2 definition and, hence, non-NEET (Table 14.3).

14.4.2.3 The Issue of Household Domestic Work

There are several factors which have led to the classifying of individuals engaged in domestic duties as outside the labor force and, hence, by extension, in our analysis, as

Table 14.2 Definition of NEET 1 using NSSO activity status

Usual principal activity	Category	NEET 1
Worked in household enterprise (self-employed)	Workers	No
Employer		
Worked as helper in household enterprise (unpaid family worker)		
Worked as regular salaried/wage employee		
Worked as casual wage labor: in public works		
In other types of work		
Attended educational institution	Students	
Did not work but was seeking and/or available for work	Unemployed	Yes
Attended domestic duties only	Outside labor force	
Attended domestic duties and was also engaged in tailoring, etc. for domestic use		
Rentiers, pensioners, remittance recipients, etc	Others	No
Not able to work due to disability		
Others (including begging, prostitution)		

Source Estimated from data

Table 14.3 Definition of NEET 2 using NSSO activity status

Usual principal activity	Category	NEET 2
Worked in household enterprise (self-employed)	Workers	No
Employer		
Worked as helper in household enterprise (unpaid family worker)		
Worked as regular salaried/wage employee		
Worked as casual wage labor: in public works		
In other types of work		
Attended domestic duties only		
Attended domestic duties and was also engaged in tailoring, etc. for domestic use		
Attended educational institution	Students	
Did not work but was seeking and/or available for work	Unemployed	Yes
Rentiers, pensioners, remittance recipients, etc	Others	No
Not able to work due to disability		
Others (including begging, prostitution)		

Source Estimated from data

NEET 1. Firstly, domestic workers are dominantly females. Women, especially the ones involved in domestic duties, have extremely low bargaining power because of a weak or completely absent fall back option (Agarwal, 1997). They are completely dependent on the earning members of the family, and hence, the tasks performed by them are undervalued. Secondly, when household chores are concerned, the boundary between work and leisure is perceived as fuzzy. For example, some people would regard gardening as a chore, while others would regard it as a hobby (UNECE, 2018). Another reason for the undervaluation of the unpaid domestic workers is the similarity of the tasks they undertake with the tasks performed by the hired domestic helps. Typically, the value assigned to the service provided by these workers is taken to be the one assigned to them by the market, namely the wages they receive. However, it is generally acknowledged that there are many other factors beyond simple supply-and-demand that affect wages and that might make the wage an inaccurate measure of value. Among others, the characteristics of the typical worker (including gender, ethnicity, caste, age and geographical origin), where the work is done, the level of formality or informality of employment and the ease of organizing and presenting collective demands, influence wages. Since, most of these workers are women and belong to marginalized socio-religious communities, their wages are likely to underestimate the "real value" of the activities they undertake. This gives rise to the perception that somehow, domestic duties require a lower skill set. This has been called the cultural devaluation of domestic work (Sen, 1990). In reality, though specifically in the poorer countries, these tasks performed by the unpaid family members are a substitute for services that would be provided by the governments in richer countries. Hence, the contribution of both paid domestic helps, and unpaid family care workers are hugely undervalued.

However, estimating the money value of household production of services is not feasible for two reasons:

(i) Households often produce services which are intangible, and
(ii) Household members may often multitask and perform several activities simultaneously.

As a result, economists have pointed out that national income will be under estimated (Clark, 1958; Nordhaus & Tobin, 1972). Moreover, the extent of under valuation of national income will increase as more women enter the labor market because the decline in unpaid household services is not taken into account (Weinrobe, 1974).

14.4.3 Methodology

We have used a logistic regression to figure out which are the significant determinants of an individual being a NEET. We have used separate models for each of the two rounds and each of the two definitions of NEET. We have also run the models firstly for the entire sample and then separately for the male and female sub-samples. The model we use for the full sample is given as:

$$\ln\left(\frac{pi}{1-pi}\right) = \alpha + \beta 1\text{sex} + \beta 2\text{rmarital} + \beta 3 \text{ rgeneduc} \\ + \beta 4 \text{ lmpce} + \beta 5 \text{ protection} + \beta 6\text{age} + \beta 7\text{src} + \beta 8\text{state}$$

Here, *pi* is the probability of being a NEET. Hence, on the left-hand side, we have the log odds of being a NEET vis-a-vis a non-NEET.

The separate male and female logistic regressions have the same set of explanatory variables. Here, we do not include the sex variable.

14.4.3.1 Variables

In the analysis, we use the following variables:

sex (type: categorical, reference: male): This is the gender dummy variable which takes the value of 1 for female respondents.

rmarital (type: categorical, reference: never married): This variable indicates the marital status of the individuals.

Currently Married=1, if the respondent was married at the time of the survey
= 0, otherwise
Widowed/Divorced/Seperated=1, if the respondent was widowed, divorced or separated at the
time of the survey.

rgeneduc (type: categorical, reference: no education): It indicates the general education level of the respondent.

Below Primary=1, if the respondent has below primary education
=0, otherwise
Primary=1, if the respondent has primary education
=0, otherwise
Middle=1, if the respondent has middle school education
=0, otherwise
HS=1, if the respondent has higher secondary education
=0, otherwise
Above HS=1, if the respondent has any education level above higher secondary
=0, otherwise

lmpce (type: continuous): It is the log of household monthly per capita expenditure.

age (type: continuous): It contains the age of the respondent in years.

protection (type: interaction): IT is obtained by multiplying the gender dummy with the lmpce variable.

src (type: categorical, reference: Hindu forward caste): It indicates the socio-religious community of the individual.[1]

HSC=1, if the respondent belonged to Hindu scheduled caste community
=0, otherwise
HST=1, if the respondent belonged to Hindu scheduled tribe community
=0, otherwise
HOBC=1, if the respondent belonged to Hindu other backward classes community
=0, otherwise
Muslims=1, if the respondent belonged to Muslim community
=0, otherwise
Others=1, if the respondent belonged to any other minority group
=0, otherwise

14.4.3.2 Estimating Costs

In the second part of the study, we have calculated the loss in earnings of the individuals as a consequence of them being NEET. This can be interpreted as the cost of being NEET. In this context, we have adopted NEET 1 definition, because the domestic care workers are unpaid and treating them as non-NEET would lead to a significant underestimation of costs. To arrive at this estimate, we have used Census 2001 and 2011 data to get the total population figures for three religion categories, namely Hindus, Muslims and other minorities for the 2004–05 and 2011–12 rounds of the NSS survey, respectively. For each of these categories, we had population figures for individuals with different levels of education. The education levels were illiterate, below primary, primary, middle, secondary, higher secondary, diploma and graduate and above. We scaled up the population figures of Census 2001 using linear interpolation to arrive at the 2004–05 population figures. We then used the NSS surveys to calculate the proportion of NEET and the mean earnings of the individuals of the non-NEET individuals corresponding to each education level and religion. In the next step, the total population, the proportion of NEET and the mean earnings were multiplied for each sub-category to arrive at the total loss in earnings. Finally, the loss was summed over all sub-categories to estimate the total loss in earnings for

[1] The variable "src" was created by combining information on the religion and caste of the respondents.

the two rounds. This methodology was adopted instead of directly calculating the proportion of NEET and mean earnings in the overall population, since earnings vary across education levels and religion, and hence, this gives a more accurate estimate of the total costs.

14.5 Findings

14.5.1 Estimates

We notice that there exists a huge difference in proportion as well as the absolute number of NEET in the two types across the two rounds (Table 14.4). This is because of the fact that majority of Type 1 NEET are actually the domestic care workers, who have been treated as non-NEET in the second definition. This finding is in line with the majority of studies conducted in other parts of the world. However, it must be kept in mind that the NSS surveys are not designed for a study on NEET. Hence, it is possible that some individuals who were reported as being engaged in household work were actually not doing any productive work. In such a case, our justification for including these workers as non-NEET breaks down. Therefore, it is likely that the actual proportion and the absolute number of NEET lie in between the values indicated by the two definitions.

We noted earlier that the absolute number of NEET is likely to lie somewhere in between the two values as indicated by the two types of NEET. In both the rounds, if we consider an average of the two NEET types, it turns out roughly around 6.5 crores. To put this number in perspective, we note that it exceeds the entire population of Canada and is almost as large as the population of the entire UK.

We observe that the proportion of NEET in the total population has actually fallen. The absolute number of NEET has also fallen significantly. These results hold for both the types of NEET. Even though this result looks optimistic, we will notice that this is not the case, when we present our findings in the costs section.

Table 14.4 Incidence of NEET in India by NEET type and years

	Percentage	No. in crores		
	2004–05	2011–12	2004–05	2011–12
NEET 1	34.07	31.02	11.36	11.22
NEET 2	7.38	5.81	2.34	2.17

Source Estimated from data

14.5.2 Correlates of NEET

14.5.2.1 Education Level

Here, we consider the proportion of NEET across the various education levels and across the two genders. We have separate plots for both the NEET definitions and for the two years.

We observe that across the two rounds, as per NEET 1 definition, the proportion of NEET is significantly higher among the females as compared to the males (Figs. 14.1 and 14.2). This is because of the fact that the domestic care workers are treated as NEET as per this definition, and most of these care workers are females. This is the case in majority of countries in the world (Gutiérrez-García et al., 2018). Thus, the gender gap which exists across almost all walks of life is also prevalent for the NEET.

Secondly, we observe that the proportion of NEET falls as we move to higher education levels smoothly. This is followed by a jump upward when we reach the highest education level of above HS. This result holds for both male and female respondents (Figs. 14.1 and 14.2). As the education level of the individuals rises, it is more likely that they will be employed and if not employed at least likely to continue further education rendering them non-NEET. However, at the lower education levels, people will work at any job they find. This, however, is no longer the case when we reach the highest education level. Here, the individuals will not accept any job they find. Rather they are more likely to stay unemployed willfully in the hopes of gaining an employment which they think they deserve. This has been referred as the mismatch

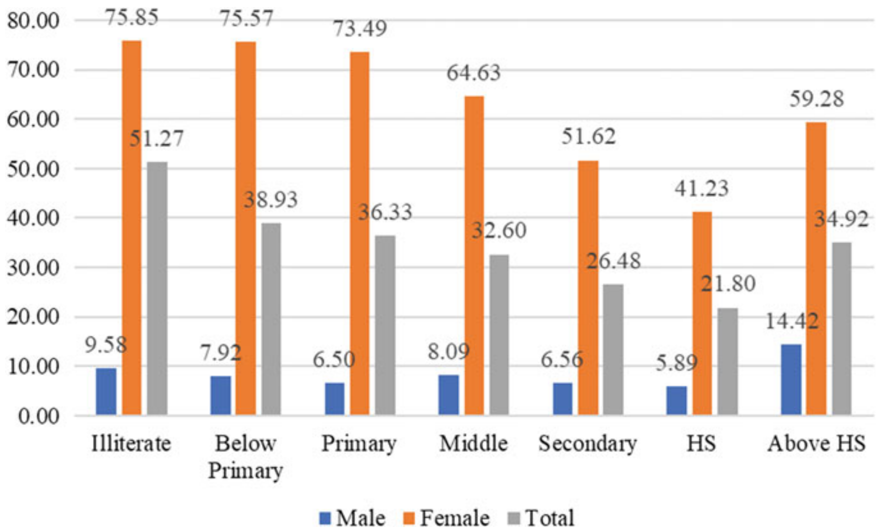

Fig. 14.1 Percentage NEET 1 by education level, 2004–05. *Source* Estimated from data

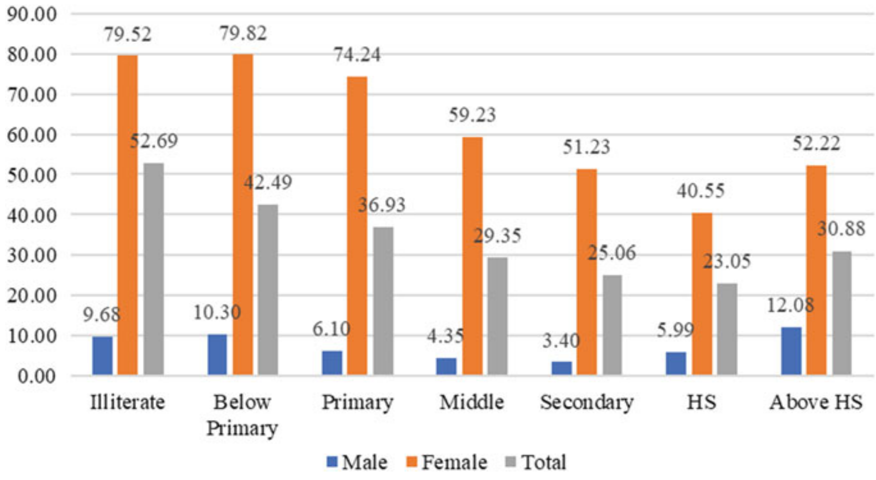

Fig. 14.2 Percentage NEET 1 by education level, 2011–12. *Source* Estimated from data

between the reservation and actual wages being received by the individual (Genda, 2007).

The picture changes dramatically, when we consider Type 2 definition of NEET (Figs. 14.3 and 14.4). The first thing we note is that across the two rounds, the NEET percentages have fallen significantly from around 50% to a maximum of, slightly less than 15%. Also, now the females are performing better across all the education levels and the two rounds. This is again due to the fact that we are treating the domestic house workers as "employed," and majority of these workers are female. But, we

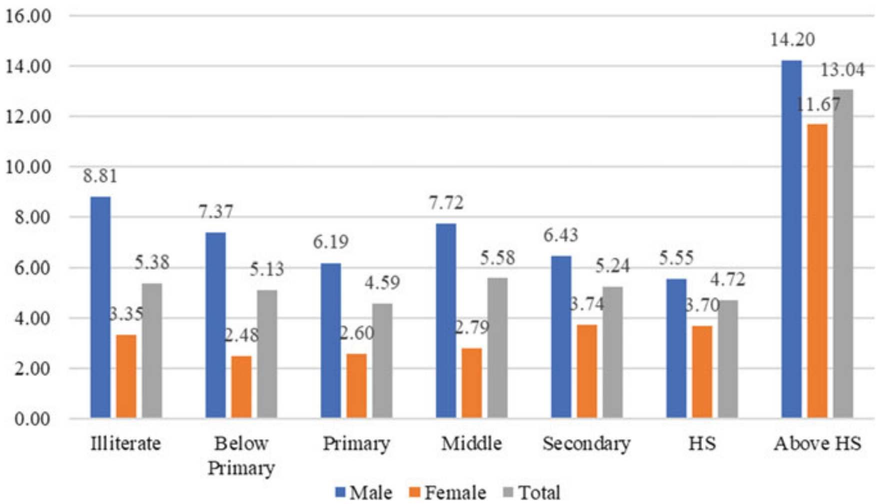

Fig. 14.3 Percentage NEET 2 by education level, 2004–05. *Source* Estimated from data

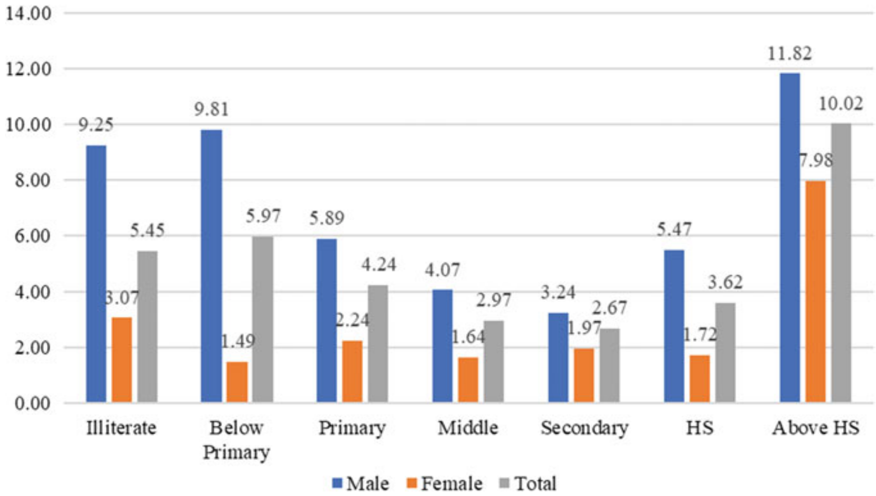

Fig. 14.4 Percentage NEET 2 by education level, 2011–12. *Source* Estimated from data

note that the difference between the proportions of NEET in males and females never exceeds 10%, unlike Type 1 results. The reservation wage effect holds in this case as well.

14.5.2.2 Socio-religious Community

The gender bias is clearly visible even when we consider the NEET proportions across socio-religious communities, across the two rounds. We get a somewhat counter-intuitive result in both the rounds. In 2004–05, the Hindu scheduled caste, the Hindu OBC and the Muslim population had higher proportions of NEET as compared to the Hindu forward cast (Fig. 14.5).

However, the Muslims, STs and the others perform better than the Hindu forward caste in terms of both the female and male population (Fig. 14.6). In 2011–12, the picture roughly remains the same. However, we note that, when only the male sub-population is concerned, the Hindu OBCs are actually better off than the Hindu forward caste, even if they are worse-off overall (Fig. 14.6).

Like in the case of education level, here as well the gender bias has been reversed across all the socio-religious categories. Additionally, the proportions of NEET have fallen as compared to Type 1 definition. In 2004–05, the scheduled caste, Muslims and the others are worse-off as compared to the Hindu forward caste (Fig. 14.7).

In 2011–12, more or less similar picture holds apart from the fact that now the women in the Hindu scheduled caste group are better off than their Hindu forward caste counterparts, indicating there have been no significant demographic shifts as compared to 2004–05 across the various socio-religious communities as far as NEET proportions are concerned (Fig. 14.8).

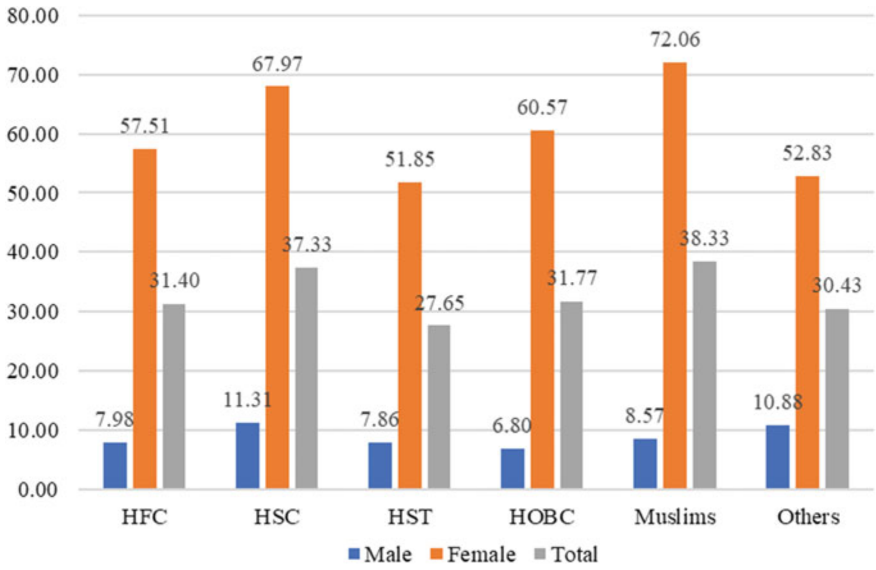

Fig. 14.5 Percentage NEET 1 by socio-religious class, 2004–05. *Source* Estimated from data

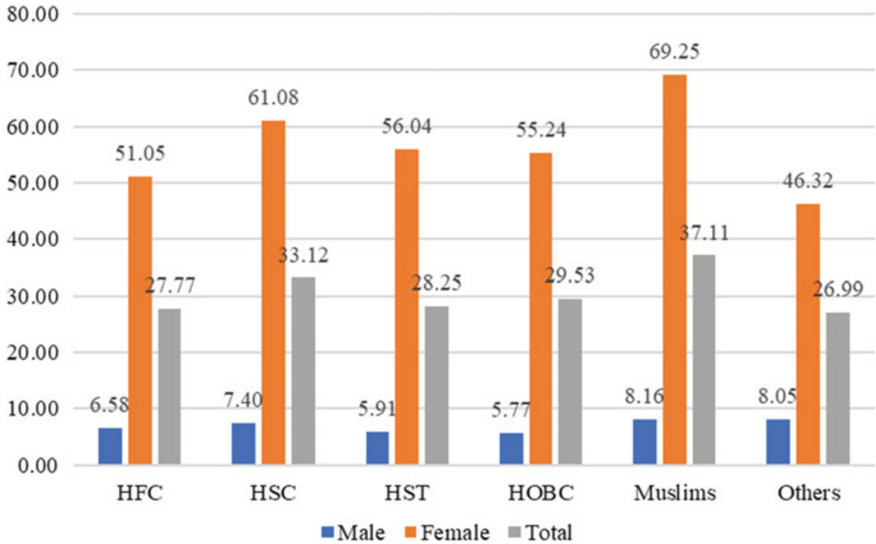

Fig. 14.6 Percentage NEET 1 by socio-religious class, 2011–12. *Source* Estimated from data

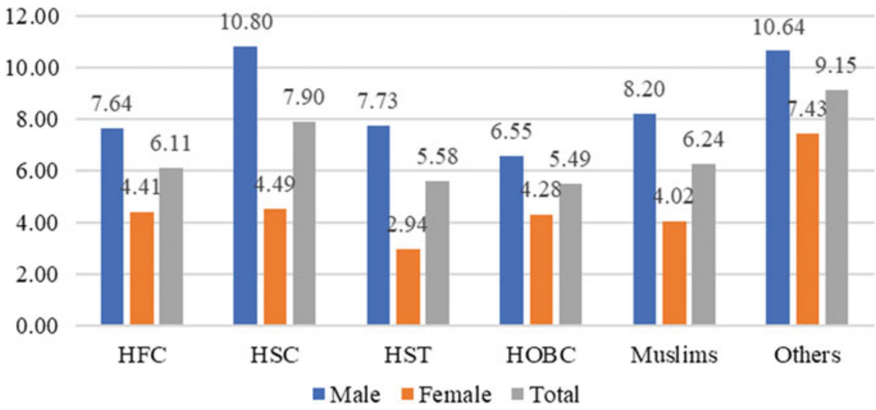

Fig. 14.7 Percentage NEET 2 by socio-religious community, 2004–05. *Source* Estimated from data

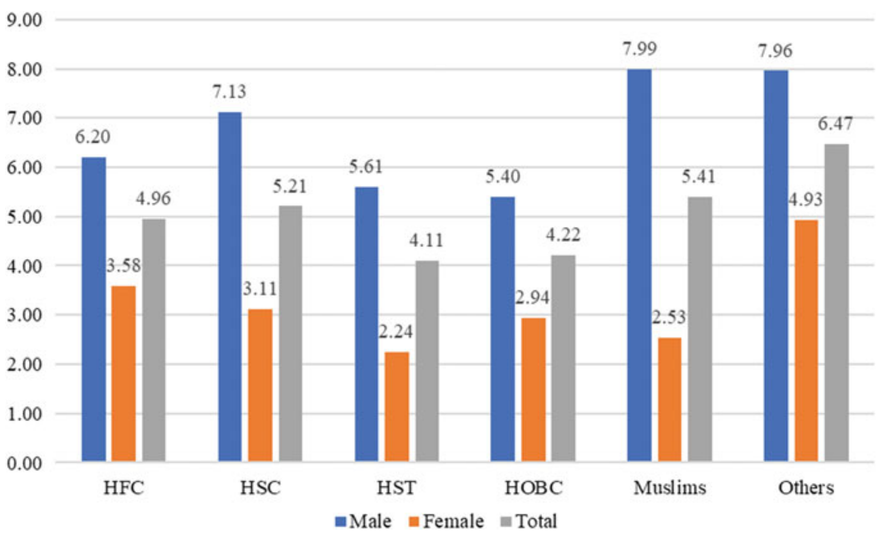

Fig. 14.8 Percentage NEET 2 by socio-religious community, 2011–12. *Source* Estimated from data

14.5.2.3 Age Cohort

For Type 1 definition, we observe that for the females as they belong to a higher age cohort, it is more likely that they will remain as NEET (Fig. 14.9).

One possible explanation for this might be the fact that, as people get older, they lose motivation and are likely to stay unemployed if they do not find a suitable opportunity.

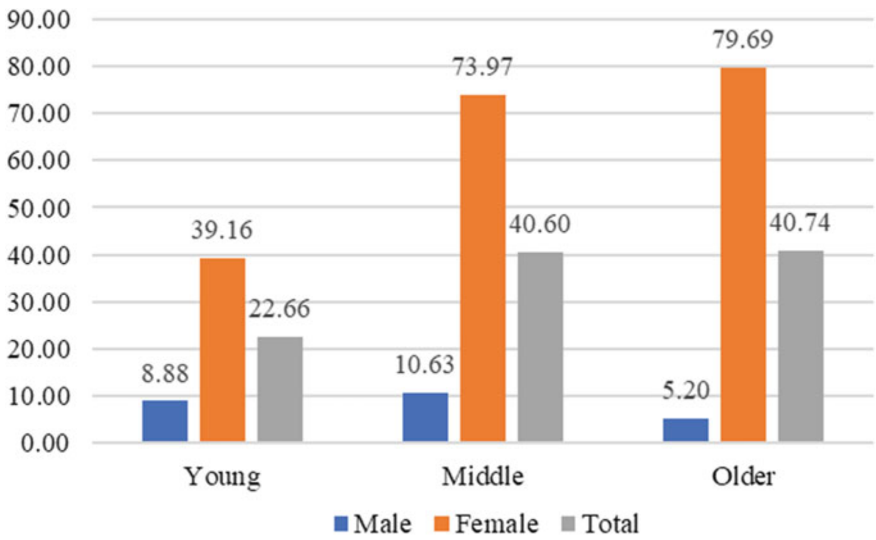

Fig. 14.9 Percentage NEET 1 by age cohort, 2004–05. *Source* Estimated from data

For the males, however, the proportion of NEET falls as they get older. This is because of the fact that older men are more likely to have responsibilities of sustaining a family. Hence, they are more likely to be engaged in something productive. Again, the proportion of NEET is higher among the females as compared to the males (Figs. 14.9 and 14.10).

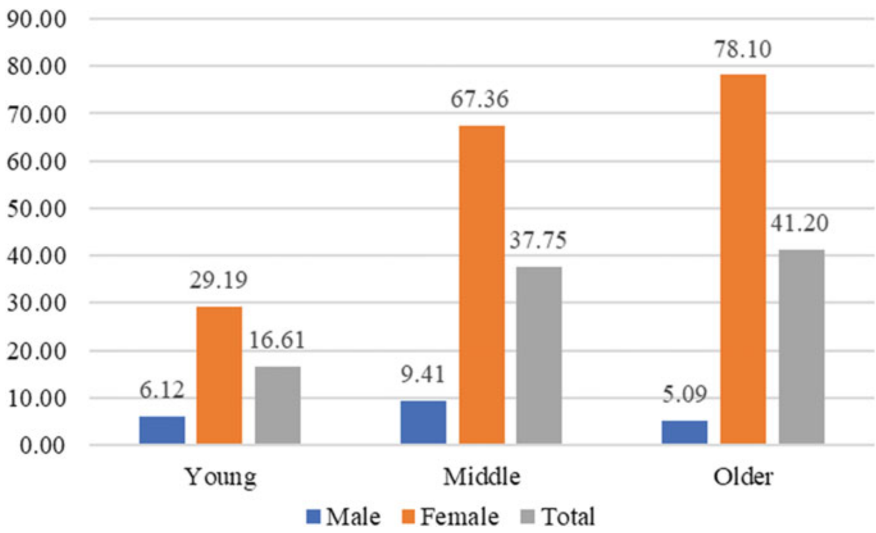

Fig. 14.10 Percentage NEET 1 by age cohort, 2011–12. *Source* Estimated from data

For Type 2 definition, we find that the proportion of NEET is the highest among the middle-age population for both the males and females (Fig. 14.11).

The women have a lower proportion of NEET in the older population (Fig. 14.12), because of the fact that many of them are getting married and may be are being forced out of the labor market. In Type 1 definition, these domestic workers were being treated as NEET. However, now, they are being treated as non-NEET, and hence, we get the fall in the proportion among the older sub-samples.

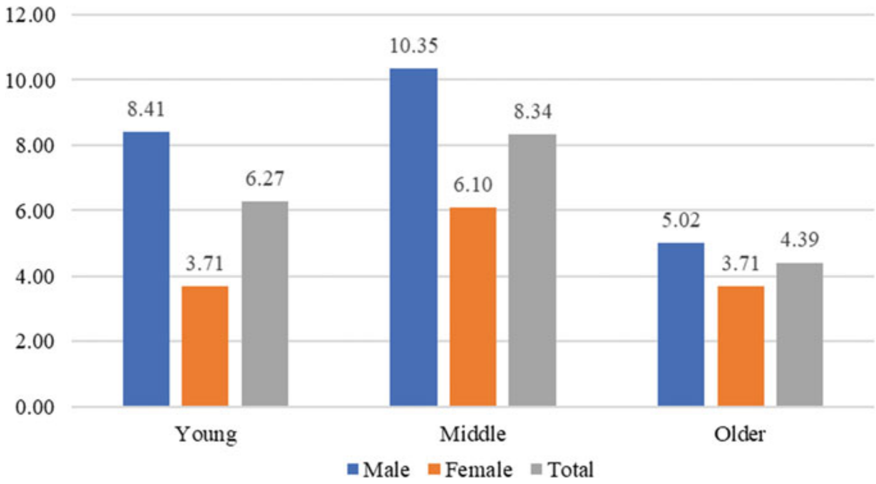

Fig. 14.11 Percentage NEET 2 by age cohort, 2004–05. *Source* Estimated from data

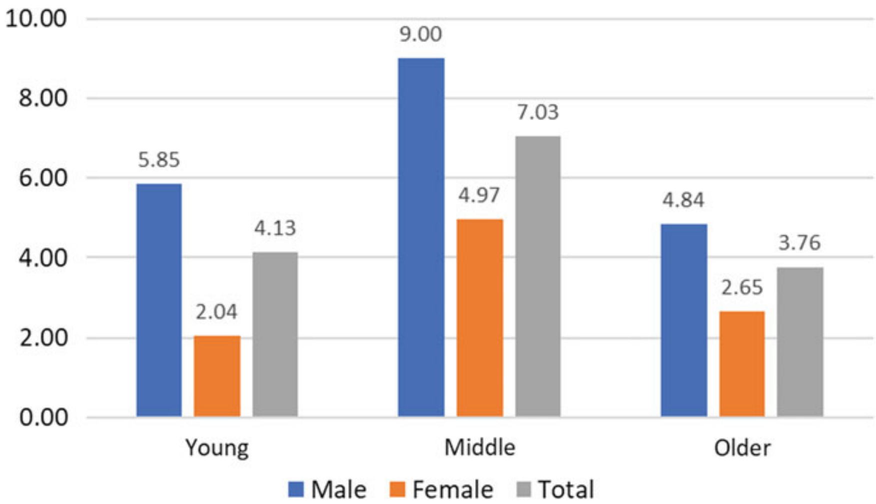

Fig. 14.12 Percentage NEET 2 by age cohort, 2011–12. *Source* Estimated from data

14.5.2.4 Marital Status

The interesting result that we note here is that the magnitude of difference between the NEET proportions shoots up significantly when we consider the currently married group as compared to the never married or the widowed/divorced/separated group (Figs. 14.13 and 14.14).

This confirms the existence of a severe marriage penalty (de Hoon et al. 2014) in India. That is, to say that as women are getting married, they are being forced out of the labor market and are getting engaged in domestic household work.

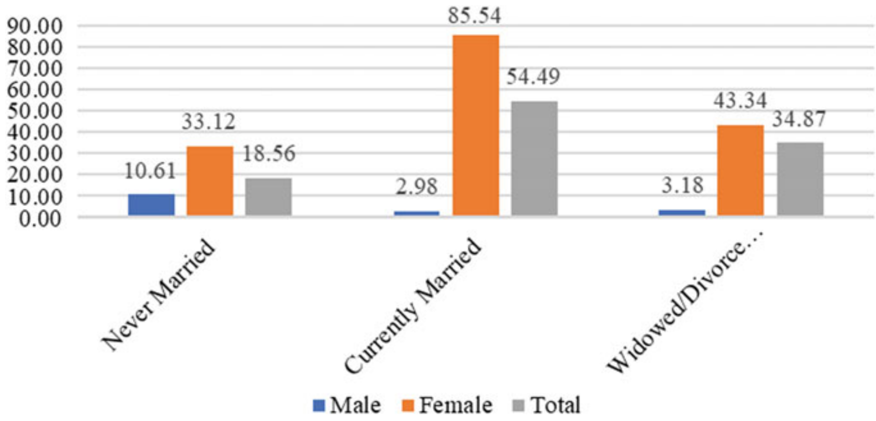

Fig. 14.13 Percentage NEET 1 by marital status, 2004–05. *Source* Estimated from data

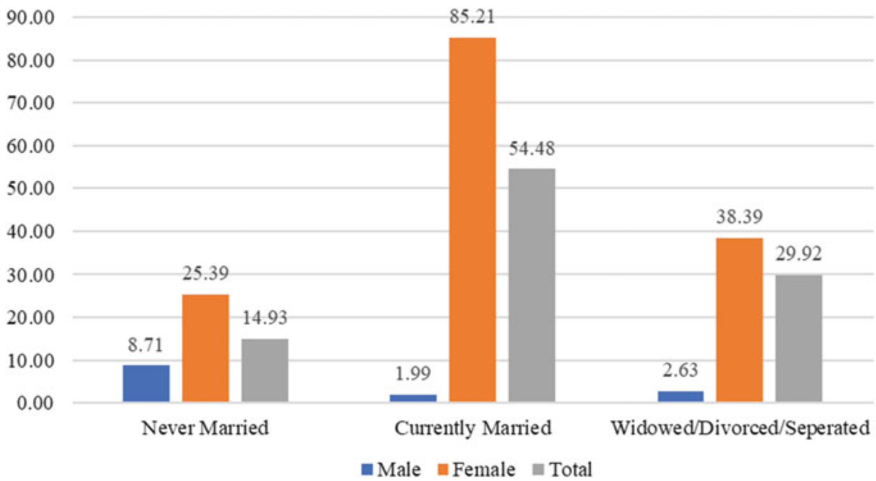

Fig. 14.14 Percentage NEET 1 by marital status, 2011–12. *Source* Estimated from data

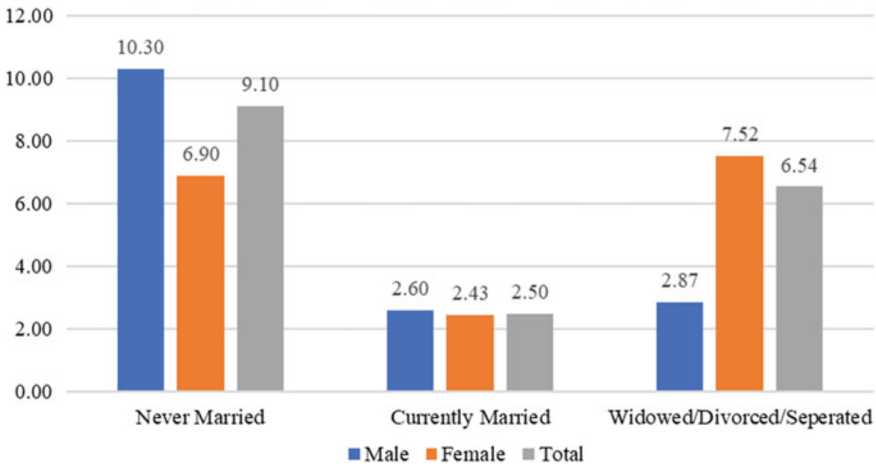

Fig. 14.15 Percentage NEET 2 by marital status, 2004–05

However, as per the stereotypical gender roles, the males are expected to sustain a family once they are married. This can be seen from the significantly lower proportions of NEET in the currently married group for both the years (Figs. 14.13 and 14.14).

The picture changes dramatically for Type 2 definition. Because of the existence of the marriage penalty and the engagement of women in household work, the NEET proportions drop sharply for the currently married group. So much so that, the proportions drop below that of the males. The NEET proportions rise somewhat for the widowed/divorced/separated population. This can be attributed to the presence of family support which means that the individuals themselves are not engaged in anything productive. These results hold for both the rounds (Figs. 14.15 and 14.16).

14.5.3 Determinants of NEET

14.5.3.1 Aggregate Sample

In this section, we interpret the odd ratios of the logistic regression which was run on the entire sample.

The first thing to note here is that the females are almost 100 times likely to be a NEET as compared to the males in the first round and Type 1 definition (Table 14.5). The odds ratio rises even further in the second round. However, for Type 2 since the domestic workers are predominantly female, the odds ratio falls below 1 and is significant at 1% level in both the rounds. For both the currently married group and the widowed/divorced/separated group, the odds of being a NEET as compared to the unmarried group are less than 1 across the two definitions and across the

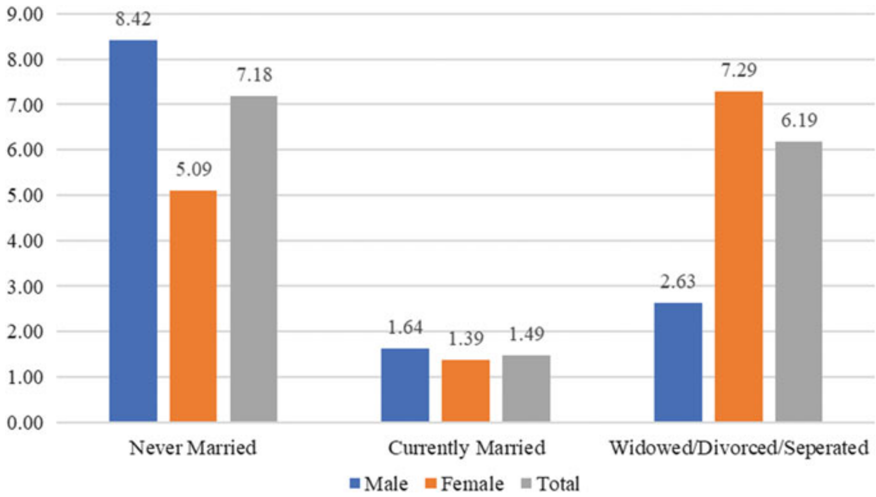

Fig. 14.16 Percentage NEET 2 by marital status, 2011–12. *Source* Estimated from data

two rounds. This can be explained by the fact that the individuals in these groups are expected to sustain themselves without any family support and, hence, more likely to be employed or at least be engaged in some other productive activity, say education. For Type 1 definition, the odds of being a NEET is as high as 94 in both the rounds are significantly higher for the currently married as compared to the never married female group. The odds are significantly lower for the widowed/divorced/separated population as compared to the never married female population for both the rounds and both definitions. For Type 2 definition, however, the odd ratios fall to around for both the rounds. This is again because of the fact that the household workers are being treated as non-NEET in this definition. For higher education levels, the odds of being a NEET as compared to the illiterate population fall smoothly and jump up only at the highest education level. However, for Type 2 definition, the odds remain always less than 1, indicating that as compared to the illiterate population, the odds of being a Type 2 NEET are always lower for any other education level. The jump at the highest education level can be explained by the reservation wage effect (Genda, 2007). The odds of being a NEET vis-à-vis a non-NEET are always greater than 1 for increasing log of household monthly per capita expenditure. Thus, the more affluent the household is, the odds move in favor of being a NEET. This has been termed as the "income effect" (Genda, 2007). This possibly means the NEET comprises of unproductive people who do nothing all day and are being supported or protected by their families financially. However, we see that the odds move against being a NEET for the female population with increasing log of household per capita expenditure indicated by the <1 odds ratio in majority of the cases for the protection variable. Thus, there exists no such income effect for the women. The odds move in favor of being a NEET with increasing age. Finally, we observe that in almost all backward communities across the two definitions and the two rounds, the odds of

Table 14.5 Odd ratios and *p*-values considering the aggregate sample

Variable	NSS61-NEET 1		NSS68-NEET 1		NSS61-NEET 2		NSS68-NEET 2	
	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$
Sex								
Female	99.443	0	184.909	0	1.710	0	0.222	0
Marital status								
Currently married	0.184	0	0.127	0	0.190	0	0.127	0
Widowed/divorced/separated	0.181	0	0.152	0	0.205	0	0.220	0
Marital status#sex								
Currently married#female	51.579	0	93.149	0	1.355	0	1.366	0
Widowed/divorced/separated #female	5.368	0	4.804	0	4.244	0	3.665	0
General education level								
Below primary	1.224	0	1.375	0	0.649	0	0.834	0
Primary	1.231	0	1.048	0	0.569	0	0.584	0
Middle	1.147	0	0.831	0	0.607	0	0.370	0
Secondary	0.854	0	0.656	0	0.587	0	0.326	0
HS	0.609	0	0.546	0	0.500	0	0.394	0
Above HS	1.201	0	0.794	0	1.833	0	1.176	0
lmpce	1.705	0	1.830	0	1.140	0	0.898	0
Protection	0.698	0	0.661	0	0.890	0	1.117	0
Age	1.046	0	1.075	0	1.022	0	1.053	0
Socio-religious community								
HSC	1.629	0	1.306	0	1.733	0	1.256	0

(continued)

Table 14.5 (continued)

Variable	NSS61-NEET 1		NSS68-NEET 1		NSS61-NEET 2		NSS68-NEET 2	
	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$
HST	0.716	0	0.892	0	1.071	0	1.000	1
HOBC	1.086	0	1.004	0	1.080	0	0.902	0
Muslims	1.946	0	1.920	0	1.311	0	1.168	0
Others	1.164	0	1.117	0	1.468	0	1.219	0
State	Yes		Yes		Yes		Yes	
Model statistics								
N	63600		53699		63600		53699	
Pseudo R-square	0.353		0.380		0.110		0.130	
Chi^2	4.22E + 07		5.60E + 07		4.49E + 06		5.16E + 06	
$P > CHI^2$	0.000		0.000		0.000		0.000	

Source Estimated from data

being a NEET are higher as compared to the Hindu forward caste. Only the Hindu STs perform better as compared to the Hindu forward caste when NEET 1 is concerned (Table 14.5).

14.5.3.2 Male Sub-sample

Now, we consider the odd ratios for only the male sub-population (Table 14.7).

The odds of being a NEET vis-à-vis a non-NEET are lower for both the currently married and the widowed/divorced/separated males as compared to the never married group. This is because of the fact that these individuals are more likely to be sustaining themselves and, hence, more likely to be non-NEET. Across the two rounds and the two NEET types, the odds of being a NEET are lower for all education levels as compared to the illiterate group. The odds are higher only for the above HS group. This can again be explained by the reservation wage effect (Genda, 2007). There is a clear indication of income effect for the males as indicated by the >1 odd ratios of the log of monthly per capita expenditure. With increasing age, the odds always move in favor of being a NEET. Apart from the Hindu OBC population in the second round, all other backward groups have higher odds of being a NEET as compared to the Hindu forward caste (Table 14.6).

14.5.3.3 Female Sub-sample

Finally, we consider the odd ratios for the female sub-population.

We observe that the odds move in favor of being a NEET for the female sub-population for the currently married group as compared to the never married group for Type 1 definition. However, for Type 2 definition, the odds move against being a NEET. This is a clear indication of the fact that women are being forced out of the labor market on getting married. However, the widowed/divorced/separated females have to support themselves and, hence, less likely to be NEET as compared to the never married group. As the education level rises, the odds of being a NEET fall smoothly until we reach the highest education level. Thus, the reservation wage effect holds for the women as well (Table 14.7). However, we must note that the odds of being a NEET for the males, for higher education levels, were always lower than that of the illiterate population except for the highest education level (Table 14.6). But for the women, even though the odds stay below 1 for the highest level of education at least for NEET 1 definition (Table 14.7).

Table 14.6 Odd ratios and p-values considering the male sub-sample

	NSS61-NEET 1		NSS68-NEET 1		NSS61-NEET 2		NSS68-NEET 2	
	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$
Marital status								
Currently married	0.224	0.000	0.165	0.000	0.195	0.000	0.138	0.000
Widowed/divorced/separated	0.214	0.000	0.247	0.000	0.192	0.000	0.252	0.000
Education level								
Below primary	0.648	0.000	1.010	0.001	0.654	0.000	1.010	0.002
Primary	0.513	0.000	0.617	0.000	0.534	0.000	0.628	0.000
Middle	0.582	0.000	0.426	0.000	0.608	0.000	0.424	0.000
Secondary	0.483	0.000	0.322	0.000	0.523	0.000	0.328	0.000
HS	0.396	0.000	0.524	0.000	0.412	0.000	0.507	0.000
Above HS	1.301	0.000	1.196	0.000	1.415	0.000	1.252	0.000
lmpce	1.134	0.000	1.051	0.000	1.091	0.000	1.029	0.000
Age	1.005	0.000	1.035	0.000	1.011	0.000	1.037	0.000
Socio-religious community								
HSC	1.892	0.000	1.355	0.000	1.908	0.000	1.409	0.000
HST	1.085	0.000	1.068	0.000	1.142	0.000	1.089	0.000
HOBC	1.049	0.000	0.939	0.000	1.062	0.000	0.940	0.000
Muslims	1.327	0.000	1.300	0.000	1.367	0.000	1.385	0.000
Others	1.574	0.000	1.279	0.000	1.644	0.000	1.365	0.000
State	Yes		Yes		Yes		Yes	
Model statistics								

(continued)

Table 14.6 (continued)

	NSS61-NEET 1		NSS68-NEET 1		NSS61-NEET 2		NSS68-NEET 2	
	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$
N	63600		53699		63600		53699	
Pseudo R-square	0.080		0.140		0.090		0.170	
Chi^2	2.11E + 06		2.81E + 06		2.19E + 06		2.94E + 06	
$P > CHI^2$	0.000		0.000		0.000		0.000	

Source Estimated from data

Table 14.7 Odd ratios and *p*-values considering the female sub-sample

	NSS61-NEET 1		NSS68-NEET 1		NSS61-NEET 2		NSS68-NEET 2	
	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$
Marital status								
Currently married	8.891	0.000	11.550	0.000	0.188	0.000	0.115	0.000
Widowed/divorced/separated	0.841	0.000	0.637	0.000	0.698	0.000	0.555	0.000
Education level								
Below primary	1.592	0.000	1.585	0.000	0.477	0.000	0.402	0.000
Primary	1.873	0.000	1.427	0.000	0.541	0.000	0.527	0.000
Middle	1.528	0.000	1.107	0.000	0.439	0.000	0.279	0.000
Secondary	1.032	0.000	0.859	0.000	0.592	0.000	0.338	0.000
HS	0.671	0.000	0.568	0.000	0.526	0.000	0.223	0.000
Above HS	0.939	0.000	0.623	0.000	2.374	0.000	1.017	0.000
lmpce	0.861	0.000	0.856	0.000	0.779	0.000	1.038	0.000
Age	1.074	0.000	1.094	0.000	1.068	0.000	1.115	0.000
Socio-religious class								
HSC	1.482	0.000	1.319	0.000	1.377	0.000	0.939	0.000
HST	0.605	0.000	0.815	0.000	0.775	0.000	0.770	0.000
HOBC	1.077	0.000	1.030	0.000	1.077	0.000	0.790	0.000
Muslims	2.532	0.000	2.463	0.000	1.171	0.000	0.775	0.000
Others	0.975	0.000	1.056	0.000	1.243	0.000	0.881	0.000
State	Yes		Yes		Yes		Yes	
Model statistics								

(continued)

Table 14.7 (continued)

	NSS61-NEET 1		NSS68-NEET 1		NSS61-NEET 2		NSS68-NEET 2	
	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$	Odds ratio	$P > z$
N	63600		53699		63600		53699	
Pseudo R-square	0.10		0.15		0.09		0.19	
Chi^2	1.38E + 07		2.24E + 07		2.72E + 06		2.36E + 06	
$P > CHI^2$	0.00		0.00		0.00		0.00	

Source Estimated from data

14.5.4 Marginal Effects

In this section, we look at the predicted probability of being a NEET across the two rounds and across the two definitions for the various socio-religious communities.

14.5.4.1 Change in Probability as Compared to Hindu Forward Caste

We observe that the Hindu scheduled caste population always has a higher probability of being a NEET, as compared to the Hindu forward caste as indicated by the negative value of the change in probability. Similarly, the Muslims and the other minorities always have a higher probability of being a NEET. However, the Hindu scheduled tribes and the Hindu other backward classes have a lower probability of being a NEET in most cases as compared to the Hindu forward caste. Only in Round 2 and definition of NEET Type 2, the female sub-groups of the Hindu scheduled tribes have a higher probability of being a NEET as compared to the Hindu forward caste (Tables 14.7 and 14.8).

14.5.4.2 Change in Probability with Changing Household Affluence

We observe that across both the rounds, as per NEET 1 definition, the probability of being a NEET rises for all socio-religious categories with increasing log of monthly household per capita expenditure. Thus, the income effect which we noted earlier (Table 14.5) is clearly visible here (Figs. 14.17 and 14.18).

Also, we note that across the two rounds, the Muslims have the highest probability of being NEET 1 as compared to the other groups for all levels of log of monthly household per capita expenditure.

On the other hand, the Hindu scheduled tribes have the lowest probabilities of being NEET, with the Hindu forward caste lying somewhere in between (Figs. 14.17 and 14.18). We found a similar result from Table 14.6.

For NEET 2 definition, however, the picture is dramatically different from Type 1. In the second round, there is a presence of clear income effect (Figs. 14.19 and 14.20).

But, in the first round as the log of household monthly per capita income rises, the probability of being NEET 2 falls for all socio-religious categories. In 2004–05, the Hindu OBCs have the least probability of being NEET 2 and the Hindu scheduled castes have the highest probability. In 2011–12, however, the Hindu forward caste population performs the best having the least probability of being NEET 2, but the Hindu scheduled caste group still bags the top spot (Figs. 14.19 and 14.20).

Table 14.8 Change in probability of NEET across socio-religious communities

	NSS61-NEET 1			NSS68-NEET 1			NSS61-NEET 2			NSS68-NEET 2		
sex	*HFC*	*SC*	*Change*	*HFC*	*SC*	*Change*	*HFC*	*SC*	*Change*	*HFC*	*SC*	*Change*
Male	0.015	0.021	−0.006	0.005	0.006	−0.001	0.046	0.069	−0.021	0.042	0.05	−0.008
Female	0.863	0.9	−0.039	0.905	0.922	−0.017	0.046	0.069	−0.021	0.024	0.029	−0.005
sex	*HFC*	*ST*	*Change*	*HFC*	*ST*	*Change*	*HFC*	*ST*	*Change*	*HFC*	*ST*	*Change*
Male	0.014	0.009	0.007	0.004	0.003	0.001	0.057	0.056	0.001	0.014	0.014	0
Female	0.86	0.788	0.062	0.932	0.919	0.013	0.042	0.041	0	0.079	0.08	−0.001
sex	*HFC*	*OBC*	*Change*	*HFC*	*OBC*	*Change*	*HFC*	*OBC*	*Change*	*HFC*	*OBC*	*Change*
Male	0.021	0.019	0.002	0.008	0.007	0.001	0.028	0.027	0	0.031	0.03	0.002
Female	0.797	0.78	0.017	0.859	0.849	0.01	0.084	0.083	0.001	0.034	0.032	0.002
sex	*HFC*	*Muslims*	*Change*	*HFC*	*Muslims*	*Change*	*HFC*	*Muslims*	*Change*	*HFC*	*Muslims*	*Change*
Male	0.005	0.008	−0.003	0.002	0.003	−0.001	0.04	0.046	−0.007	0.02	0.025	−0.005
Female	0.952	0.971	−0.021	0.965	0.982	−0.017	0.056	0.065	−0.009	0.054	0.067	−0.013
sex	*HFC*	*Others*	*Change*	*HFC*	*Others*	*Change*	*HFC*	*Others*	*Change*	*HFC*	*Others*	*Change*
Male	0.014	0.014	0	0.004	0.004	0	0.045	0.067	−0.019	0.013	0.016	−0.003
Female	0.854	0.858	−0.004	0.923	0.923	0.001	0.054	0.079	−0.022	0.094	0.111	−0.017

Source Estimated from data

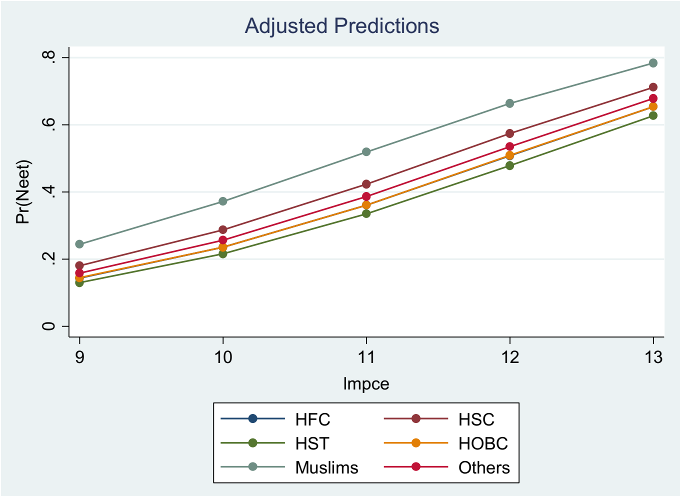

Fig. 14.17 Change in probability of being NEET 1, 2004–05. *Source* Estimated from data

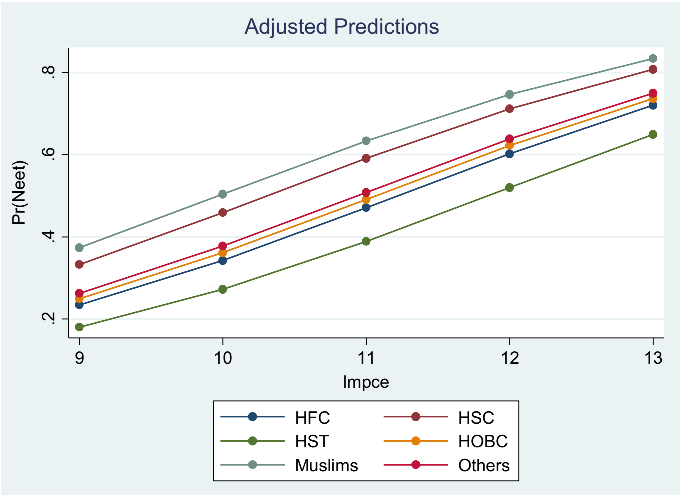

Fig. 14.18 Change in probability of being NEET 1, 2011–12. *Source* Estimated from data

14.5.5 Costs

Finally, we consider the costs of NEET. Even though we noted earlier (Table 14.4) that the proportion and the absolute number of NEET have fallen from 2004–05 to 2011–12, we see the cost of being NEET has actually risen significantly as a proportion of GDP by above four percentage points over the study period (Table

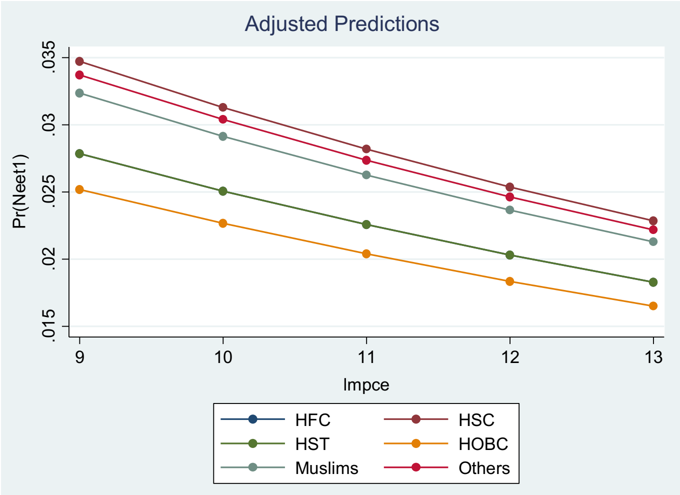

Fig. 14.19 Change in probability of being NEET 2, 2004–05. *Source* Estimated from data

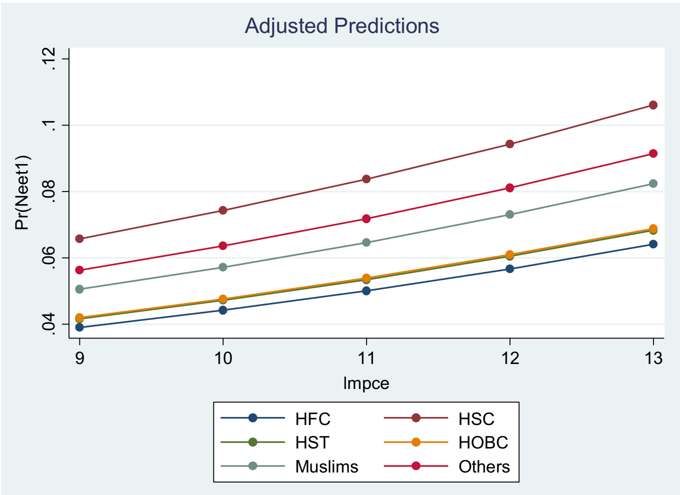

Fig. 14.20 Change in probability of being NEET 2, 2011–12. *Source* Estimated from data

14.9). The income loss to the individuals as a consequence of being a NEET in both the years exceeds the entire GDP of many smaller countries.

Here, we would like to reiterate the fact that NEET consists of not only the unemployed, but also the individuals who are not engaged in any sort of productive

Table 14.9 Costs of NEET

	Loss in rupees crores	Percentage of GDP
2004–05	33,216.08	1.38
2011–12	354,470.55	6.76

Source Estimated from data

or skill developing activity. Hence, the sheer size of the problem rings the alarm bells, and decisive action is required without any further delay.[2]

14.6 Conclusion

The proportion of NEET in India turned out to be about 34% in 2004–05 and fell to about 31% in 2011–12 by the most pessimistic estimate (NEET 1). By, the most optimistic estimate (NEET 2), the proportions were about 7% in 2004–05 and 5% in 2011–12. The absolute number of NEET 1 turned out to be around 11 crores in both the rounds and about 2 crores for NEET 2. Thus, incidence of NEET in India exceeds the entire population of many larger nations. However, it was found that both the proportion and the absolute number of NEET fell from 2004–05 to 2011–12. This gave us cause for some optimism.

We further found in the study that marital status, education level, gender, age and socio-religious community of the respondent were all significant determinants of the individual being a NEET. We found that the incidence of NEET is much higher among the women as compared to the men for NEET 1 definition. However, the situation is completely reversed for NEET 2 definition. This situation was confirmed both by the proportions of NEET and by the corresponding values of the odds ratios in the econometric analysis. This indicates to the fact that the majority of NEET 1 in the country are actually women who are engaged in household domestic work. It was further found that there exists a serious penalty for women who are getting married as indicated by the odds ratio of the interaction term between the marital status and female gender dummy. The odds moved in favor of being a NEET, for the currently married women as compared to the women who were not married. There was a clear presence of an "income effect," indicating that, with increasing family affluence, the odds moved in favor of being a NEET. This was also confirmed by the plot of probability of being a NEET vs. the log of monthly per capita household

[2] It should be noted that we are including two groups of people within NEET. They are persons engaged in illegal activities such as theft, or smuggling, or drug peddling all of which can prove to be quite financially rewarding. Unfortunately, there are no data on such activities as they are illegal, so that no one will own up to them. The second group comprises political party workers who get paid by the political party they belong to and are "allowed" to augment their legal incomes by bribes, hush money or cut-money. Joining politics is legal, so that part of the income earned by such grassroots full timers is legal. However, it is not considered to be an occupation, and NSSO does not give any figures for them. The inclusion of these two categories will reduce the estimate of NEET, so that our estimate of costs will be less than that stated in Table 14.9.

expenditure. This begs the question that, perhaps, the NEET comprises of unproductive individuals who are plain lazy and demotivated and are being supported by their families. However, we found that this "income effect" was present only for the males, since the odds ratio for the protection variable was all less than unity except in one case. This was also confirmed further from the separate male and female logistic regressions. The odds of being a NEET for the individuals belonging to various minority groups were mostly higher as compared to the Hindu forward caste. Only the Hindu scheduled tribes were better off in most cases. This was further confirmed by the marginal effects' analysis.

The optimism we found by looking at the fall in the incidence of NEET is extinguished quickly, when we looked at the aggregate income loss to the individuals as a result of them being a NEET. The costs rose from about 2% of the GDP to about 6% in a span of just seven years, and as noted earlier, this loss exceeded the entire GDPs of many smaller countries.

Standing in 2018, where the unemployment rates are at a historic high, we can safely presume that the incidence and the costs of being NEET have worsened further from 2011 to 2018. It is a high point for the researchers and the government to focus their attention to a more comprehensive measure of disengagement like NEET, instead of simply focusing on unemployment. NEET gives us an idea regarding the potential future levels of unemployment, since the NEET is not adding any significant skills currently. We hope that our paper can be a starting point which creates awareness regarding the issue of NEET and paves way for further analysis on the issue.

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Chapter 15
An Exploration into Inter-Generational Occupational Mobility in India: Evidences from IHDS-II

Prithviraj Guha and Nirban Roy

15.1 Introduction

It is a well-known and much researched fact that there exists a close relationship between economic development and occupational structure of a country. The per capita income of a country is positively related to the proportion of the working class employed in tertiary industries, i.e. higher the percentage of working class employed in tertiary industries, higher is the per capita income of a country—an indicator of the country's economic development. While studying the structural change in an economy, it becomes important to study, therefore, the occupational structure of the economy and how it has changed over the generations. So, to critically analyse the process of economic growth in a country, it is important to pay due attention to the evolution of its occupational structure. One of the ways to do so is to study the intergenerational occupational change or mobility. An upward occupational mobility across generations with more people entering the tertiary sector is desirable as it is likely to promote economic growth in the country. The study of occupational mobility is also important because it shows the availability and changes in the opportunities faced by the continuing workforce in the society (Tiwari, 2016).

In India, occupational mobility across generations, especially for the better, has historically suffered for numerous exclusionary social practices that blocked large sections of the population from access to education and better jobs. Occupation of the household head is the key determinant of the economic and social status of the household and occupation of an individual has a very important role in deciding his standard of living. Occupational choice of an individual is expected to be dependent on the educational status and wealth status of the family. In a country like India

P. Guha (✉)
Department of Economics, Presidency University, Kolkata, India
e-mail: prithvi.econ@presiuniv.ac.in

N. Roy
HSBC, Kolkata, India

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where the society has been historically known to be stratified into castes on the basis of occupation where an individual's occupation is fixed at birth with no room for innovation, current occupational choice is also likely to depend on caste and religion. Past evidences suggest that choice of occupation in India is sticky when we look at intergenerational occupational mobility. This can be linked to the lack of or inequality in opportunities where people cannot choose better occupations and are forced to adopt their parental occupation. So, when tens of millions of Indians remain mired in poverty even in the present time, it becomes important to analyse how the occupational structure across social groups have evolved vis-a-vis the previous generations'. The persistence or fluidity in the structure across groups, regions and over generations may well explain the success and failure of India's development experience. Hence this project.

It therefore becomes important to focus on the intergenerational occupational mobility of a country like India where there are so many axes of stratification and determine the key factors that contribute to this state and accordingly take necessary policy measures to promote upward mobility and hence growth of the country. Before proceeding with the work, we at first should look at first look into some of the prevailing literature and try to gain insights from it.

The objective of this paper is to first analyse the occupational mobility and persistence level across birth cohorts, zones and socio-religious communities. Next, we plan to find out the variation in the absolute rates of mobility over time for different occupational categories to get an idea of the intergenerational occupational mobility that was persistent in India. Thereafter, we will try to capture the variation in the Shorrock-Prais and Bartholomew Indexes for different occupational categories across zones, socio-religious communities and birth cohorts.

Following these, we plan to identify the different factors (indicators of social, economic and wealth status of family) that affect the intergenerational occupational mobility in India and also examine the extent of effect of these factors on the mobility. We also focus on how these factors have contributed to upward mobility from each specific occupational group, i.e. how these factors helped in moving to the higher levels of occupation for each occupational group. Doing so will help us identify the main causes of occupational mobility across generations and also enable us design factor targeted policies to promote upward mobility in general and from each occupation to increase the growth rates of the country.

With these being the primary objectives of the paper, we proceed by first discussing the relevant literature, discuss the dataset and the empirical strategy, present the exploratory and regression analyses and conclude by discussing the key findings of our study with a few policy prescriptions.

15.2 Literature Review

Though the body of academic work on intergenerational occupational mobility that exists at the international level, especially in the context of developed countries, until recently, it was not a very well researched area in the Indian context, perhaps because of unavailability of suitable datasets. The earliest work that has been done in the Indian context is by Driver (1962) where the focus was on the male household heads of the Nagpur district, and it found that intergenerational mobility was frequent among both rural and urban castes but confined to occupations of similar rank. On a similar regional theme, a more recent study by Deshpande and Palshikar (2008) focuses only on Pune city to look at intergenerational occupational mobility across different castes and uses both mobility matrix and regression techniques to infer that there is substantial upward mobility in aggregate and while caste does matter for upward mobility but, in general, occupational mobility across generations is not shaped by caste identity.

Tiwari (2016) focused on the factors behind this occupational mobility in Uttar Pradesh by using the database of a study conducted by Giri Institute of Development Studies in 2014–15 since NSS and IHDS data have their own limitations. But Tiwari has mentioned in his paper that the data he has used also has certain limitations because he survey conducted mainly includes Muslim OBCs and Dalits and fails to capture the full spectrum of the stratified Indian society. Just like in his previous works, he has also concluded that there is very little occupational mobility in Uttar Pradesh. The three main factors affecting the mobility are landholding, caste and education. Results showed that households with medium and low land have more odds in choosing parental education. The odds increase significantly for OBCs and SCs compared to the General category. Also, as the respondents level of education increases, the odds of choosing paternal education decreases significantly.

Though India has been historically known to be stratified into castes on the basis of occupation and caste has always been an important issue in determining various socio-economic and political dimensions, there has been very little work which focuses on the caste effect on intergenerational mobility, both educational and occupational, until the last decade. In recent years, a body of research has emerged which has emphasised the issue of social exclusion. Kumar et al. (2002a, 2002b) used the mobility matrix to discuss the caste and community roles in class mobility using National Election Study data of 1971 and 1996 from 80 to 108 parliamentary constituencies, respectively, across India. He concluded that there is more of stagnation rather than mobility. Surveys undertaken for identifying the behaviour patterns of the voter however did not pay enough attention to socio-economic, and hence, the quality of information on occupation and land ownership in these surveys was not very reliable. Thus, these inequalities could attribute to financial and other resource related factors also and not caste alone. Motiram and Singh (2012) used the IHDS-1 data (2005) to study intergenerational occupational mobility. They compute mobility matrices for different birth cohort, castes and sector (rural and urban) and find considerable occupational stagnation across all categories especially for low-skilled and low-paid workers, i.e. a substantial proportion of sons of low-skilled and low-paid workers remained in the same occupation as their fathers at the all India level, both rural and urban. Though comparison across castes gave ambiguous results, they found that downward mobility was more pronounced in lower castes compared to their high caste counterparts.

Another strain in the related literature has tried to link the issue of educational access to that of occupational mobility and have explored intergenerational occupational as well as education mobility simultaneously. Jalan and Murgai (2007) focused on educational mobility in India among the age group of 15–19 to look at inequalities in educational outcomes across different generations using the NHFS data for 1992–93 and 1998–99 and concluded that educational mobility has increased significantly over time (between 1992–93 and 1999–00) to match up to international standards. He also inferred that differences in mobility were more due to differences in socio-economic statuses rather than castes. An important limitation of their analysis is that, in the NHFS data, the respondents are not directly asked about their parents' education. Hence, parental education outcomes are generally known for children who live in the same household as their parents. As a result, they only focused on children aged 15–19 years who are more likely to be living with their parents. Majumder (2013) tried to determine levels of both intergenerational educational and occupational mobility separately for excluded castes and advanced castes in India and also studied the difference in gender wherever possible. He used the NSSO database on employment and unemployment for 50th and 61st rounds pertaining to the years 1993 and 2004. He also regressed the child's characteristic on parental characteristics and took income and other effects into consideration to study this mobility. He concluded that intergenerational upward mobility is moderate of for education and significantly low for occupation, especially for the excluded classes thereby inferring that educational mobility fails to get transformed to occupational mobility questioning the tradition of caste reservation in educational institutions.

Azam (2013) used the concept of Altham statistics which compared all possible odds ratios of mobility for different occupation categories across cohorts and castes in India. The work tried to distinguish between the effect of prevalence and association in context of mobility. Data from the first round of IHDS, conducted during 2004–05, was used to answer the research questions.

A work of a similar genre was conducted by Reddy and Swaminanthan (2014) where they wanted to focus on the intergenerational occupational mobility within villages. They studied the absolute intergenerational mobility for ten villages in India using the matrix mobility approach and calculated the odd ratios of mobility to compare it across the castes. The main finding of the paper is of low intergenerational occupational mobility in all the ten surveyed villages, especially among big farmers and rural manual workers, and this immobility among rural manual workers was more pronounced for Scheduled Castes than from Other Castes. Odds ratios were evident that downward mobility from any occupation to manual labour was higher for Scheduled Castes than for Other Castes thus inferring that it is more difficult for men from Scheduled Castes to come out of rural manual employment trap.

Iversen (2016) considered the IHDS-II dataset to study the occupational mobility and compare it with past historical results and also compare with for different castes. They used finer grained categorization that takes into account differences in skill levels across different occupations and examines both sharp and moderate occupational movements. They compare India with elsewhere and also link the movements to social identity and urban location. They conclude that there are vast differences in upward mobility of rural versus urban residents and upper-caste Hindus versus Scheduled Castes and Scheduled Tribes. Additionally, prospects of downward mobility are large, larger among rural residents and among Scheduled Castes and Scheduled Tribes.

Thus, we can see from the literature review that little work has been done on upward occupational mobility and towards the search for the factors that affect mobility, so that targetted policies could be designed. Hence, this paper focuses on these issues and exploit the availability of the information rich IHDS-II dataset.

15.3 Dataset

We use the data from the Indian Human Development Survey (IHDS) II, 2011 that was completed in 2011–12 covering 42,152 households in 1,420 villages and 1,042 urban neighbourhoods in all states and union territories in India except Andaman/Nicobar and Lakshadweep. 83% of the data are re-interviews of households who were interviewed for IHDS-I in 2004–05. The survey was conducted under the supervision of National Council for Applied Economic Research (NCAER) in collaboration with the University of Maryland. A two-stage stratified sampling design was followed to draw a sample consisting of 27,579 rural households (in 1,420 villages) and 14,573 urban households (in 1,042 urban blocks).

The IHDS data offers some unique advantages in context of a study on intergenerational occupational mobility over the other available datasets. For example, the NSS surveys data has the information on the occupation of the individual and his or her relationship with the head of the individual. Using these two data, it can be attempted to find the parental occupation of each individual. However, the process is limited to the fact that it is only valid when the individual and his/her parents live in the same household, and the parent is the head of the family. Hence, the cases of specific groups like the urban elites, who mostly live in nuclear families, will be underrepresented in the study and conversely regions or groups who have a lesser probability of belonging to such extended families will be systematically overrepresented.

Secondly, the NSS reports the current occupation of an individual and not the primary occupation (i.e. the occupation in which the person was employed for the most of his life). The IHDS, on the contrary, provides data on the *primary* occupation of the parent of each individual who is the head of the household. For every individual who is not the head of the household, there exists an indirect way to find out his parental occupation. The survey reports the relationship of that individual with the head of the household. For example, for every individual, who is the son or daughter of the head of the household, his parental occupation is nothing but the occupation of the head. Despite these advantages, this data suffers from some disadvantages too. Since in India married women live in their husbands' household, this indirect method cannot be used to find their parental occupation. Secondly, for women who are head of their respective households, the survey reports the occupation of their husbands instead of their fathers. Hence, we claim that this study complements the other studies which were conducted using different datasets and is in no way a substitute.

15.4 Empirical Strategy

15.4.1 Data Mining

We at first merge the individual dataset to the household dataset of IHDS-II. Then we take the entire male population of the age group 16–65 years as that is the working population of India. Thereafter, we also remove the fathers, mothers and spouses who have separated or are deceased and proceed with the dataset where the fathers, mothers and the spouses live in the households. We then link the son's ID to his father's ID who live in the household. Similarly, we also do it for the mothers and the spouses. When the head of the household is male, we get the information of the father and the son directly after merging. In case the head of the household is a female, we merge the son's information with their mother's, then we merge the mother's information with their spouse's information and hence we get the information of the father and son of that household. We consider the wage/salaried workers (WS4 variable) and the people who are self-employed in their own business (NF1B variable) as the occupation variables of the son. A person who is not classified in either of the two variables is classified as a farmer. We take the head of the household's information as the son's occupational information. We then record the two variables into four main categories: White collar, skilled/semi-skilled, unskilled and farming into a variable called 'rocc' which gives us occupation of the son. There are 99 occupational codes in the IHDS dataset. We have clubbed the occupations according to the Indian National Classification of Occupations (NCO, 2015). The National Classification of Occupations is based upon a categorisation scheme which is endorsed by ILO and is suitably adjusted for the Indian employment conditions. It divides the workers into ten different categories. The ten major groups are:

1. Legislators, senior officials and managers
2. Professionals
3. Technicians and associate professionals
4. Clerks
5. Service workers and shop and market sales workers
6. Skilled agricultural and fishery workers
7. Craft and related trades workers
8. Plant and machinery operators and assemblers

9. Elementary occupations
10. Armed forces.

Now we know that the NCO groups people on the basis of the similarity of work that they perform. It can also be interpreted as classifying the workers based on skill or status. For example, the senior officials have a higher status than the professionals who in turn have a higher status than the technicians and the clerks. In our analysis, we could have used all the categories but that would result into many groups and could well lead to mobility in less number of cases. In order to simplify the matter, we have divided the workers into the following groups: White collar, skilled/semi-skilled, unskilled and farming. The head's father's occupation variable is a categorical variable given by ID18A. Then we again aggregate the occupation into four main categories: White collar, skilled/semi-skilled, unskilled and farming and construct the variable ID18A. In the case where the head of the household is female, we merge the occupation information of the spouse of the mother to their sons. Now as brother of the head has the same father, head's father's occupation is also the head's brother's father's occupation. We then merge the head's father's occupation to the brother's father's occupation. After linking the father's occupational information to their sons, we get the variable 'fatherrocc'. Some of the occupations which are clubbed in the categories are stated below (Table 15.1).

To find the educational mobility of the IHDS-II respondents, we repeat similar steps. We take the entire male population of 16–65 years. Then, we take the fathers, mothers and spouses who live in the household and drop the deceased and separated data. We then merge their information to their son's information. We take two

Table 15.1 Various occupational categories

White collared jobs	Skilled/semi-skilled jobs	Unskilled jobs	Farming
Physical science technicians, architects, engineers, technologists and surveyors, engineering technicians, aircraft and ships officers, physicians and surgeons, elected and legislative officials, administrative officials of government and local bodies, managers and working proprietors, wholesale and retail trade, managers and directors, etc.	Clerical, transport, communication supervisors, village officials, stenographers, typists, technical sales, commercial traveller, sales, shop assistants, related workers insurance, real estate, securities, business service sales, dress makers, sewers, blacksmiths, tool makers, machine tool operators, stationery engines operators, oilers and greasers, etc.	Hotel and restaurant keepers, house keepers, matron and stewards (domestic and institutional), cooks, waiters, bartenders and related workers (domestic and institutional), maids, other house keeping service workers, hunters and related workers, fishermen and related workers, labourers, etc.	Farm managers, supervisors, farmers

variables ED4 (whether the person has attended school or not) and ED6 (number of years of Education). We create a new variable 'yrssch' which implies the number of years of schooling the person has completed. The ID18C variable gives us the head's father's educational information. In the case where the head of the household is female, we merge the occupation information of the spouse of the mother to their sons. Now as brother of the head has the same father, head's father's occupation is also the head's brother's father's occupation. We then merge the head's father's occupation to the brother's father's occupation. After linking the father's educational information to their sons, we get the variable 'fatheryrssch'.

We have also.

- Divided the entire male population into five birth cohorts: 1946–55, 1956–65, 1966–75 1976–85 and 1986–95.
- Divided the entire male population on the basis of socio-religious communities: HFCs, HOBC, HSCs HSTs and Muslims.
- Divided the entire male population into five zones: North, south, east, west and central.

The classifications of the five zones are as follows:

North: Jammu and Kashmir, Himachal Pradesh, Punjab, Chandigarh, Uttarakhand, Haryana, Delhi, Rajasthan and Uttar Pradesh.

South: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Pondicherry.

East: Sikkim, Arunachal Pradesh, Nagaland, Manipur, Tripura, Meghalaya, Assam, West Bengal and Orissa.

West: Gujarat, Daman and Diu, Dadra + Nagar Haveli, Maharashtra and Goa.

Central: Bihar, Jharkhand, Chhattisgarh and Madhya Pradesh.

We shall now discuss the different strategies that we will be using to analyse the different objectives that this paper deals with in the sub-sections below.

15.4.2 Absolute Mobility

As occupation and education are categorical variables, to proceed with our study, we first form the mobility matrices to measure the extent of mobility in India in aggregate, by social group and by religious group.

We then construct the mobility matrices of the form (Table 15.2):

The columns represent the father's occupation and the rows represent the son's occupation. An entry P_{ij} represents the number of sons who had fathers working in the ith occupation category but who themselves are working in the jth occupation category. From here, we can also calculate the probability that the son works in the jth sector given the father worked in the ith sector. The diagonal entries will

Table 15.2 Typical mobility matrix

Son/father	White collar (W)	Skilled (S)	Unskilled (U)	Farming (F)
White collar (W)	P_{WW}	P_{SW}	P_{UW}	P_{FW}
Skilled (S)	P_{WS}	P_{SS}	P_{US}	P_{FS}
Unskilled (U)	P_{WU}	P_{SU}	P_{UU}	P_{FU}
Farming (F)	P_{WF}	P_{SF}	P_{UF}	P_{FF}

represent cases where there has been no occupational mobility, whereas the off-diagonal entries above it will represent upward mobility and below it will represent downward mobility. These mobility matrices will be constructed for the entire male population for five different birth cohorts, five socio-religious communities. We will use these mobility matrices to compare the absolute mobility rates in India over time using the five birth cohorts and also compare them across socio-religious groups.

We calculate the absolute mobility rates from the matrices given by:

$$M = 1 - \left(\sum P_{ii} / \sum \sum P_{ij}\right) \tag{15.1}$$

We also calculate the upward absolute mobility rates by:

$$M' = 1 - \left[\left(\sum_{i} P_{ii} + \sum_{i>j} P_{ij}\right) / \sum \sum P_{ij}\right] \tag{15.2}$$

15.4.3 Level of Mobility

We then measure the level of mobility and the upward mobility through the command 'igmobil' in STATA. It gives us the inter-generational mobility estimates from the Shorrock-Prais and Bartholomew Index which helps us to measure and compare the level of mobility in each zone, socio-religious groups and birth cohorts. The Shorrock-Prais Index is given by

$$M_{SP} = \frac{1}{n-1}(n - \text{tr}(k)) \tag{15.3}$$

where $\text{tr}(P)$ is the sum of the diagonal elements of a transition matrix k, n is the number of occupational categories and $M_{SP} \in [0, 1]$.

The Bartholomew Index is given by

$$M = \frac{1}{n(n-1)} \sum_{k=1}^{n} \sum_{j=1}^{n} P_{kj} |k - j| \qquad (15.4)$$

There are a total of $n(n\text{-}1)$ conversions possible between the son's occupation and a father's occupation. Also, for the son's occupation (j) given the occupation of the father (k), the expected distance (n) between the occupations of the father and son is $P_{kj}|k–j|$.

For upward mobility, we will only be using both the Shorrock-Prais and the Bartholomew Index after dropping the cases where the occupation of the son is lower to that of the father, i.e. the downward triangle of mobility.

15.4.4 Wealth Index

We now create a 'wealth index' taking 15 variables which are as follows (Table 15.3):

This wealth index consists of both moveable and non-moveable assets and signifies the basic luxuries that a household enjoys and we wish to study the dependency of mobility on this wealth index. We run a polychoric PCA on these 15 variables and then create the wealth index.

Table 15.3 Assets ownership

Sl. No.	Variable name	Asset ownership
1	rCG1	Owns house
2	CGMOTORV	Owns motor vehicle
3	DB91	Owns gold jewellery
4	CG4	Owns cycle
5	CGCOMPUTER	Owns computer
6	CG26	Credit card
7	DB9D	Fixed deposit
8	FM1	Any owned or cultivated land
9	CGCOOLING	Own cooler or AC
10	CG10	Owns colour TV
11	CG18	Owns refrigerator
12	CG19	Owns pressure cooker
13	CG20	Cable/dish TV
14	DB9A	Invests in buying house or property
15	DB9B	Invests in expanding house or property

15.4.5 Regression Specification

Finally to identify the different factors affecting the intergenerational occupational mobility, we take the entire data for male population and consider the dependent variable to be a binary dummy variable taking value 0 if there is no mobility and 1 if there is mobility. We at first merge the educational data with the occupational data for every socio-religious communities, zone, birth cohort and also overall. We have created a variable called 'mob' which takes the value 1 if there is mobility and 0 if there is not. The explanatory variables will be (1) education of the father, (2) wealth of the household, (3) own education, (4) father's occupation, (5) household size, (6) socio-religious communities and (7) zones. Here, we run a logit model to measure the odds of mobility as these factors change.

The model:

$$P_i = \frac{e^{\alpha+\beta_1 \text{yrssch}+\beta_2 \text{fatheryrssch}+\beta_3 \text{fatherrocc}+\beta_4 \text{wealth}+\beta_5 \text{householdsize}+\beta_6 \text{src}+\beta_7 \text{zone}}}{1+e^{\alpha+\beta_1 \text{yrssch}+\beta_2 \text{fatheryrssch}+\beta_3 \text{fatherrocc}+\beta_4 \text{wealth}+\beta_5 \text{householdsize}+\beta_6 \text{src}+\beta_7 \text{zone}}}$$

Here, P_i is the probability of getting success, i.e. $Y_i=1|X_i$.

The odds ratio is $P_i/(1-P_i) = e^{\alpha+\beta X_i}$, therefore, log of odds ratio will give $\alpha + \beta X_i = \log(P_i/1 - P_i)$,which is the ratio of the successes to the failures. If the odds ratio is greater than 1, then there is a high chance (probability of occurring vis-à-vis not occurring is greater) of mobility, and if it is less than 1, then there would be less chance of mobility.

Here, the study variable is 'mob' which is a dichotomous dependent variable, and hence, logit is the most appropriate method for estimating the model. Logistic regression is used to predict a categorical or dichotomous dependent variable when the independent variables are continuous or categorical. We cannot use OLS as the categorical variable violates the linearity assumption of OLS. Logistic regression does a logarithmic transformation to the dichotomous dependent variable and allows to model a nonlinear relation in a linear way.

We now take each socio-religious community, zone, birth cohort and check the contribution of the factors to upward mobility of the occupation categories. The dependent variable here will also be a binary variable 'upmob' taking value 0 if there is no upward mobility from the respective occupation category and value 1 if there is upward mobility. The independent variables will be the same as considered in the previous regression model. This therefore gives us three more regression models, upward mobility for all socio-religious communities, zones and birth cohorts. We run logit regression for each model to conclude our results. Now, the model would be similar to the earlier model. Only in this case, the data would be different as we are dropping the diagonal elements and there is only an upper triangle which signifies upward mobility and a lower triangle which signifies a downward mobility. The study variable over here is 'upmob' which is also a dichotomous dependent variable which takes the value 1 when there is upward mobility and 0 when there is no upward mobility. Hence, in this case also, a logistic regression will best fit the model.

$$P_j = \frac{e^m}{1 + e^m}$$

The model therefore becomes:

$$m = \alpha + \beta_1 \text{yrssch} + \beta_2 \text{fatheryrssch} + \beta_3 \text{fatherrocc} + \beta_4 \text{wealth} + \beta_5 \text{householdsize} + \beta_6 \text{src} + \beta_7 \text{zone}$$

Here, P_j is the probability of getting success, i.e. $Yj{=}1|Xj$. The odds ratio is $Pj/(1{-}Pi) = e^{\alpha+\beta Xj}$; therefore, log of odds ratio will give $\alpha + \beta Xj = \log(Pj/1{-}Pj)$.

Here, if the odds ratio is greater than 1, then there is a high chance (probability of occurring vis-à-vis not occurring is greater) of upward mobility, and on the contrary if the odds ratio is less than 1, then there is a low chance of upward mobility.

15.5 Analysis and Results

15.5.1 Mobility Matrix

See Table 15.4.

Table 15.5 shows that mobility across birth cohorts has increased for all occupational categories as persistence values have steadily reduced with the stickiest category being unskilled labour work which may have resulted from steady mechanisation of the farming sector coupled by low access to education.

Table 15.5 shows that intergenerational occupational mobility in farming is lowest in central India while the persistence of being in an unskilled occupation is highest in the south.

Table 15.6 shows, quite intuitively, that the STs suffer from the lowest transition rate to white collar jobs; however, their persistence rate is also high.

15.5.2 Absolute Mobility

We have constructed the matrix for the indices in the form described before.

The average absolute mobility and the average upward absolute mobility rates for the entire population are 0.2921335 and 0.2234476, respectively.

Table 15.7 shows that upward intergenerational occupational mobility has increased over time and is maximum for the central Indian people and highest among STs which perhaps collectively suggest that these are reflective of upward transitions below the highest occupation category, which is not entirely a very rosy situation.

Table 15.4 Mobility analysis across birth cohorts

	Farming/farming	*Unskilled/farming*	*Skilled/farming*	*White collar/farming*
1946–55	95.77	1.12	2.85	0.25
1956–65	53.41	12.94	30.59	3.06
1966–75	34.12	18.8	40.96	6.12
1976–85	34.12	19.88	38.94	7.06
1986–95	51.79	13.73	28.6	5.88
	Farming/unskilled	*Unskilled/unskilled*	*Skilled/unskilled*	*White collar/unskilled*
1946–55	6.59	87.07	6.07	0.26
1956–65	3.54	66.27	28.21	1.98
1966–75	4.95	51.56	39.1	4.39
1976–85	10.38	46.04	38.71	4.87
1986–95	29.66	36.72	29.87	3.74
	Farming/skilled	*Unskilled/skilled*	*Skilled/skilled*	*White collar/skilled*
1946–55	3.94	1.35	94.51	0.2
1956–65	1.74	3.27	93.07	1.92
1966–75	2.89	5.3	85.54	6.27
1976–85	5.74	7.66	77.11	9.49
1986–95	23.57	7	60.27	9.16
	Farming/white collar	*Unskilled/white collar*	*Skilled/white collar*	*White collar/white collar*
1946–55	5.13	0.43	4.81	89.64
1956–65	2.43	2.51	16.4	78.66
1966–75	5.73	5	28.05	61.22
1976–85	4.96	5.95	37.1	51.98
1986–95	32.06	3.49	28.89	35.56

15.5.3 Level of Mobility: Other Indexes

Table 15.8 confirms the finding of the previous Table 15.7.

Now, when we look at the Absolute Mobility, Shorrock-Prais and Bartholomew Index zone wise and plot it, we could see the following:

When we plot the Absolute Mobility Index and the Shorrock-Prais Index zone wise, we see that central India has the highest level of mobility followed by east and north.

Table 15.5 Mobility analysis across zones

	Farming/farming	*Unskilled/farming*	*Skilled/farming*	*White collar/farming*
North	61.24	6.22	28.7	3.84
South	63.91	15.41	17.1	3.58
East	50.5	14.29	29.25	5.96
West	69.62	14.23	13.44	2.71
Central	51.78	14.17	30.64	3.41
	Farming/unskilled	*Unskilled/unskilled*	*Skilled/unskilled*	*White collar/unskilled*
North	10.23	46.15	40.28	3.33
South	9.43	64.16	23.64	2.77
East	6.32	58.63	31.55	3.51
West	10.15	70.42	16.61	2.83
Central	7.99	57.51	31.91	2.58
	Farming/skilled	*Unskilled/skilled*	*Skilled/skilled*	*White collar/skilled*
North	4.83	3.35	88.59	3.23
South	5.69	4.85	85.6	3.86
East	4.47	2.83	87.89	4.81
West	4.31	4.36	87.49	3.84
Central	3.7	4.02	89.7	2.58
	Farming/white collar	*Unskilled/white collar*	*Skilled/white collar*	*White collar/white collar*
North	6.36	2.35	19.38	71.92
South	6.74	3.7	20.34	69.22
East	7.37	3.76	19.36	69.51
West	5.64	2.82	18.22	73.32
Central	7.05	3.34	22.45	67.16

Here, we can see that the number of upward or downward transitions traversed is the highest in eastern India followed by central India and northern India.

The implication of Figs. 15.1, 15.2 and 15.3 are obviously consistent with the previous findings but throws up in addition the possibility that the intergenerational upward mobility experienced by the STs could be residents of the eastern India.

Table 15.6 Mobility analysis across socio-religious groups

	Farming/farming	*Unskilled/farming*	*Skilled/farming*	*White collar/farming*
HFC	67.25	7.21	20.08	5.47
HSC	55.77	12.81	28.59	2.83
HST	45.33	23.6	29.03	2.04
HOBC	59.26	12.44	24.65	3.65
Muslims	59.57	7.77	29.2	3.45
	Farming/unskilled	*Unskilled/unskilled*	*Skilled/unskilled*	*White collar/unskilled*
HFC	14.39	48.3	30.59	6.72
HSC	7.03	60.65	30.25	2.06
HST	8.1	70.52	20.6	0.78
HOBC	9.24	60.74	26.81	3.21
Muslims	9.79	53.37	34.11	2.73
	Farming/skilled	*Unskilled/skilled*	*Skilled/skilled*	*White collar/skilled*
HFC	5.45	2.53	85.9	6.12
HSC	4.33	5.87	87.41	2.4
HST	3.18	6.16	89.32	1.35
HOBC	4.69	3.39	88.91	3.02
Muslims	4.67	2.93	88.97	3.43
	Farming/white collar	*Unskilled/white collar*	*Skilled/white collar*	*White collar/white collar*
HFC	7.94	1.82	19.13	71.11
HSC	4.32	5.89	21.81	67.98
HST	9.3	8.14	11.63	70.93
HOBC	6.65	3.23	18.24	71.88
Muslims	4.57	2.86	24.95	67.62

15.5.4 Logistic Regression: Results and Explanation

Having observed the pattern of overall and upward intergenerational occupational mobility via mobility matrices and spatial plots, we now present to confirmatory analyses via logistic regression. Successively, in Tables 15.9 and 15.10, we present those results, respectively. In the former, the dependent variable is a dummy which takes up 1 whenever the son's occupational category is different from that of his father's. In the next model, the dependent variable is a dummy which assumes value 1 whenever the son's occupational category is higher his father's.

Table 15.7 Absolute mobility estimates—overall and upward

	Absolute mobility	*Upward absolute mobility*
HFC	0.2775167	0.2008035
HSC	0.3019502	0.2289005
HST	0.3563672	0.3030602
HOBC	0.2951572	0.2342316
Muslims	0.2597129	0.1826683
	Absolute mobility	*Upward absolute mobility*
North	0.2886475	0.2219291
South	0.2807902	0.196301
East	0.3227106	0.258974
West	0.2480869	0.1830412
Central	0.3240153	0.2636595
	Absolute mobility	*Upward absolute mobility*
1946–55	0.0625183	0.0260249
1956–65	0.2394824	0.1911275
1966–75	0.4211126	0.3533947
1976–85	0.4983112	0.4080162
1986–95	0.5041296	0.3330686

Table 15.9 shows that the model is statistically significant. However, the key explanatory variables have mixed interpretations. For example, counterintuitively father's schooling level and father occupation is inversely related to son's occupational mobility is perhaps explained by the fact that the data does exhibit considerable intergenerational persistence as well as the dependent variable is also picking up any change in son's occupation vis-a-vis his father's, including downward.

Therefore, we now present a more appropriate model where the dependent variable is an indicator of upward mobility (at the individual, son's level). The results of the logistic regression model are summarised in Table 15.10.

We find that the model is statistically significant and the interpretations of the odd ratios for the key explanatory variables are more coherent.

When we see that father's occupation and education level being negatively correlated with son's upward occupational mobility and simultaneously, all the backward social groups performing better than the Hindu forward castes, then it strongly suggests that most of the upward mobility is happening at levels below the top one and confirms our suspicions based on observations from Table 15.9. Quite expectedly, we find that resource constraints are binding at the household level as family size is inversely correlated with upward intergenerational occupational mobility while wealth index is positively correlated. Both these correlations are statistically significant. The fact that the east and central Indians do better than the reference zone north while the south and the west do worse is also intuitive in the sense that it is universally accepted that the south and west represent the most economically developed

Table 15.8 Shorrock-Prais and Bartholomew estimates—overall and upward

	OVERALL mobility MOBILITY		UPWARD mobility MOBILITY	
	Shorrock-Prais	*Bartholomew*	*Shorrock-Prais*	*Bartholomew*
HFC	0.425	0.157	0.277	0.102
HSC	0.427	0.153	0.272	0.098
HOBC	0.413	0.156	0.265	0.094
Muslims	0.397	0.146	0.257	0.094
HST	0.435	0.155	0.283	0.103
	Shorrock-Prais	*Bartholomew*	*Shorrock-Prais*	*Bartholomew*
North	0.440	0.160	0.303	0.109
South	0.390	0.139	0.232	0.081
East	0.445	0.168	0.307	0.114
West	0.331	0.116	0.187	0.065
Central	0.446	0.163	0.295	0.107
	Shorrock-Prais	*Bartholomew*	*Shorrock-Prais*	*Bartholomew*
1946–55	0.110	0.043	0.037	0.012
1956–65	0.362	0.130	0.266	0.099
1966–75	0.559	0.204	0.395	0.147
1976–85	0.636	0.225	0.418	0.153
1986–95	0.719	0.292	0.364	0.129

regions of the country. So, upward occupational transitions maybe less possible for the residual lagging households in absence of complementary inputs like education and assets.

15.6 Summary and Conclusion

The mobility matrices inform us that the skilled and the white collared job categories are sticky in terms of occupational mobility. Specifically, the jump from the skilled sector to the white collared sector is very high so the persistence level in the skilled sector is the highest among all the occupational categories. We have seen that there is very high persistence level in the farming sector in western and southern India. When we analysed the data through birth cohorts we found that the persistence in each sector has decreased over generations. Interestingly, the mobility rates to an upward category has increased when we go from an relatively older generation to a relatively younger generation. On analysis with respect to across socio-religious communities, it is found that the upward occupational mobility of a son from their father's occupation has been more for the Hindu Schedule Castes and Hindu Schedule

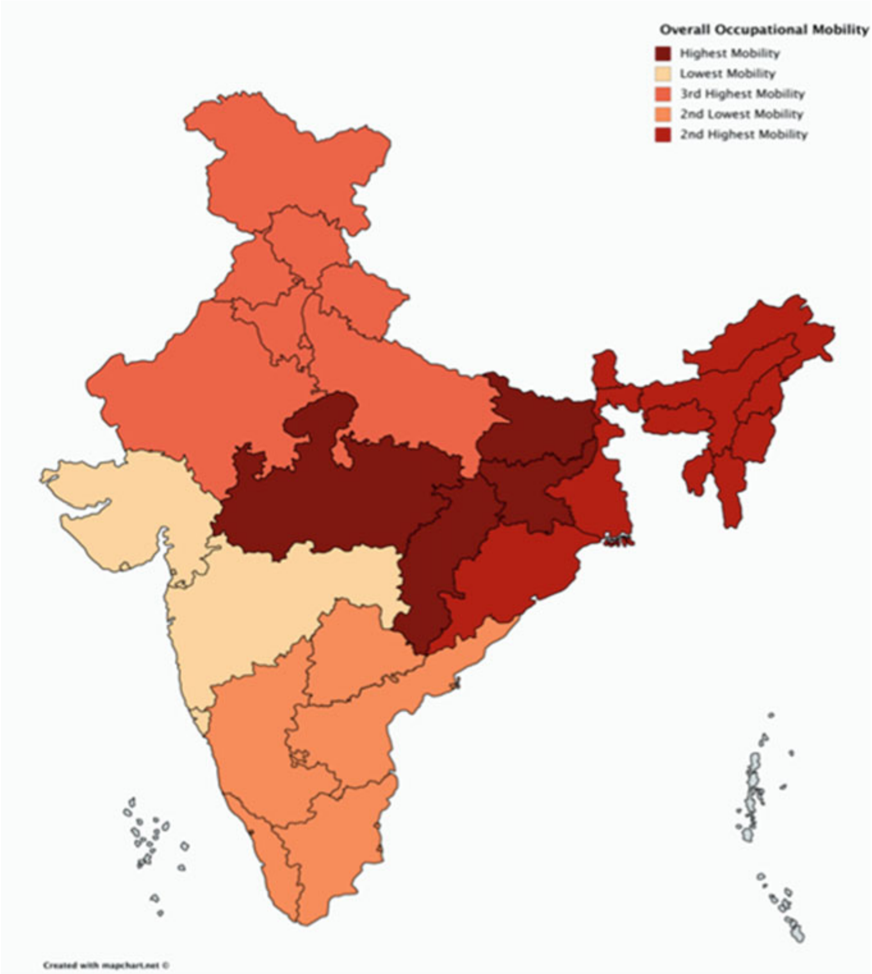

Fig. 15.1 Absolute Mobility and Shorrock-Prais Index for overall mobility

Tribes than the Hindu Forward Castes. The mobility rates of the Muslims are also impressive. This hints of things changing for better, but the magnitude of this change is uncertain.

On scrutinising the Absolute Mobility and Absolute Upward Mobility Indices across zones, socio-religious communities and birth cohorts, it is found that as we look at more recent generations, mobility increases. It is further observed that the absolute mobility rates of Hindu SCs, Hindu STs and Hindu OBCs are higher than the Muslims and the Hindu Forward Castes and are above the national average. Similarly, the upward absolute mobility rates are also higher than the national average which

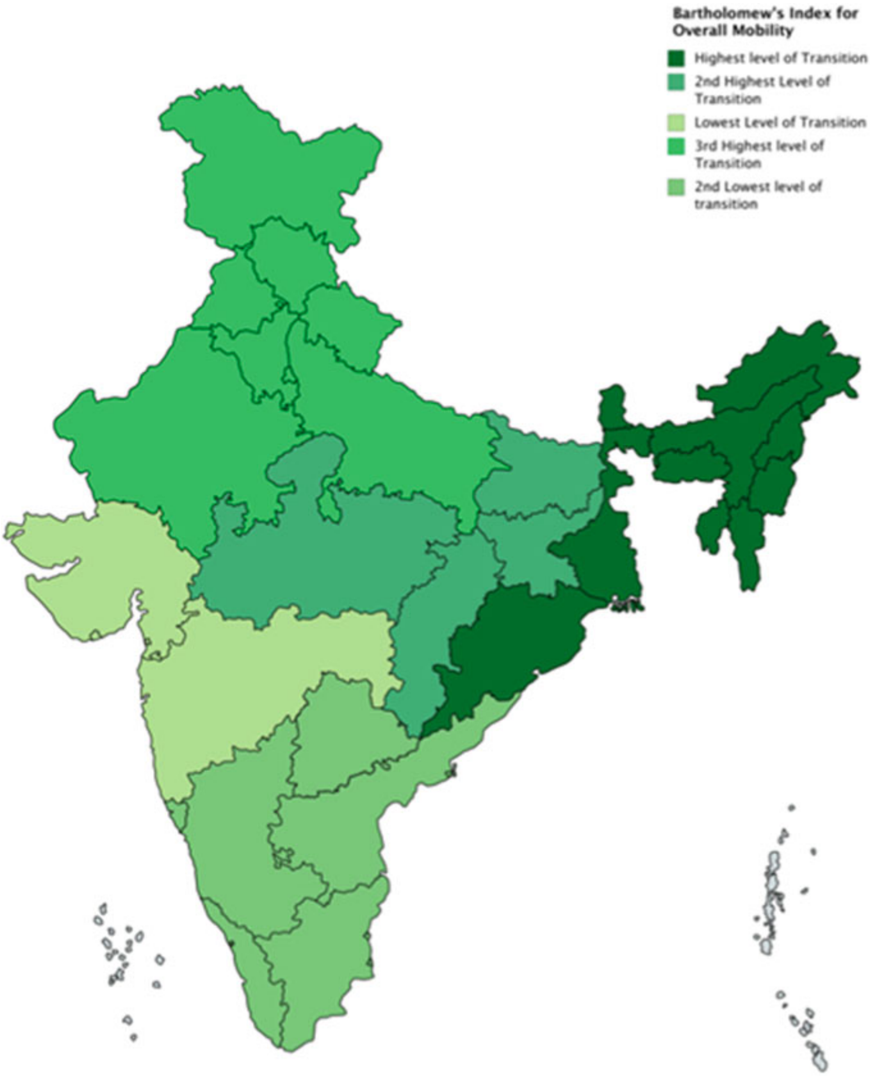

Fig. 15.2 Bartholomew's Index for Overall Mobility

hints of some social progress, at least. We also find that the central India and eastern India have recorded the highest amount of mobility and upward mobility with north India following up. South India and west India have low the lowest trends of mobility and upward mobility, suggesting of some steady state being attained.

The confirmatory analysis via logistic regression finds schooling level in the household—both of the self as well the father's matters significantly. So, upward

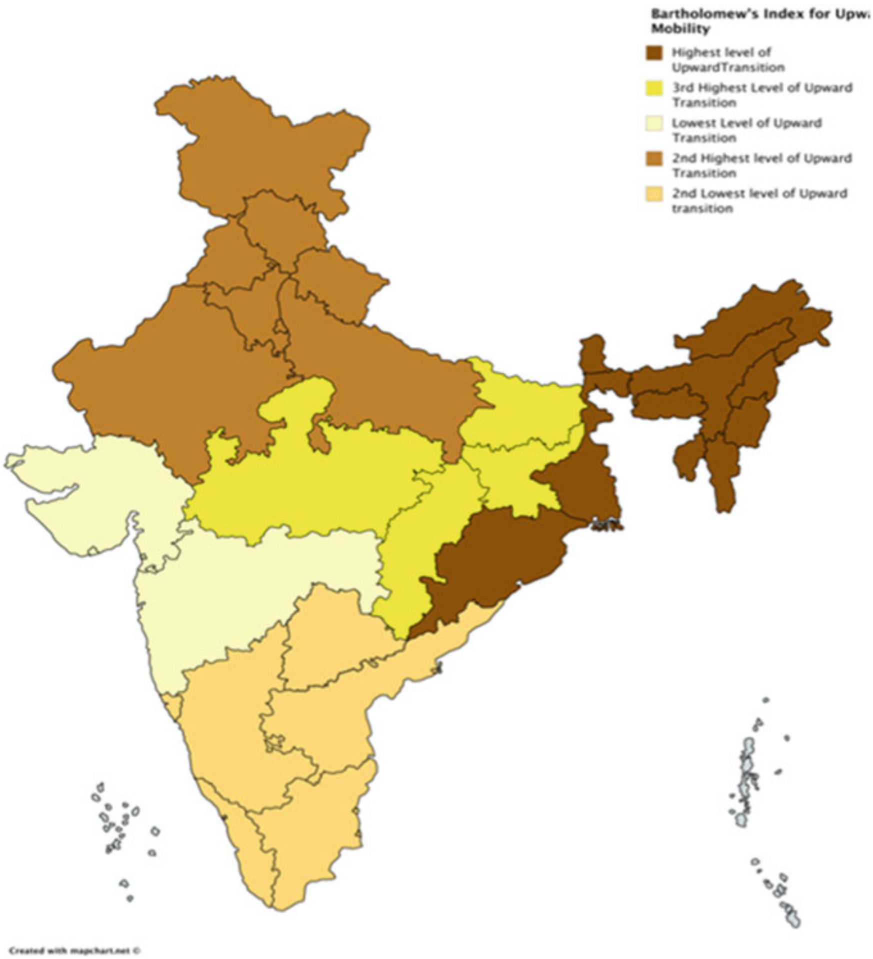

Fig. 15.3 Bartholomew's and Shorrock-Prais's Index for Upward Mobility

occupational mobility can only follow upward educational mobility across generations. Lowering educational inequality across social groups and regions will also lead to smaller family sizes and bigger labour force participation if not bigger market participation as both the demand and the supply sides will receive impetus. That is what perhaps should be strived for, via enhanced public investment in all levels of education.

Table 15.9 Determinants of overall mobility for India

Mob	Odds ratio	Std err	*Z*	*P* > |*z*|	[95% Conf. interval]	
yrssch	1.055384	0.0030426	18.7	0.000	1.049437	1.061364
fatheryrssch	0.8051128	0.0023254	−75.05	0.000	0.8005679	0.809683
Fatherrocc	0.6125836	0.0070455	−42.61	0.000	0.5989291	0.626549
Wealth	1.425661	0.0458589	11.02	0.000	1.338554	1.518436
NPERSONS	0.8777446	0.0040235	−28.45	0.000	0.869894	0.885666
Zone*	*reference category: North					
Central	1.154799	0.0367914	4.52	0.000	1.084895	1.229208
East	1.240264	0.0402332	6.64	0.000	1.163863	1.321681
West	0.7414217	0.0258385	−8.58	0.000	0.6924701	0.793834
South	0.8418844	0.0253984	−5.71	0.000	0.7935476	0.893166
*src**	**reference category: Hindu forward castes*					
Hindu OBCs	0.8892885	0.0265875	−3.92	0.000	0.8386753	0.942956
Hindu SCs	0.8621738	0.0287812	−4.44	0.000	0.8075694	0.92047
Hindu STs	0.9262433	0.0419893	−1.69	0.091	0.8474959	1.012308
Muslim	0.8946944	0.0347845	−2.86	0.000	0.829051	0.965536
_cons	3.667078	0.1765737	26.99	0.000	3.336828	4.030012
	No. of iterations to convergence	*log likelihood*	*Number of obs*	*LR* chi^2 *(13)*	*Prob >* chi^2	*Pseudo* R^2
	5	−27,991.865	56,524	12,239.98	0.0000	0.1794

Table 15.10 Determinants of upward mobility in India

Mob	Odds ratio	Std err	*Z*	*P* > |*z*|	[95% Conf. interval]	
yrssch	1.052222	0.0034971	15.32	0.000	1.04539	1.059099
fatheryrssch	0.7810471	0.0027746	−69.56	0.000	0.7756278	0.7865041
fatherrocc	0.2584874	0.0043398	−80.58	0.000	0.2501199	0.2671348
wealth	1.453662	0.0550068	9.89	0.000	1.349752	1.565572
NPERSONS	0.870399	0.0047449	−25.56	0.000	0.8611488	0.8797487
*Zone**	**reference category: North*					
Central	1.198983	0.045005	4.83	0.000	1.113942	1.290517
East	1.392606	0.0536124	8.60	0.000	1.291394	1.50175
West	0.6590823	0.0272241	−10.09	0.000	0.6078268	0.7146599
South	0.7978491	0.0287608	−6.26	0.000	0.7434242	0.8562583
*src**	**reference category: Hindu forward castes*					
Hindu OBCs	1.065796	0.0379012	1.79	0.073	0.9940406	1.142731
Hindu SCs	1.138087	0.0453001	3.25	0.001	1.052676	1.230429

(continued)

Table 15.10 (continued)

Mob	Odds ratio	Std err	*Z*	*P* > |*z*|	[95% Conf. interval]	
Hindu STs	1.119093	0.0585057	2.15	0.031	1.010104	1.239843
Muslim	1.186185	0.056494	3.59	0.000	1.08047	1.302244
_cons	10.01411	0.5774997	39.95	0.000	8943857	11.21244
	No. of iterations to convergence	*log likelihood*	*Number of obs*	*LR* chi^2 *(13)*	*Prob >* chi^2	*Pseudo* R^2
	5	−20,722.089	56,524	18,620.68	0.0000	0.3100

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Part IV
Banking and Credit: Access, Efficiency and Stability

Chapter 16
Openness and Potential Fragility of the Global Banking System

Gagari Chakrabarti

16.1 Introduction

Global financial meltdown and its colossal aftermath have raised concern about the potential vulnerability of a country's banking system when it operates with minimal restriction on it. With stronger financial network at the global level, financial shocks proliferate from center to periphery, often at magnified rate, and render the credit institutions susceptible to extreme market shocks or, inherently fragile. While issues of exposure and contagion require sincere addressal, empirical evidence to relate a country's openness to systemic vulnerability of its banking system is scanty.

A growing body of literature, ranging from individual country-specific studies to multi-country analyses, explores different aspects of banking sector performance. Dietrich and Wanzenried (2011), Garcia-Herrero et al. (2009), Goddard et al. (2013), Pasiouras and Kosmidou (2007), Staikouras and Wood (2004), Sufian and Habibullah (2012), for example, explore the determinants of bank profitability. Few others focus on the competitiveness and lack of efficiency of the sector (Claessens, 2009; Delis, 2012; Demirguc-Kunt et al., 2004; Fernández de Guevara & Maudos, 2007; Jeon et al., 2011; Mirzaeia & Moore, 2014). It is often conjectured that the efficacy of these determinants in countries would depend on their income and other aspects of financial system such as structure, efficiency, size and depth (e.g., Abiad et al., 2010; Delis, 2012; Demirguc-Kunt & Huizinga, 1999, 2000; Demirguc-Kunt & Vojislav, 2000; Levine, 2000). These studies have limitations in the sense that mere identification of factors and exploring their impact on performance, efficiency or competitiveness of the banking sector are not sufficient to gauge its potential fragility when the sector integrates itself into the global economy.

G. Chakrabarti (✉)
Department of Economics, Presidency University, 86/1 College Street, Kolkata 700073, India

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The present paper recognizes that the risk of banking sectors might escalate with strengthening financial globalization (specifically, through *contagion*) and the situation could worsen during financial crises. It explores the issues behind the risk of default of the commercial banking sector in different countries that stand at different stages of financial, investment and trade openness. The openness theory of financial development highlights the efficacy of trade and financial openness to usher in financial development (Rajan & Zingales, 2003) particularly in developing economies by facilitating competition, reducing monopolistic rent and generating incentives to support and promote financial development. While the proposition receives empirical support at macro-level (Baltagi et al., 2009; Hauner et al., 2013; Law, 2009), scepticism is well documented in the literature. Excessive and unregulated flow of credit into the private sector might render the financial sector inherently risky (Cecchetti & Kharroubi, 2012; Ductor & Grechyna, 2015) or even build up risks of financial crises (Borio & Drehmann, 2009; JordÀ et al., 2013). The scepticism prevails in the micro-level studies that consider the impact of openness on the risk-taking behavior of the banks. Extensive financial openness increases risk taking (Bourgain et al., 2012; Cubillas & González, 2014). Although trade openness leads to improved economic growth, diversification opportunities and efficient allocation of resources (Braun & Raddatz, 2007; Wagner, 2013), one cannot ignore its destabilizing impacts that comes in form of escalated exposure to adverse global market conditions (Loayza & RanciÈRe, 2006). Studies addressing issues relating to risk and openness, however, are scarce in the literature.

While concentrating on this relatively less explored area, the present study considers sixty-four countries standing at different levels of *openness* to explore two equally important issues. First, it inquires whether greater openness could escalate risk of bank default and impede the system to survive financial meltdown. At this point, the study contributes to the literature in its treatment of *openness*. Instead of considering trade or financial openness alone, it ranks countries in terms of their financial freedom, investment freedom and business freedom simultaneously. Hence, a country ranking high in terms of *openness* in the study is strongly integrated with the global financial and capital markets while offering a free business environment for the players. Second, it explores relative importance of a range of factors in affecting the probabilities of banking sector default in countries with different degrees of openness. The factors include efficiency and depth of the commercial banking system, depth of other financial and non-financial institutions, market structure, stock market development, risks from foreign market participation and the levels of corruption. Such an exhaustive and comparative approach contributes to the literature and helps us address several issues. Crucial implications follow when banks operating under different degrees of openness differ in terms of their risk of default and its determinants. With more openness being translated into intensified risks of default and of plunging into crisis, euphoria about the efficiency of minimally regulated market is likely to be challenged. Moreover, if the factors behind such default differ across levels of openness, one might question the justification for adopting a common (or even similar) system of banking reforms and regulations across the globe.

After this introductory section, the trajectory of the paper goes as follows: Sect. 16.2 presents a brief review of literature; Sect. 16.3 describes the data and the variables; Sect. 16.4 describes the methodology; Sect. 16.5 reports the results with interpretation; and Sect. 16.6 concludes.

16.2 Literature Review

Over the last three decades or so, economies are witnessing increasing financial globalization in the form of continuous withdrawal of restrictions and regulations on the system (Kaminsky & Schmukler, 2003). The potential benefit of financial globalization, particularly for the emerging economies, lies in its ability to promote a better functioning financial system leading consequently to improved economic growth (Beck & Levine, 2002; Levine, 2000; Levine & Zervos, 1998; Levine et al., 2000). Historically, many countries have liberalized their financial system to reap such benefits (Bekaert et al., 2006), but those have usually been associated with costs, particularly in the form of crises and contagion.

Financial liberalization and the associated financial instability are often considered as an important cause of banking crises (Demirgüç-Kunt and Detragiache 1999; Glick & Hutchison, 1999; Hamdaoui et al., 2016; Ranciere et al., 2006). Eichengreen and Arteta (2002) while distinguishing between the effects of internal and external liberalization found the probability of banking sector crises to escalate in an economy where capital account liberalization precedes the internal liberalization. Instances of *twin crises,* that is, the intertwining of banking and currency crises, are evidenced in a number of countries particularly after they had liberalized their financial system (Kaminsky & Reinhart, 1999). The vicious cycle begins when a banking crisis, incited predominantly by a financial shock, triggers a currency crisis. It acquires its ugliest form when the collapsing currency hits back the already fragile banking sector to collapse further. Noy (2004), however, identifies lack of supervision in a liberalized market as the prime determinant of banking sector crisis. Banking sector globalization, particularly the entry of foreign banks, is found to have generated economic vulnerability in the host nation with reduced bank-profit and efficiency (Cetorilli & Goldberg, 2012a, 2012b; De Haas & Horen, 2011; Demirguc-Kunt & Huizinga, 1999). This is in sharp contrast to the views of Dages et al. (2000) and Levine (1996) who among others emphasize the presence of positive economic effects that that foreign banks could bring in their host nations. While "fickle lending" by foreign banks (Cull & Peria, 2007) transmits shocks to the host countries, their tendency to withdraw from host markets in the face of a crisis deteriorates the situation and reduces stability (Peek & Rosengren, 2000).

Some, however, sought to relate banking sector fragility to the factors internal to the industry and/or to the economy as a whole. Development of other financial sectors, particularly the stock market has significant bearing on a country's banking sector. Developing countries, with their relatively less-developed stock markets and banking sector, are essentially bank-based (Demirgiuc-Kunt & Huizinga, 2000), and financial crises are found to have more devastating impacts on such bank-based economies in contrast to those that are relatively more market-based (Gambacorta et al., 2014; Langfield & Pagano, 2016). Moreover, stock market developments lead to improved performances of the banking sector, particularly at the lower levels of development (Demirgiuc-Kunt & Huizinga, 2000), thereby implying complementarities between the two sectors.

Development of banking sector itself and other financial institutions might have impact on its profitability (Demirgiuc-Kunt & Huizinga, 2000). Barth et al. (2013) and Caprio and Peria (2000) found the banking sector of a country to be less vulnerable where public banks, specifically with government guarantees, dominate. Inefficiencies, if any, bred by public banks under such system, however, could make the system inherently fragile (Beck et al., 2006).

Few studies relate fragility of the banking industry to its market structure. Economic theories as well as empirical researches, however, fail to relate bank concentration with its fragility in a conclusive way. Studies by Allen and Gale (2000), Beck et al. (2006) and Hellmann et al. (2000) establish the "concentration-stability" view by showing that relatively less concentrated banking sectors characterized by the presence of many small banks are more susceptible to financial crises. This is particularly because large banks can diversify better, earn more profit and are easy to monitor. A "concentration-fragility" view, however, runs parallel that condemns large banks for their excessive risk taking, lack of transparency in behavior and for making the system vulnerable (Boyd & De Nicolo, 2003; Boyd & Runkle, 1993; Boyd et al., 1993). Literature on banking sector finds significant relationship between market power and stability of the banking sector. Banks with significant market power, measured in terms of Lerner Index, are found to be less exposed to risks and more stable in the context of developed (Berger et al., 2009) as well as developing countries (Turk-Ariss, 2010). The study hence takes market power of the banks as an explanatory variable and measures it in terms of Lerner Index following the existing literature (Anginer et al., 2014; Delis, 2012). The index measures market power by comparing output pricing and marginal costs with an improvement indicating a deterioration of the competitiveness of financial intermediaries.

Two trajectories are hence discernible in the existing literature. While one holds financial openness as responsible to initiate banking crises, the other explores factors causing banking sector fragility. The present study seeks to establish a link between the two by considering a range of such factors (apart from considering only a few as it is usually done in literature) and their relative effectiveness in countries standing at different levels of financial, investment and business openness.

16.3 Data and Variables

16.3.1 Choice of Countries

The data set comprises of a balanced panel of sixty-four countries for a period ranging from 1996 to 2017. The countries are selected from the World Bank reports for different years that classify roundabout 180 countries from different regions and income groups according to their *freedom* in terms of different indicators (www.heritage.org). The study considers three such aspects, namely Business Freedom, Investment Freedom and Financial Freedom, for ranking the countries. The *Business Freedom Indicator* considers the factors affecting the ease of starting, operating and closing a business. Such measures range from 0 to 100, with 100 signifying the freest business environment. The index for *Investment Freedom* assigns a score of 100 to countries with no constraint on the flow of investment capital. It considers regulatory restriction on investment such as transparency and efficiency of policies toward foreign investment; restrictions and controls on land ownership, sectoral investment, foreign exchange and other capital, lack of investment infrastructure and/or other government policies. Finally, the index of *Financial Freedom* measures banking efficiency and freedom from government control and interference in the financial sector. The study groups the 180 countries based on the past values of the indexes and then selects countries from the top, median and bottom 15% categories based on the availability of data on choice variables for the entire study period. For example, it selects twenty-four countries (Tier-1) from the top 15% group that rank high in terms of the three indicators. This group has least restriction on their financial, investment and business environment. Similarly, it selects twenty-four (Tier-2) and sixteen (Tier-3) countries from the median 15% and bottom 15% respectively.[1]

The following sections describe the variables used in the study. Data for these have been collected from Global Financial Development Database (2018), the country-level database published by the World Bank.

16.3.2 Dependent Variable: The Stability Index

Stability of a banking sector minimizes its risk of default and reduces the economic and social impact that might arise from the problem it faces (Jokipii & Monnin,

[1] Tier-1: Hong Kong, Switzerland, Australia, Luxembourg, Denmark, United Kingdom, Netherlands, Estonia, Singapore, Finland, Sweden, United States, Czech Republic, Bahrain, Ireland, Austria, Iceland, Belgium, Chile, Spain, Germany, Colombia, Hungary, France.

Tier-2: Latvia, Norway, Mexico, Japan, Bulgaria, Indonesia, Italy, South Africa, Brazil, Argentina, Malaysia, Turkey, Romania, Peru, Portugal, Egypt, Saudi Arabia, Costa Rica, Jordan, Thailand, Lebanon, Philippines, Croatia, Kuwait.

Tier-3: Dominican Republic, Greece, Pakistan, India, Uruguay, Bangladesh, Russia, China, Venezuela, Ecuador, Ukraine, Uganda, Senegal, Sri Lanka, Bolivia, Nigeria.

2013). Instead of considering a single measure of risk of default (as in, for example, Boyd & Graham, 1986; Boyd et al., 1993; Hannan & Hanweck, 1988; Zigraiova & Havranek, 2016), the study constructs a *stability index* or, an *index of bank default* to include different variables from the World Bank's group of *stability factors* (Global Financial Development Database, 2018). Based on the availability of data and with appropriate weights, the index includes z-score of the commercial banking sector, ratio of bank capital and reserves to total (financial and non-financial) assets, bank credit to bank deposits, bank nonperforming loans to gross loans, bank regulatory capital to risk-weighted assets, liquid assets to deposits and short-term funding and provisions to nonperforming loans.

The index is constructed by running principal component analysis on the standardized variables to club them under different factors. The factors are chosen according to the Eigen values, and the individual factor scores are then normalized by the following (16.1).

$$(\text{Factor Score})_t^i = \left(\text{factor\_max}^i - -\text{factor\_score}_t^i\right) / \left(\text{factor\_max}^i - -\text{factor\_min}^i\right) \tag{16.1}$$

factor_max^i and factor_min^i are the two extreme values for the scores obtained for the *i*th factor. factor_score_t^i is the factor score obtained for factor *i* at time *t*. The factor score series thus obtained would lie between 0 and 1. The normalized factor scores are then weighted to get the final index. The weights used are the proportion of the variation explained by the respective factors to the total variation explained by all of them.

The method allows us to reduce the number of (possibly correlated) explanatory variables to be used in estimation, but to capture the impact of all the relevant factors as members of individual indexes.

By construction, an improving *stability index* would imply reduced risk of bank default and enhanced ability of the banking sector to survive crisis.

16.3.3 Independent Variables

Available literature, as discussed earlier, identifies diverse factors that affect the performance and profitability of the banking sector, and some of those may be anticipated to have impacts on the sector's probability of default.

The first area of concern may be the cost and profit efficiency of a banking sector. An efficient banking sector is resilient to shock and can modulate the adverse effect of financial crises on growth for industries that rely on external financing (Belke et al., 2016; Diallo, 2018; Ferreira, 2012). An *Efficiency Index* is hence constructed employing the technique described earlier using variables from the World Bank's group of *efficiency factors* (Global Financial Development Database, 2018). The variables include bank cost to income ratio, bank net interest margin, bank noninterest income to total income, bank overhead costs to total assets, commercial banks' return on assets, commercial banks' return on equity and bank credit to GDP.

To consider the complementarities between a country's banking sector and its stock market, in line with Demirgiuc-Kunt and Huizinga (2000), Gambacorta et al. (2014) and Langfield and Pagano (2016), the study introduces a stock market index as a possible explanatory variable of risk of default of the banking sector. The index includes market capitalization to GDP, year-on-year stock market return, value of traded shares to GDP, stock market turnover ratio and stock market volatility.

Following the lines of Demirguc-Kunt and Huizinga (2000), the study includes the depth of the banking sector itself and that of other financial institutions as possible explanatory variables of the default risk of any banking sector. The data on percentage of deposit money banks' assets to GDP and the percentage of private credit by deposit money banks to GDP are normalized to construct an equally weighted index to capture the depth of the *deposit money banking sector*. This takes into account the balance sheet structure of the firms and dependence of the system on relatively stable and cheaper modes of financing (Garcia-Herrero et al., 2009).

Five factors are selected from the World Bank defined group of *depth* for non-commercial banks and other institutions to construct an index of *depth of non-commercial banks and other institutions* employing the methodology described earlier. The index includes percentage of Central Bank assets to GDP, percentage of insurance company assets to GDP, percentage of mutual fund assets to GDP, percentage of pension fund assets to GDP and percentage of nonbank financial institutions' assets to GDP.

Moreover, one should concede that the systematic risk of banking sector might escalate as soon as it integrates itself with the global economy. As mentioned earlier, banking sector globalization might generate economic vulnerability in the host nation with reduced bank-profit and efficiency. Increasing lending, borrowing and leasing activities at the global level are likely to affect the sector's risk of default. Moreover, exposure to exchange rate movements, particularly when the banks fail to hedge, adds to the element of risk associated with banking sector globalization. The study, using PCA, constructs an index of *risk from foreign market participation* by giving appropriate weights to real effective exchange rate change and other relevant factors listed in the World Bank dataset. These include outstanding international private debt securities to GDP, outstanding international public debt securities to GDP, outstanding loans from non-resident or offshore banks to GDP, percentage of external loans and deposits of reporting banks vis-à-vis the banking sector to the domestic bank deposits, percentage of total bank assets held by foreign banks and the percentage of global leasing volume to GDP.

16.3.4 Other Explanatory Variables

Following the literature (Anginer et al., 2014; Berger et al., 2009; Delis, 2012; Turk-Ariss, 2010) on relationship between the market structure of the banking industry and its fragility, the study uses *Lerner Index* to explore the relationship between market power and stability of the banking sector. The index measures market power by comparing output prices and marginal costs. A rising *Lerner Index* implies deteriorating competitiveness of financial intermediaries.

Following Beck et al. (2006), the relationship between market concentration and banking structure fragility is explored using the *Bank Concentration* indicator of World Bank as an explanatory variable. The Indicator measures the assets of the three largest commercial banks in a country in terms of the total commercial banking assets.

The study further considers the impact of people's perception of corruption and lack of transparency at the governmental level on the stability of its banking sector. The Corruption Perceptions Index (CPI) was introduced in 1995 as a composite indicator to measure perceptions of corruption in the public sector in different countries around the world. The twelve data sources that consider people's perception about the transparency, accountability and corruption in the Public Sector are standardized to a scale of 0–100. Moving up the scale implies lower levels of perceived corruption. The CPI scores for selected countries over the period of study were extracted from www.transparency.org.

Moreover, banking sector in countries at different levels of economic development might differ in terms of opportunities, technologies, regulations and/or any other aspects that may not be captured by the variables chosen in the study. Hence, following the line of Demirguc-Kunt and Huizinga (1999), it takes real GDP per capita (constant 2010 US$) to capture those factors.

16.4 Methodology: Dynamic Panel Data

Estimation of relationships such as those proposed in the study is often associated with problems like endogeneity of the independent variables, omitted variables and measurement errors leading to bias in the least squares estimates. The industry-specific variables are often endogenous, while the vulnerability of the banking sector might tend to persist over time.

The available literature addresses such issues through generalized method of moments estimators applied to dynamic panel data models. The initial approach to use first-difference GMM estimator (Arellano & Bond, 1991) has later been modified into system GMM estimator to incorporate lagged levels as well as lagged differences (Arellano & Bover, 1995; Blundell & Bond, 1998). The system GMM allows introduction of more instruments and yields greater precision and efficiency with smaller finite sample bias while estimating autoregressive parameters using persistent series (Bond, 2002). Ever since their inception, the models are finding applications in the literature on banking sector performances (e.g., Messai et al., 2015; Mirzaeia & Moore, 2014).

The study employs two-step system GMM estimation developed by Arellano and Bover (1995) and Blundell and Bond (1998) adjusted with the Windmeijer (2005) correction for standard errors. The system GMM combines the first difference in equations with equation at level in which the variables are instrumented by their first differences. The two-step estimation relaxes the assumptions of independent and homoscedastic errors, as is adopted in the one-step method, by using the residuals obtained from the first-step estimation to develop consistent estimate of the variance–covariance matrix. With heteroscedastic error terms, the two-step method produces efficient estimator.

The relationship used in the study is thus modeled as:

$$Y_{it} = a_{it}^{0} + \delta(Y)_{it-1} + \sum_{k=1}^{K} \beta_k X_{it}^{k} + \sum_{l=1}^{L} \beta_l X_{it}^{l} + e_{it} \tag{16.2}$$

δ is the speed of adjustment. ε_{it} contains fixed effects, v_i and the idiosyncratic shocks, μ_{it}, and hence, $\varepsilon_{it} = v_i + \mu_{it}$.

The study estimates system GMM as in (16.2) using stability index as the dependent variable Y. While banking sector-specific variables (X^k) are treated as endogenous, the macroeconomic variables and corruption perception indexes (X^1) are treated as exogenous. To capture the effect of global meltdown of 2007–2008, a crisis dummy, D_{it}, is included that assumes the value one for the years 2007–2009. The estimation is done in two steps.

In the first step, two additional dummy variables termed as *openness_high* and *openness_mid* are introduced along with the crisis dummy and the explanatory variables as follows:

$$\begin{aligned} openness\_high &= 1 \text{ if the country stands at high levels of openness} \\ &= 0 \text{ otherwise} \\ openness\_mid &= 1 \text{ if the country stands at moderate levels of openness} \\ &= 0 \text{ otherwise} \end{aligned}$$

In the next stage, the model is run separately for the three groups of countries with the crisis dummy and explanatory variables to explore their relative importance in affecting the default risk at different levels of openness.

For all the estimation processes, instruments are validated using the Hansen test of over-identifying restriction. Similarly, the absence of the autoregressive process of first and second is verified for all estimates.

The study limits the lags in GMM-style instruments and collapses the instruments to optimize on the number on instruments used. This is to avoid the problem of instrument proliferation and the resultant over-fitting of endogenous variables. The joint validity of the additional instruments is tested using the Sargan tests of over-identifying restrictions. Further, the test for no second-order serial correlation of the disturbances of the first-differenced equation is important for the consistency of the GMM estimator. Hence, the Arellano–Bond tests for AR(1) and AR(2) in first differences are crucial for such studies.

16.5 Results and Discussion

16.5.1 Descriptive Statistics and Panel Unit Root Testing

Table 16.1 reports the average normalized values of the individual variables and those of the indexes constructed. Average default risk increases as countries open up to integrate themselves to the global economy. The countries with greater openness have higher GDP per capita, and their residents perceive the public sector to be relatively more transparent and less corrupt. With increasing openness, stock markets develop, banking sector deepens, and markets become more concentrated. Risk of operating in the foreign market, however, escalates, and efficiency decreases with increased openness. None of these variables contains unit root (Table 16.2).

Table 16.3 shows the absence of any strong correlation among the explanatory variables in the model.

16.5.2 Results of the Dynamic Panel Data Analysis

Results of applying two-step system GMM method to the group of sixty-four countries and for the three individual groups are presented in Table 16.4. Apart from the factors related to the bank performances and activities, the estimation for the entire group considers three dummies, namely the *crisis dummy*, the *openness_high* and the *openness_mid*. The estimations for separate groups include the crisis dummy but

Table 16.1 Average values across openness for explained and explanatory variables

Mean	Greater openness	Moderate openness	Low openness
Stability index	0.52	0.50	0.44
Stock market index	0.52	0.42	0.38
Lerner index	0.48	0.61	0.61
Efficiency index	0.45	0.48	0.48
Index of depth of commercial banking sector	0.48	0.44	0.45
Index of depth of non-commercial banking sector and other financial institutions	0.48	0.50	0.53
Bank concentration ratio	0.53	0.42	0.39
Index of risk from foreign market operation	0.50	0.46	0.42
GDP per capita	0.59	0.54	0.50
Corruption perception index	0.74	0.42	0.31

Source Author's own computation

Table 16.2 Results for panel unit root test

ADF regressions: 1 lag								
LR variance: Bartlett kernel, 8.00 lags average (chosen by LLC)								
Levin–Lin–Chu test (Adjusted t*)								
	All countries		Moderate openness		Low openness		High openness	
Time trend (whether included)	Yes	No	Yes	No	Yes	No	Yes	No
Stability index	−8.61*	−5.31*	−6.40*	−3.08*	−4.61*	−1.67**	−3.81*	−4.23*
Stock market index	−9.14*	−9.86*	−4.88*	−7.54*	−4.73*	−5.00*	−6.26*	−6.87*
Lerner index	−6.43*	7.23*	−5.78*	−7.54*	−2.38*	−2.52*	−2.41*	−1.99**
Efficiency index	−4.07*	−3.07*	−5.41*	−2.40*	−2.32*	−3.89*	−2.35*	−1.73**
Index of depth of commercial banking sector	−8.02*	−5.75*	−3.86*	−3.27*	−4.50*	−2.61*	−5.46*	−3.98*
Index of depth of non-commercial banking sector and other financial institutions	−6.49*	−2.64*	−6.20*	−3.26*	−2.15*	−1.4***	−1.63**	−2.75*
Bank concentration	−7.57*	−4.41*	−5.74*	−3.55*	−1.87**	−0.75	−5.30*	−3.28*
Index of risk from foreign market operation	−6.03*	−2.91*	−2.27*	−2.25*	−3.96*	−0.25	−5.49*	−2.13*
Real GDP per capita	−9.38*	−2.73*	−6.10*	−7.46*	−5.23*	−3.27*	−5.08*	−1.96**
Corruption perception index	−10.91*	−14.70*	−7.54*	−4.93*	−12.22*	−9.26*	−5.78*	−3.18*

Ho: Panels contain unit roots (*/**/*** implies significance at 1/5/10% level)
Source Author's own computation

not the openness dummies. All the instruments are validated using the Hansen test of over-identifying restriction, and the absence of the autoregressive process of first and second is verified for all estimates.

Table 16.3 Correlation matrix for explanatory variables

	Var-1	Var-2	Var-3	Var-4	Var-5	Var-6	Var-7	Var-8
Var-2	−0.01	1						
Var-3	−0.02	0.00	1					
Var-4	0.02	−0.03	−0.26	1				
Var-5	0.10	0.05	−0.10	0.27	1			
Var-6	−0.05	−0.03	−0.01	−0.12	−0.12	1		
Var-7	−0.04	0.02	−0.18	0.22	0.12	−0.03	1	
Var-8	0.17	0.05	−0.14	0.28	0.37	−0.11	0.19	1
Var-9	0.18	−0.10	−0.07	0.07	−0.05	0.22	0.15	0.17

Var-1: stock market index; Var-2: Lerner index; Var-3: efficiency index; Var-4: index of depth of commercial banking sector; Var-5: index of depth of non-commercial banking sector and other financial institutions; Var-6: bank concentration; Var-7: index of risk from foreign market operation; Var-8: GDP per capita; Var-9: corruption perception index.
Source Author's own computation

16.5.2.1 Estimation for Overall Sample

The coefficient of the (one period) lagged value of stability index is significantly positive for the entire group. This establishes the dynamic nature of the model. An ailing banking sector is likely to suffer further deterioration in its health, at least for one more year in future. The crisis dummy is significantly negative. Thus, the stability of a banking sector falls, or its probability of default increases during the periods of financial crisis. Moreover, the coefficients of *openness_high* (0.11) and *openness_mid* (0.06) are significantly positive with the former exceeding the latter. Hence, the stability of a country's commercial banking sector increases as the country relaxes regulations on its financial, investment and business environment. This has significant implication. The available literature condemns financial openness for generating vulnerability in the banking sector. The study, however, modifies the concept of financial openness to include free investment and business opportunities in it. Such modification has significant implications for the study. The result establishes that the banks tend to be less fragile when they operate in an environment where financial market deregulations come, not in isolation, but in combination with free investment and business opportunities. Thus, condemning financial openness for generating vulnerability may not be wise enough. Financial openness in a piecemeal fashion might be undesirable but adopting an all-encompassing approach toward openness would ultimately be beneficial for the banking system.

A less-developed stock market is associated with greater stability. This is in line with Demirguc-Kunt and Huizinga (2000) who found underdeveloped financial systems, particularly stock markets to be associated with significantly higher levels of bank profits. Efficiency reduces fragility and deepening of the activities of non-commercial banks, and other financial institutions increases the stability of the commercial banking sector establishing the complementarities between the two.

Table 16.4 Results of dynamic panel data estimation, two-step system GMM

Variables	All countries	Levels of openness		
		High	Moderate	Low
Lagged stability index	0.60*	0.54*	0.57*	0.57*
Crisis_dummy	−0.03*	−0.09*	0.003	0.02
openness_high	0.11*	–	–	– -
openness_mid	0.06*	–	–	– -
Stock market index	−0.21*	0.18*	−0.21**	−0.09
Lerner index	0.04*	0.04*	0.14***	0.08
Efficiency index	0.47*	0.57*	0.49*	0.33*
Index of depth of commercial banking sector	0.001	0.00	−0.01	−0.09
Index of depth of non-commercial banking sector and other financial institutions	0.05**	0.21**	−0.17**	0.02
Bank concentration	−0.02	−0.12**	−0.08	−0.06
Index of risk from foreign market participation	0.01	−0.36*	−0.19***	−0.05
GDP per capita	0.06*	−0.12	0.09*	0.03**
Corruption perception index	0.08*	−0.23	0.13**	0.32*
Constant	−0.18*	−0.19*	0.07	-0.17
Wald chi^2(lag)	3080.5* (14)	642.4*(12)	3719.1(12)	288.84*(12)
AR(1) (p value)	0.00	0.00	0.04	0.02
AR(2) (p value)	0.42	0.46	0.71	0.11
Hansen test (p value)	0.14	0.62	0.20	0.52
Number of countries	64	24	24	16
Number of years	20	20	20	20
Number of instruments	24	21	20	16

Source Author's own computation

Banks with significant market power, measured in terms of Lerner index, are found to be less fragile as it was mentioned in Berger et al. (2009) and Turk-Ariss (2010). Moreover, countries with higher growth and lesser corruption have less fragility in their banking sector.

16.5.2.2 Estimation for Countries with Greater Openness

Statistically significant positive coefficient of one-period lagged value of stability index reveals persistence in banking sector fragility. The countries in this group of greater openness (henceforth Tier-1) have relatively higher GDP per capita and better developed and efficiently functioning stock market (Table 16.1). The significantly positive coefficient of stock market index establishes a complementary relationship between the stock market and the banking sector in these countries. Ideally, incremental growth in an already developed stock market should reduce probabilities of bank default. The reasons are twofold: First, the stock market development reduces the risk of default on loans by making the firms better capitalized, and second, significant volume of company-level information available in a developed stock market helps the banks in evaluating the credit risk with greater precision. The banking sector, however, may remain susceptible to the shocks in the stock market. This is shown by the negative coefficient of the crisis_dummy implying greater fragility for banks in Tier-1 countries during the financial meltdown of 2007–08. These countries have greater risks of foreign market participation and any increase in risk coming from ill-managed foreign market operation would lead to dwindling stability of the banking sector. Banks with significant market power enjoy lower fragility, but risk of their default escalates in concentrated market. The competition–fragility theory (Allen & Gale, 2000) thus finds relevance. In competitive markets, banks receive less informational rents from the relationship with borrowers. This leads to subsequent increase in the risk of bank default. Moreover, larger banks might strategically collaborate to provide liquidity to a bank under temporary liquidity shortages (Saez & Shi, 2004). The deepening of the non-commercial banking and financial institutions and the efficiency of the banking sector increase stability in Tier-1 countries. However, in these high-income countries with supposedly less-corrupt government, further growth or more transparency fails to affect the probabilities of banking sector default. These countries are already employing rigorous corporate governance practices that restricts banks and other financial institutions from ill-functioning. As pointed out by Boudriga et al. (2009), lower nonperforming loan ratios are associated with lower corruption. The Tier-1 countries have already created an optimal environment for banks to operate in. Further reduction in corruption thus fails to have any significant effect on banking sector fragility.

16.5.2.3 Estimation for Countries with Moderate Openness

This group of countries standing at a moderate level of openness (henceforth, Tier-2) has relatively lower GDP per capita with supposedly moderately corrupt government. Unlike Tier-1, improvements in GDP per capita and reductions in perceived corruption at governmental level lead to better health of the banking sector in these countries. Fragility persists over time, and the coefficient of persistence is slightly greater than that in Tier-1 countries. For these countries with moderately developed stock markets, any slide in stock market actually increases stability of the banking sector. This may be explained in lines of Demirguc-Kunt and Huizinga (2000) who found less-developed stock markets in relatively less-developed countries to generate higher profits for its banking sector. The financial system is essentially bank-based where information generated by the stock market about the firms does not help in improving the stability of the banking sector. Moreover, stock market developments might not lead to better functioning of the banking sector particularly if such developments, attained through policies and regulations, tend to reduce dependence on bank-based system. The banks in Tier-2 countries, however, could manage to avoid the adversities of financial meltdown of 2007–08. This is shown by the insignificant coefficient of the crisis dummy. Banks with greater market power and higher efficiency enjoy greater stability. The findings are similar to what we obtained for the Tier-1 countries, but the impacts are stronger in Tier-2. Increase in risk arising from ill-managed foreign market operations escalates the fragility of the banking sector. Such impacts are more pronounced for the Tier-1 countries where the risks from foreign market operation are relatively greater. The complementary relationship between the commercial and non-commercial banking and other financial institutions, on the contrary, is absent for the Tier-2 countries. The depth of the non-commercial banking and other financial institutions has been more than that of the commercial banking sector (Table 16.1), a feature that is well observed in relatively less-developed countries (Demirguc-Kunt & Levine, 2001). Deepening of the non-commercial banking sector and other financial institutions leads to escalated fragility for the commercial banking sector in such countries. The concentration–fragility or competition–stability theories, however, do not find support in Tier-2 countries. Neither the concentration of assets in few hands (specifically three banks) nor the degree of competition among financial intermediaries could affect the stability of the banking sector.

16.5.2.4 Estimation for Countries with Minimal Openness

This group of countries at a low level of openness (henceforth Tier-3) is characterized by lower GDP per capita and lesser transparency and greater corruption at governmental level. Reduction in corruption leads to significant improvement in stability of their banking sector. Improvement in banking sector stability following greater economic development (proxied by improvement in GDP per capita), however, is more significant in Tier-2 countries. With relatively less-developed stock market, these countries are essentially bank-based and the link between market-based and bank-based systems is indeed non-existent. The financial crisis of 2007–08 hence could not affect the stability of the banks of the Tier-3 nations. Such banks moreover are not affected by the increased risk from foreign market operation. While the non-commercial banking sector and the other financial institutions are more active than the commercial banking sector, complementarities do not exist between them. The competition among the banks or the concentration of assets in few hands does not affect the stability of the banking sector. The only factor that could affect the soundness of the banks in Tier-3 is the efficiency of the commercial banking sector.

16.6 Conclusion

The study relates a country's risk of bank default to its openness and explores the factors affecting the fragility of the banking sectors that operate under different levels of openness. The findings bear significant policy implications. Relaxed financial market regulations, as is emphasized in literature, might render a country's banking sector vulnerable, but the study finds the banks to be less fragile when they operate in an environment where financial market deregulations come in combination with free investment and business opportunities. The concept of *openness* therefore requires modification before one could hold it responsible for making the banks fragile. The inherent fragility of the banking sector is often higher in countries where the financial sector interlinkages benefitting the sector are absent and the institutions needed for efficient functioning of financial market are not established. Openness in its broader sense could bring about such developments that might reduce (but not of course, eliminate) fragility. The factors affecting fragility differ across countries. The sources of such fragility may be traced in the varying economic structures of the countries that operate under different degrees of openness.

The Tier-1 countries operate under greater openness, enjoy higher GDP per capita and appear to be less corrupt. While incremental improvement in economic growth or transparency at the governmental level does not help banks in Tier-1 countries to enhance their stability, such opportunities exist in two other groups. A threshold exists, beyond which further transparency does not help and the benefit of growth is most significantly felt at moderate levels of openness, growth and governmental-level transparency. The Tier-1 countries are already employing stringent regulations on their banking system to ensure better functionality and to reduce risks. The Tier-2 and Tier-3 countries with their higher levels of corruption, on the other hand, have defective institutions that hampers stability of their banking system. A reduction in corruption thus has immense potential to reduce the fragility of the banking system. The relatively stronger stock markets in Tier-1 maintain complementarities with the banking sector. Tier-2 countries with their moderately growing stock market find substitutability between bank-based and market-based systems. Link between stock market and commercial banking sector is non-existent in countries with least-developed stock markets and greater restrictions on financial systems (Tier-3). Incidentally, banks operating in countries with moderate and minimal openness and relatively less-developed stock markets could escape the financial meltdown of 2007–08. Moreover, the risks from ill-managed foreign market participation increase with openness and any further increase in such risk tends to escalate the fragility of the banking sector more significantly at higher levels of openness. These two remain the points of concern for the Tier-1 countries. Moreover, while the competition–fragility and concentration–fragility theories find relevance in Tier-1 markets, anti-competitive behavior and concentrated banking sector do not lead to bank failure in countries with lesser openness. The depth of the non-commercial banks and other nonbank financial sector is often more than that of the commercial banking sector in countries operating under moderate and minimal openness. The complementary relationship between the two is obtained only when they are similar in terms of depth as it is the case in Tier-1 countries. Increased efficiency of the banking sector, however, always improves its performances.

Crucial implications follow from the result of the study that finds the banks operating under different degrees of openness to differ in terms of their risk of default and its determinants. As greater openness does not translate into intensified risks of default, euphoria about the efficiency of minimally regulated market may still be maintained but only in cases where openness is defined to encompass a broader spectrum. Moreover, since the factors determining the risk of bank default differ across countries that stand at different levels of openness, justification for adopting a common (or even similar) system of banking reforms and regulations across the globe might be questioned.

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Chapter 17
Informal Trade Credit Guarantee Networks

Jayeeta Deshmukh

17.1 Introduction

Provision of trade credit via networks often provides a way for producers in many industries who face uncertain demand to finance production when they are in the need for such thing. However, trade credit, in general, is offered after the usual waiting period when creditworthiness is determined (Fisman & Raturi, 2004). The readymade garment manufacturing industry of Metiabruz, Kolkata, is one such industry where producers often take trade credit from the sellers of input when their creditworthiness is established. In general, suppliers of input provide trade credit to those producers who belong to their trade credit networks, with whom they have long-term business relationships. Interestingly, a member input supplier of a trade credit network often provides trade credit to producers who do not belong to their direct trade credit networks if they produce a guarantor to the former.[1] Extending trade credit guarantee has become a trade norm in this industry where almost all the firms are engaged in the provision of trade credit guarantees. We call this as trade credit guarantee networks, i.e. networks of producers who can act as guarantors for each other.

However, all the firms do not extend trade credit guarantee to all the firms in the industry and hence who is connected to whom becomes important. In particular, the paper aims to study the architecture, i.e. who is connected to whom, of strategically stable trade credit guarantee networks observed in the input markets of this industry. As it is difficult to survey all the firms in the industry, exploring the architecture of the trade credit guarantee networks based on survey data is not possible; the paper explores the architecture of it theoretically. The paper explores too the efficiency properties of strategically stable trade credit guarantee networks. This extends the

[1] A unique feature of this industry.

J. Deshmukh (✉)
Presidency University, Kolkata 700073, India
e-mail: jayeeta.econ@presiuniv.ac.in

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usual trade credit network literature by incorporating a complementary network of potential recipients of trade credit guarantors which effectively increases the trade credit available to individual producers in the high-demand states when they need additional trade credit over and above what their input sellers agree to provide. Fisman (2001) makes a similar observation about trade credit as a way of facilitating production when demand is stochastic and producers face cash or credit constraints in the high-demand states.

The paper assumes that forming a bilateral link is costly and requires mutual consent. However, a bilateral link can be severed unilaterally. An important feature of the model is that benefits from network membership do not decay with the number of links separating two individuals as in Bala and Goyal (2000), Jackson and Watts (2002), Jackson and Wolinsky (1996), Watts (2001), as opposed to Bramoulle and Kranton (2007), Bloch et al. (2008) where only players who are directly linked can help each other. In this paper, it is assumed that the role of the network is to allow friends to introduce friends to other friends, who in turn introduce the first person to more friends, and so on till a guarantor can be found. That is, a producer acts as a guarantor for another one if they are path connected in a network: a potential guarantor does not discriminate between his direct neighbours and indirect neighbours. This trade credit guarantee can be viewed as a kind of positive externality that has been generated by the trade credit networks.

What I have found is that cycle-free networks, e.g. tree networks, star networks, line networks, are strategically stable networks. This further shows that formation of a complete network or a triad is not possible. I have also found that strategically stable networks are efficient as well; i.e. there is no tension between stability and efficiency, a problem that plagues much of the literature (Bloch & Dutta, 2009; Dutta & Muthuswami, 1997; Jackson, 2005, 2008). It is also found that gross-expected profit of a firm from being a member of a network is concave with respect to the number of members of a network, i.e. size of the network. In this industry, guarantors and those using the guarantee to access trade credit had minimum business relationships of four years, though in many cases, the business relationship extended to twenty years. This shows that trade credit guarantee links are long-term links in nature and ensures the stability of a network. I have further found that seventy-one firms out of eighty-one firms I surveyed had acted as guarantors for around two to three firms on the average in the last two years, and seventy-seven firms out of eighty-one firms had asked around three to four other firms to act as guarantors at least the last two years. This shows that formation of a complete network is not supported empirically too.

The rest of the paper is organized as follows. Section 17.2 describes the network. Section 17.2.1 describes the model. Section 17.3 presents the network formation and the architecture of strategically stable networks and their efficiency properties. Section 17.4 provides some concluding remarks.

17.2 Networks

A pair $(i, j) \in N \times N$ and designated by ij is called a *link* between producers i and j. A set of pairs $ij \in N \times N$ and designated by $g(N)$ is called a *set of links* or edges on the set of nodes N. The pair $(N, g(N))$ is called a *network*, or graph, on N and is denoted by $g(N)$.[2] Let $g(N) - ij$ denote the network obtained by severing an existing link between nodes i and j from network $g(N)$, while $g(N) + ij$ be the network obtained by adding a new link between nodes i and j in network $g(N)$. An *undirected network* $(N, g(N))$ is a pair of sets $N = \{1, 2, 3, \ldots, n\}$ and $g(N)$ with $ij \in g(N)$ iff $ji \in g(N)$ for all $i, j \in N$ and $i \neq j$. A *walk* in a network $(N, g(N))$ between nodes i and j is a sequence of links $i_1i_2, i_2i_3, \ldots, i_{K-1}i_K$ such that $i_ki_{k+1} \in g(N)$ for all $k \in \{1, 2, 3, \ldots, K-1\}$ with $i_1 = i$ and $i_k = j$. A *path* in a network $(N, g(N))$ between nodes i and j is a sequence of links $i_1i_2, i_2i_3, \ldots, i_{K-1}i_K$ such that $i_ki_{k+1} \in g(N)$ for all $k \in \{1, 2, 3, \ldots, K-1\}$ with $i_1 = i$ and $i_k = j$, such that each node in the sequence is distinct. If such a sequence of nodes between i and j exists, one can say producers i and j are path connected. A walk $i_1i_2, i_2i_3, i_3i_4, \ldots, i_{K-1}i_K$ in a network $(N, g(N))$ is called a *cycle* when it starts and ends at the same node, i.e. $i_1 = i_K$, and such that all other nodes are distinct ($i_k \neq i_{k'}$) where $k < k'$ unless $k = 1$ and $k' = K$. A tree network is a path-connected network that has no cycles. The path-connected network $(M_i, g(M_i))$ is said to be *pair-wise stable* if the following hold:

(i) If $ij \in g(M_i)$, then $E\pi_i(g(M_i)) - E\pi_i(g(M_i) - ij) \geq f$, and $E\pi_j(g(M_i)) - E\pi_j(g(M_i) - ji) > f$
(ii) If $ij \notin g(M_i)$, and $E\pi_i(g(M_i) + ij) - E\pi_i(g(M_i)) > f$, then $E\pi_j(g(M_i) + ji) - E\pi_j(g(M_i)) < f$

where f is the cost of forming a bilateral link with $f > 0$, $|M_i| = m$ and gross-expected profits of producer i and j are $E\pi_i(g(M_i))$ and $E\pi_j(g(M_i))$, respectively. Let $G(N))$ be the set of all networks on the set of players N. Let $W(g)$ be the sum of gross-expected individual profits generated by the network g. A network g is called *efficient* if and only if for all $\overline{g} \in G(N)$ and $g \neq \overline{g}$, $W(g) - 2\eta_g f \geq W(g) - 2\eta_{\overline{g}} f$, where η_g and $\eta_{\overline{g}}$ are total number of bilateral links in network g and $\overline{g}$, respectively, and $2f$ is the total cost of forming a bilateral link.

17.2.1 Model

Let $N = \{1, 2, ..., n\}$, $n > 1$, be the set of *ex ante* identical readymade garment producers in the output markets. Producers sell their product in identical independent markets.[3] It is assumed that producers face stochastic and idiosyncratic demand shocks in the output markets. If a producer faces a good demand shock in his output

[2] In this paper, the terms node, player and producer are synonymous.

[3] Sell output to a different group of buyers or at different points in time.

market, then it does not necessarily mean that other producers will face the same demand shocks in their respective output markets. The probabilities that a producer will face a low- or a high-demand shock in the output market are $p > 0$ and $(1-p) > 0$, respectively. It is assumed that each producer has trade credit link with a single input seller, but an individual input supplier may have trade credit link with more than one producer in the input markets. However, a producer can have multiple potential guarantors and he can ask for a guarantee from all of them simultaneously if required. It is assumed further that enforcement problems do not arise and producers who take trade credit via guarantors do not default strategically or voluntarily. Forming a bilateral link is costly and is the same for all.

Suppose the demand for trade credit by an individual producer from his regular input supplier is $TC_l \geq 0$ in the low-demand state and $TC_h > 0$ in the high-demand state. Let $TC_m > 0$ be the maximum trade credit that an input supplier offers to a producer, where $TC_l < TC_m < TC_h$. A producer needs some additional credit, $TC_A = (TC_h - TC_m) = G > 0$, over and above what his own input supplier is willing to provide when he faces a high-demand shock for his product in the output market. However, a producer has a surplus of available trade credit $(TC_m - TC_l) > 0$, over and above his own needs when he faces a low-demand shock in the output market. However, sometimes a producer having trade credit surplus acts as a guarantor and extends the trade credit surplus for another producer looking for additional trade credit if the latter purchases inputs from the guarantor's own input seller. For computational simplicity, we assume that $G = TC_A = TC_m - TC_l$. Volume of profit of producer $i \in N$ in the high-demand state depends on the size of trade credit guarantee TC_g that he receives from his network. Designate profit of producer $i \in N$ when he faces a high-demand state in the output market by $\pi_i(TC_g)$, where $0 \leq TC_g \leq TC_A$. A producer's profit is designated by π_{ld} when he faces a low demand for his output. It is assumed that $\pi(0) > \pi_{ld}$, where $\pi(0)$ is the level of profit that producer i earns when he faces high-demand shock in the output market but gets no trade credit guarantee from his network. The next three assumptions state the rule of trade credit provision within a network $(N, g(N))$.

Assumption 17.1 [*A 17.1*] $\pi_i(TC_g)$ is upward rising and concave in TC_g with $\pi_i(0) > 0$.[4]

Since, by definition, TC_h is the maximum trade credit that the producer demands in the high-demand state, $\pi_i(TC_g)$ attains its maximum at $TC_A = G$.

Assumption 17.2 [*A 17.2*] If a path in the network $(N, g(N))$ exists between producers i and j, then the two producers can serve as guarantors for each other.

Assumption 17.3 [*A 17.3*] Producers belong to $(N, g(N))$ who are in a position to act as guarantors do not discriminate between their immediate neighbours and other producers in N when providing the guarantees to those who want them.

[4] A similar assumption is made in Deshmukh and Moitra (2016).

In this paper, producers' level of profit in the high-demand states depends on the amount of trade credit guarantees that they get from their networks. Since a producer does not know a priori who will be facing low-demand shocks and who will be facing high-demand shocks in the respective output markets in his network, he forms expectation regarding how much trade credit guarantee he can get from the network. The next section formalizes this.

17.2.2 Trade Credit Guarantee

Suppose that producer $i \in (N, g(N))$ with network size n receives a good demand shock in his output market and is in a need for additional trade credit. Let $n - 1 \geq$ s ≥ 0 be the number of producers who face low-demand shocks in the output market and are in a position to provide trade credit guarantee. Thus, $n - s$ is the number of producers, who face high-demand shocks in the output market and are in a need for trade credit guarantee. The maximum number of potential guarantors that producer i has in this network is s $\leq (n - 1)$. Here, $s = 0$ implies that there is no one in the network who can extend producer i a trade credit guarantee, and $s = n - 1$ implies that all other producers in the network except producer i are in a position to extend trade credit guarantee to producer i. As long as $n - s \leq s$, producer i gets the full amount of loan guarantee, G that he wants, otherwise he will get a trade credit guarantee equivalent to $\left[G\frac{s}{n-s}\right] < G$. Formally, the maximum amount of trade credit guarantee that producer i will receive from the network $(N, g(N))$ is given by:

$$\overline{G} = \min\left[G, G\frac{s}{n-s}\right] \tag{17.1}$$

Here, gross profit of producer i before deducting his link formation costs depends on how much trade credit guarantee he receives from his network in a high-demand state. Since s and $n - s$ are not known a priori to producer i as demand shocks in different output markets are uncorrelated, the volume of trade credit guarantee that he can get from the network is uncertain, and hence, producer i calculates gross-expected profit before deducting his link formation costs that he is supposed to earn by being a member of the network of size n in the following way: the gross-expected profit of producer i from the non-empty path-connected network $(N, g(N))$ before deducting his link formation costs is:

$$E\pi_i(g(N)) = p\pi_{ld} + \sum_{s=0}^{n-1} {}^{n-1}c_s p^s (1-p)^{n-s} \pi \left\{ \min\left(G, \frac{s}{n-s} G\right) \right\} \tag{17.2}$$

This gross-expected profit function is similar to Deshmukh and Moitra (2016). The first term on the right-hand side of Eq. (17.2) describes a situation when producer i faces a bad demand shock in the output market, hence, does not want a trade credit guarantee and earns a profit π_{ld} with probability p. The second term of Eq. (17.2) describes a situation where some producers $s \leq n-1$ are in a position to extend trade credit guarantees to network members, who are in the need for this. The joint probability that s number of producers face low demand shocks in their respective output markets, and the remaining $(n-s)$ producers (including producer i) get high-demand shocks in their respective output markets, is ${}^{n-1}c_s p^s (1-p)^{n-s}$. The trade credit guarantee that producer i receives in this situation is: either G or $\frac{s}{n-s}G$, whichever is smaller depending on $n-s \leq s$, is satisfied or not. However, the number of producers in N can be even or odd. Simplifying and modifying Eq. (17.2), we get:

$$\begin{aligned} E\pi_i(g(N)) = &\sum_{s=1}^{\frac{n}{2}-1} {}^{n-1}C_s p^s (1-p)^{n-s} B_s + \frac{1}{n-1} {}^{n-1}C_{\frac{n}{2}} p^{\frac{n}{2}} (1-p)^{\frac{n}{2}} B \\ &+ \sum_{s=\frac{n}{2}+1}^{n-2} (n-1-s) p^{n-s} (1-p)^{n-s} B \\ &+ p(1-p)B + (1-p)\pi(0) + p\pi_{ld} \end{aligned} \tag{17.2a}$$

when n is an even number, and

$$\begin{aligned} E\pi_i(g(N)) = &\sum_{s=1}^{\frac{n-1}{2}} {}^{n-1}c_s p^s (1-p)^{n-s} B_s + \sum_{s=\frac{n-1}{2}+1}^{n-2} (n-1-s) p^{n-s} (1-p)^{n-s} B \\ &+ p(1-p)B + (1-p)\pi(0) + p\pi_l \end{aligned} \tag{17.2b}$$

when n is an odd number, where $B_s = \pi\left\{\min\left(G, \frac{s}{n-s}G\right)\right\} - \min\left(1, \frac{s}{n-s}\right)\pi(G)$ $-\left\{1 - \min\left(1, \frac{s}{n-s}\right)\right\}\pi(0)$; $B = \pi(G) - \pi(0)$.

The next four theorems establish the properties of the gross-expected profit function of an individual producer, say, producer i. Proposition 17.1 says that given Assumption 17.1, the gross-expected profit of producer i is positive for any network size $n > 1$; Proposition 17.2 establishes that the marginal gross-expected profit is positive if the probability of getting a bad shock is sufficiently high; Proposition 17.3 demonstrates the existence of network externality; Proposition 17.4 establishes that the marginal gross-expected profit before deducting link formation costs decreases with the number of producers in $(N, g(N))$.

Proposition 17.1 *Assumption 17.1 implies that* $E\pi_i(g(N)) > 0, \forall i \in N$ *with* $n > 1$.

Proof See appendix. ■

Suppose now that $\{j\}$ is an isolated node of $(N, g(N))$. Let $N' = N \cup \{j\}$. If a link is formed between some producer in N and producer j, we get the new network denoted by $\left(N', g(N')\right)$, where $\left|N'\right| = n + 1$. Suppose n is an even number. Then using Eq. (17.2a), the gross-expected profit of producer i, $E\pi_i(g(N'))$, from adding this link is:

$$E\pi_i(g(N')) = \sum_{s=1}^{\frac{n}{2}} {}^{n}C_s p^s (1-p)^{n+1-s} B'_s + \sum_{s=\frac{n}{2}+1}^{n} (n+1-s) p^{n-s} (1-p)^{n-s} B + (1-p)\pi(0) + p\pi_{ld} \tag{17.3a}$$

where $B'_s = \pi\left\{\min\left(1, \frac{s}{n+1-s}\right)G\right\} - \min\left(1, \frac{s}{n+1-s}\right)\pi(G) - \left\{1 - \min\left(1, \frac{s}{n+1-s}\right)\right\}\pi(0)$. We can find a similar expression for $E\pi_i(g(N'))$ when n is an odd number. This is as follows:

$$E\pi_i(g(N')) = \sum_{s=1}^{\frac{n-1}{2}} {}^{n}C_s p^s (1-p)^{n+1-s} B'_s + \sum_{s=\frac{n-1}{2}+1}^{n} (n+1-s) p^{n-s} (1-p)^{n-s} B + (1-p)\pi(0) + p\pi_{ld} \tag{17.3b}$$

From Eqs. (17.2a) and (17.3a), we get:

$$E\pi_i(g(N')) - E\pi_i(g(N)) = np(1-p)^n B'_1 + \sum_{s=2}^{\frac{n}{2}} p^{s-1}(1-p)^{n-s+1} \frac{(n-1)(n-2)\ldots(s+1)}{(s-1)(s-2)\ldots 3.2.1} \left(\frac{n}{s} p B'_s - B_{s-1}\right) \tag{17.4}$$

where $B'_1 = \pi\left\{\min\left(1, \frac{1}{n}\right)G\right\} - \min\left(1, \frac{1}{n}\right)\pi(G) - \left\{1 - \min\left(1, \frac{1}{n}\right)\right\}\pi(0)$. A similar expression can be found by using Eqs. (17.2b) and (17.3b) when n is an odd number. The following proposition comes from this.

Proposition 17.2

(i) *Let n be an even number. Assumption 17.1 implies that* $E\pi_i(g(N')) - E\pi_i(g(N)) > 0$ *if* $p > \frac{s}{n}$, *where* $s = 2, 3, 4, \ldots, \frac{n}{2}$.

(ii) *Let n be an odd number. Assumption 17.1 implies that* $E\pi_i(g(N')) - E\pi_i(g(N)) > 0$ *if* $p > \frac{s}{n}$ *where* $s = 2, 3, 4, \ldots, \frac{n-1}{2}$.

Proof See appendix. ■

What Proposition 17.2 shows is that the gross-expected profit of a producer $i \in (N, g(N))$ increases monotonically with n for sufficiently high value of p; adding one more producer in the network increases benefit. Now suppose that producer $i \in N$ does not form the link with producer j, and some producer $m \in N$ forms the link with producer j. The next proposition, Proposition 17.3, establishes that there is a positive network externality in this model (Jackson, 2008, pp. 213); i.e. inclusion of an additional, previously isolated producer in the network $(N, g(N))$ increases the gross-expected profit (before deducting the cost of link formation) for all existing producers in the network, irrespective of who among them form the link.

Proposition 17.3 *$E\pi_i(g(N) + mj) > E\pi_i(g(N))$, where $i \neq m \in N$, $i \neq j$, and $\{j\} \cap N = \varphi$.*

Proof See appendix. ■

What Propositions 17.1, 17.2 and 17.3 do not tell us is the curvature of $E\pi_i(g(N))$, i.e. whether expected gross profit before deducting link formation costs increases with network size or decreases with network size. For this, we need to know the sign of $\left[\{E\pi_i(g(N_i')) - E\pi_i(g(N_i))\} - \{E\pi_i(g(N_i)) - E\pi_i(g(N_i''))\}\right]$. Suppose first that n is an odd number. Then,

$$\left\{E\pi_i\left(g\left(N'_i\right)\right) - 2E\pi_i(g(N_i)) - E\pi_i\left(g\left(N''_i\right)\right)\right\}$$
$$= \left[\sum_{s=1}^{\frac{n-1}{2}-1} p^s(1-p)^{n-1-s\,n}C_s(1-p)^2 B'_s + \sum_{s=1}^{\frac{n-1}{2}-1} p^s(1-p)^{n-1-s\,n-2}C_s B''_s \right.$$
$$\left. -2\sum_{s=1}^{\frac{n-1}{2}-1} p^s(1-p)^{n-1-s\,n-1}C_s(1-p)B_s\right] + \left[p^{\frac{n-1}{2}}(1-p)^{\frac{n+1}{2}\,n}C_{\frac{n-1}{2}}(1-p)B'_{\frac{n-1}{2}}\right.$$
$$\left. +\frac{1}{n}p^{\frac{n-1}{2}}(1-p)^{\frac{n+1}{2}\,n}C_{\frac{n-1}{2}+1}pB - 2p^{\frac{n-1}{2}}(1-p)^{\frac{n+1}{2}\,n-1}C_{\frac{n-1}{2}}B_{\frac{n-1}{2}}\right] \quad (17.5a)$$

Now suppose that n is an even number. Then,

$$\left\{E\pi_i(g(N')) - 2E\pi_i(g(N)) + E\pi_i(g(N''))\right\}$$
$$= p^{\frac{n}{2}}(1-p)^{\frac{n}{2}-1}\left[{}^nC_{\frac{n}{2}}(1-p)B'_{\frac{n}{2}} - {}^{n-1}c_{\frac{n}{2}}\frac{1}{n-1}B\right]$$
$$+\sum_{s=1}^{\frac{n}{2}-1} p^s(1-p)^{n-1-s}\left[{}^nC_s(1-p)^2B'_s + {}^{n-2}C_sB''_s - 2\,{}^{n-1}C_s(1-p)B_s\right] \quad (17.5b)$$

where

$$B''_s = \pi\left(\min\left(1, \frac{s}{n-1-s}\right)G\right) - \min\left(1, \frac{s}{n-1-s}\right)\pi(G)$$
$$-\left\{1 - \min\left(1, \frac{s}{n-1-s}\right)\right\}\pi(0)$$

$$\begin{aligned}
B'_s =& \pi\left(\min\left(1, \frac{s}{n+1-s}\right)G\right) - \min\left(1, \frac{s}{n+1-s}\right)\pi(G) \\
&- \left\{1 - \min\left(1, \frac{s}{n+1-s}\right)\right\}\pi(0) \\
B_s =& \pi\left(\min\left(1, \frac{s}{n-s}\right)G\right) - \min\left(1, \frac{s}{n-s}\right)\pi(G) \\
&- \left\{1 - \min\left(1, \frac{s}{n-s}\right)\right\}\pi(0) \\
B'_{\frac{n}{2}} =& \pi\left(\min\left(1, \frac{n}{n+2}\right)G\right) - \min\left(1, \frac{n}{n+2}\right)\pi(G) \\
&- \left\{1 - \min\left(1, \frac{n}{n+2}\right)\right\}\pi(0) \\
B'_{\frac{n-1}{2}} =& \pi\left(\min\left(1, \frac{n-1}{n+2}\right)G\right) - \min\left(1, \frac{n-1}{n+2}\right)\pi(G) \\
&- \left\{1 - \min\left(1, \frac{n-1}{n+2}\right)\right\}\pi(0) \\
B_{\frac{n-1}{2}} =& \pi\left(\min\left(1, \frac{n-1}{n+1}\right)G\right) - \min\left(1, \frac{n-1}{n+1}\right)\pi(G) \\
&- \left\{1 - \min\left(1, \frac{n-1}{n+1}\right)\right\}\pi(0)
\end{aligned}$$

This gives us the following proposition, Proposition 17.4. What Proposition 17.4 shows is that expected gross total benefit and expected gross marginal benefit before deducting link formation costs from being a network member increases and decreases, respectively, with the network size. That is expected gross profit from being a network member increases with a decreasing rate with network size.

Proposition 17.4 *Suppose* $n \geq 3$. *Then* $E\pi_i(g(N))$ *is concave in* n, *where* $|N| = n$, *if* $p > \frac{s}{n}$.

Proof See appendix. ■

17.3 Network Architecture

In this paper, benefit comes from indirect links and network members enjoy network externality. As the provision of trade credit guarantee is purely informal in nature and guarantors do not have any legal rights, stability of a network ensures that producers will not default strategically. If a producer defaults strategically, then his reputation as a credible borrower within the network is shot and he will have to search for guarantors who belong to other networks. However, a bilateral trade credit guarantee link cannot be formed overnight with other network members and hence he will not be permitted to enter in other networks overnight; he has to wait. Therefore, stability of networks ensures that a producer will not be defaulting voluntarily because if he does so then no producer (irrespective of his own network member or member of another network) will provide him trade credit guarantee hereafter. As stability is so important, the central focus of the paper is to explore what kinds of networks are stable. However, all the producers do not extend trade credit guarantee to all the producers in the industry and hence who is connected to whom becomes important. In particular, the paper aims to explore the architecture, i.e. who is connected to whom, of strategically stable trade credit guarantee networks. A full network may contain disjoint path-connected subnetworks. We are interested in the architecture of these non-empty components. The next proposition shows when the empty network, which contains no producer, is strategically stable.

Proposition 17.5 *Suppose that $f > 0$. An empty network $(N, g(N))$ is pair-wise stable if and only if $E\pi_i(g(N) + ij) - E\pi_i(g(N)) < f$, for all $i \in N$.*

Proof See appendix. ■

Proposition 17.5 says that if f is sufficiently high then the trade credit guarantee network $(N, g(N))$ will be empty; i.e. producers will not form bilateral links with each other for credit guarantee; they will prefer to stay alone and rely on their own input suppliers only for trade credit. The next proposition, Proposition 17.6, identifies a property of the architecture of trade credit guarantee networks when the cost of forming a bilateral link, f, is positive, but less than $E\pi_i(g(N) + ij) - E\pi_i(g(N)) < f$.

Proposition 17.6 *Suppose $E\pi_i(g(N) + ij) - E\pi_i(g(N)) < f$. Then, $(N, g(N))$ has no cycles.*

Proof See appendix. ■

What Proposition 17.6 establishes is that strategically stable networks are free from cycles; i.e. it rules out the formation of circular, triad, cliques, and complete networks since formation of these networks increases the costs to individual producers without increasing the benefit from being members of the network. It shows that tree networks, line networks, and star networks are likely to evolve and strategically stable. However, which cycle-free network among these three cycle-free networks will evolve cannot be told beforehand; it may happen that one subnetwork takes the form of a link network, whereas the next subnetwork is a star network and so on. Here, no producer will form a link with another one if they are already indirectly path connected, irrespective of the length of the path. This is in sharp contrast with the result for distance-based utility models where such links may be formed if the extra benefit from a direct link over the benefit from an indirect link is greater than the cost of forming a link.[5] Figure 17.1 shows some cycle-free network architectures.

[5] See Propositions 6.3.1 and 6.3.2 in Jackson (2008).

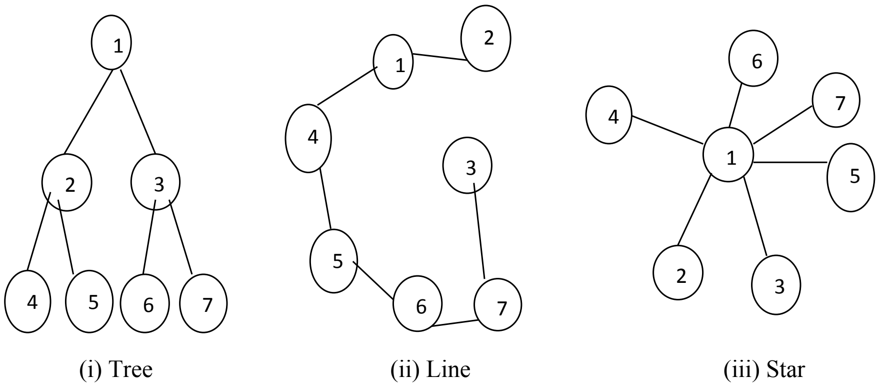

Fig. 17.1 Three alternative cycle-free network architectures when n = 7. **a** Tree. **b** Line. **c** Star. *Source* Author

However, Proposition 17.6 does not tell about the efficiency property of strategically stable networks. In the literature, one sees a tension between pair-wise stability and efficiency: a stable network need not be efficient and vice versa.[6] Proposition 17.7 shows that in this model the tension does not exist for path-connected pair-wise stable networks; here strategically stable networks are efficient too. That is, cycle-free networks, i.e. star networks, line networks, and tree networks, are both strategically stable and efficient.

Proposition 17.7 *Suppose that* $f > 0$. *Then, pair-wise stable and cycle-free path-connected networks are efficient.*

Proof See appendix. ■

17.4 Concluding remarks

In this paper, it is assumed that enforcement problems do not arise. By itself, this reduces the role of a guarantor to that of an introducer only. However, in the absence of formal legal contracting, the guarantor, in effect, promises to compensate fully in the event of a default. The absence of enforcement problems, therefore, means that there is a mechanism in place that ensures that refusal to act as a guarantor (even an indirect one) and strategic default can be ruled out. Stability of trade credit guarantee networks is that mechanism. A second important feature of the model is that the size of the guaranteed amount does not decline with the number of links between the ultimate guarantor and the one taking the loan. This means that as long as the two players are linked through common friends or even a sequence of friends

[6] See Jackson (2008) for an extensive introduction to this problem.

of friends the size of the amount guaranteed is the same as it would have been if they were directly linked. Most importantly, the paper shows that there does not exist any tension or conflict between stability and efficiency; cycle-free networks, i.e. star networks, line networks or tree networks, are both strategically stable and efficient.

Appendix

Proof of Proposition 17.1 Suppose that n is even. In Eq. (17.2a), the term $\{p\pi_{ld} + (1-p)\pi(0)\}$ is independent of the network size. Moreover, $\pi(G) - \pi(0) > 0$ by construction as G maximizes $\pi(G)$ on $[0, \propto)$. The right-hand size of Eq. (17.2a) will be positive if the values of $B_s, \forall s = 1, 2, ..., \frac{n}{2} - 1$, are positive. Now as $\pi_i(TC_g)$ is concave in TC_g, all these terms are positive. Using Eq. (17.2b) and noting that $s = 1, 2, ..., \frac{n-1}{2}$, an analogous argument establishes the theorem for odd values of n. ■

Proof of Proposition 17.2 Suppose that n is an even number. The first term of right-hand side of Eq. 17.4 is positive as $\pi(TC_g)$ is upward rising and concave in TC_g and $B'_s > B_{s-1}$, for all $s = 2, 3, 4, \ldots, \frac{n}{2}$. The sign of the second term of right-hand side is positive if $\frac{n}{s}pB'_s - B_{s-1} > 0$, i.e. if $p > \frac{s}{n}$. Therefore, if $p > \frac{s}{n}$, then $E\pi_i\big(g\big(N'_i\big)\big) - E\pi_i(g(N_i)) > 0$. We can find a similar expression (17.4a) like Eq. (17.4) when n is an odd number (Eq. 17.4a will be identical to Eq. 17.4 except that the term s runs from 2 to (n-1)/2 . As this can be understood easily, Eq. 17.4a is not explicitly written here). Using Eqs. (17.2a) and (17.4a), and noting that $s = 2, 3, 4, \ldots, \frac{n-1}{2}$, an analogous argument establishes the proposition for odd values of n. ■

Proof of Proposition 17.3 Proposition 17.2 shows that adding one more producer in the network is beneficial for an existing network member and it increases monotonically with network size. Given Proposition 17.2 and Assumption 17.2, the gross-expected profit of a producer before deducting link formation costs depends on the size of a network only. Therefore as long as two producers are path connected in a network, it does not matter who among them forms a new link. Hence, $E\pi_i(g(N_i) + mj) - E\pi_i(g(N_i)) > 0$. ■

Proof of Proposition 17.4 Suppose n is odd. $E\pi_i(g(N_i))$ will be concave in n for all values of $n \geq 3$ if $[\{E\pi_i\big(g\big(N'_i\big)\big) - E\pi_i(g(N_i))\} - \{E\pi_i(g(N_i)) - E\pi_i\big(g\big(N''_i\big)\big)\}] < 0$. That is when the signs of Eqs. (17.5a) are negative, i.e. when the signs of first third bracketed term and second third bracketed term of Eq. (17.5a) are negative for all values of $s = 1, 2, 3, \ldots \frac{n-1}{2}$. Equation (17.5a) shows that signs are negative as profit function $\pi(TC_g)$ is concave in TC_g. In a similar manner, we can show that $\big[\big\{E\pi_i\big(g\big(N'_i\big)\big) - E\pi_i(g(N_i))\} - \{E\pi_i(g(N_i)) - E\pi_i\big(g\big(N''_i\big)\big)\big\}\big] < 0$ when n is even by using Eq. (17.5b) and for all values of $s = 1, 2, 3, \ldots \frac{n}{2} - 1$. ■

Proof of Proposition 17.5 Notice first that gross-expected profit functions are the same for all producers $i \in N$,$\{E\pi_i(g(N) + ij) - E\pi_i(g(N)\} =$, $\{E\pi_j(g(N) + ji) -$

$E\pi_j(g(N)\}\forall i \neq j \in N$. Suppose that $\{E\pi_i(g(N)+ij) - E\pi_i(g(N)\} < f$. Then, neither producer i nor producer j has an incentive to form the link between themselves as cost of forming a bilateral link is higher than the marginal benefit from forming this link. To establish the only if part, suppose that $(N, g(N))$ is pair-wise stable. This means that for any pair ij in N, $\{E\pi_i(g(N)+ij) - E\pi_i(g(N)\} < f$. Further since $(N, g(N))$ is an empty network, there is no link to delete. ■

Proof of Proposition 17.6 Suppose $(N, g(N))$ has a cycle and producers i and j, who are indirectly path connected in the network $(N, g(N))$, have a direct link between them as well. Since $E\pi_i(g(N)-ij) = E\pi_i(g(N))$, producers i and j can save the cost $f > 0$ without any loss in benefit by deleting the direct link between them and maintain the indirect link between them as the benefit does not decay with path length between them (A 17.3). Therefore, given the positive cost of forming a link, f, no two producers i and j, who are indirectly path connected in the network, have any incentive to maintain this direct link between them. ■

Proof of Proposition 17.7 From Proposition 17.6, any network $(N, g(N))$ is a tree with $|N| = n$ players and, therefore, has $(n-1)$ links (see Fig. 17.1 as an example). Any alternative path-connected non-empty network on the set of N has at least as many links. Hence, the total cost of link formation for the network $(N, g(N))$ is no greater than that on any other path-connected network on N, and since there is no decay, the total benefits are the same. ■

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Chapter 18
Repeated Lending in Informal Credit Markets with Adverse Selection and Strategic Default

Saswatee Mukherjee

18.1 Introduction

An interesting feature of many LDCs is that interest rates on informal sector credit tend to be significantly higher than interest rates on loans from the formal sector banks and lending agencies, and further, the interest rates on informal loans can vary widely even within small areas (Basu, 1997).[1] One possible explanation for this could be based on the lender's risk hypothesis (LRH): interest rates in areas with a higher average probability of default are higher than in areas with lower average probabilty of default to cover for the higher expected loss caused by default in the former case. However, as Basu (1997) points out, this is not a very plausible explanation because informal lenders typically lend to those over whom they have enough control to ensure repayment. While this may rule out wilful (strategic) default, a borrower who has incurred losses may not be in a position to repay immediately. The degree of control that the lender has may then determine the outcome of renegotiation of repayment schedules.

Consider a situation where a single lender offers to provide fixed size loans to borrowers who invest in a risky project. In a single period model without adequately strong institutions to enforce lending contracts, all borrowers have the incentive to default strategically, i.e. strategic default is certain, irrespective of the type of the borrower and state of nature. The urban–rural distinction in Basu (1997) may be interpreted to be a reflection of the relative efficiencies of the underlying strategic default prevention mechanisms. Looked at it in this way, the empirical assertion is open to dispute because rural borrowers typically live and work in the same mileu

[1] Basu (1997) and Bottomley (1964) explain the dualistic nature of capital markets in LDCs due to high default rate in rural areas.

S. Mukherjee (✉)
Department of Economics, Presidency University, Kolkata 700073, India
e-mail: saswatee.econ@presiuniv.ac.in

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as the lender[2] and are less likely to get away with strategic default than their urban counterparts because of their relatively lower mobility.[3] In that case, the lender's risk hypothesis explanation of higher rural interest rate collapses.

We adopt a different approach by explicitly modelling the incentive to default strategically in a repeated lending–borrowing framework, while retaining the single instrument feature of the lender's risk hypothesis. Our principal result is that interest rates will be higher in a market where the default probability *on the average* is lower. Our result does not depend on empirical assertions about the efficiency of contract enforcement institutions prevailing in rural and urban markets, but it does indicate why interest rates may be higher in rural areas where close contacts, lack of mobility and limitedd access to alternative sources of credit make strategic default a lot more difficult.

There is an extensive literature that suggests that lending rates in credit markets may be influenced by the presence of adequate collateral,[4] proper legal contract enforcement mechanisms[5] and the presence of credible guarantors. Stiglitz and Weiss (1981) show that equilibria with credit rationing can exist in the presence of adverse selection. Strikingly, such credit rationing does not resolve the problem of adverse selection per se. With a single lending parameter, both the borrowers who invest in risky projects and those who invest in relatively safer ones get access to credit, and in equilibrium, some of the safe borrowers may fail to get loans at the prevailing interest rate. However, lenders using more than one screening parameter (collateral, interest rates, guarantors, etc.) may be able to induce potential borrowers to self-select from a set of contracts by designing an optimal contract for each borrower type. In general, the lender's profit turns out to be less than the full information profit because of the incentive compatibility constraint.[6] The literature suggests that lending rates in the credit market can be influenced by the presence of adequate collateral, proper legal contract enforcement mechanism, credible guarantors or even

[2] Bell (1990) argues that local moneylenders in order to avoid adverse selection confine their lending only to a group of known clients. Again, lenders belonging to the same village as the borrowers may be able to tackle strategic default (ex post moral hazard) problem as within the same locality the state of the nature (flood, drought, etc.) is always the same.

[3] Refer to Wharton (1962), Bhaduri (1973), Rahman (1979) and Saleem (1987).

[4] Jain (1999) shows simultaneous coexistence of formal and informal lenders in the same market where the formal lenders offer credit to borrowers in exchange of collateral to resolve strategic default (ex post moral hazard), while the local moneylenders use personal information as a screening device to provide credit without collateral. Hoff and Stiglitz (1990) observe that formal lenders tend to operate in areas where farmers have land titles which can be substituted as collaterals.

[5] Kranton and Swamy (1999) show that legal security to lenders induces competition among them. Single lender derives monopoly rent by charging high interest rate in periods of good harvest which compensates for losses in years of low cropping. Competition, on the other hand, forces the market interest rate to go down even in the years of good harvest whereby the lenders fail to cope with defaults (involuntary) in seasons of bad harvest.

[6] Refer to Mas-Colell et al. (1995).

interlinked contracts.[7] However, the last two mechanisms require credible bilateral, or multilateral enforcement schemes with which such contracts can be sustained.[8]

Jain (1999) shows that a bank facing an adverse selection problem about borrower types may be able to extract the information available to better informed lenders by asking each potential borrower to find part of the project cost elsewhere. The borrower then approaches an informal lender who has perfect information about borrower's type. By definition, informal lenders, with better information about a potential borrower's type, will lend less to a risky borrower and more to a good borrower. Hence, the size of the loan from the informal lender to the borrower provides an exact signal to the formal bank about the borrower's type, and, so, the formal sector bank can implement the first best solution,[9] where the interest rate is positively related to the size of the loan sought and both types of borrowers are driven to their reservation pay-off level.[10] In its elemental form, this is just like a self-selection model with two instruments, interest rate and loan size,[11] where the bank has full information. In all these cases, discriminating between the borrowers is possible, but they do not explain why interest rates in one area are uniformly higher than in another.[12]

In this paper, we return to a version of the lender's risk hypothesis where lenders have monopoly power over their borrowers, but such control may not be absolute. As in lender's risk hypothesis, lenders have a single control instrument (interest rate) at their disposal. While individual borrowers may find it difficult to seek loans from other lenders, the possibility is not ruled out. Instead, we assume that some borrowers have a higher chance of finding an alternative lender than others. We show that in areas where people *on the average* have lower access to alternative

[7] Refer to Bose (1993). Bell (1990) shows that increased commercialization in Indian agriculture has led to a rise in trader–moneylender contracts. Such contracts can resolve the problem of strategic default by the farmers-cum-borrowers, since the traders-cum-moneylenders can exercise their first claim on the output proceeds.

[8] Refer to Greif (1993). Bendor and Mookherjee (1990) analyse the circumstances under which bilateral and multilateral informal contracts will be adequate as well as required.

[9] The bank knows that the informal lender has correct information. This is different from using a guarantor because the bank has some power over the guarantor for him to be acceptable, whereas in this case the bank has no power over the better informed guarantor, i.e. informal lender.

[10] If a borrower fails to repay a loan in any period, the bank cuts off future lending, and the borrower has to fall back on the informal lender.

[11] Mas-Colell et al. (1995) show that incentive compatible constraints with more than one screening instrument can remove adverse selection problem by enforcing the agents to reveal their true nature through self-selection. Bester (1985) completely negates credit rationing thereby advocating credit contracts with collateral size and interest rate as two decision-making parameters to induce self-selection among the borrowers. He shows that risky borrowers prefer small collateral and high interest contracts while safe types prefer contracts with relatively large collateral and lower interest rate. Hence, with separating contracts, there must be no credit rationing at equilibrium. Also see Wette (1983).

[12] Stiglitz and Weiss (1981) show that equilibria with credit rationing can exist in the presence of adverse selection. This means that, in equilibrium, the lender will lend to a subset of potential borrowers whose default risk distribution, at the equilibrium interest rate, is the same as that of the entire population of potential borrowers.

sources of credit, interest rates are higher than in areas where this proportion of eligible borrowers is higher. In a way, this explains why in areas where geographic mobility is low and access to alternative creditors is limited, on the average people, may be less willing to default on loans and, therefore, end up paying higher interest rates. In each period, a borrower uses the borrowed capital to invest in a project whose lifetime is one period. All the projects are identical in the sense that they have the same pay-offs and probability of success across borrower types. We assume that outcomes are uncorrelated across time and individuals. As we shall see, the multi-period framework allows us to explicitely model the incentive to default (or not to default) strategically.[13] With multi-period lending, a borrower compares the profit from defaulting strategically in the current period with the present value of profit from maintaining a good long-term credit record with his current lender. Borrowers who have a higher probability of accessing credit from some other source are more likely to default and go elsewhere than those who have a lower probability of getting credit elsewhere who are, therefore, more likely to stay with their current lender. For want of a better term, we shall call the former type of borrowers the myopic borrowers, and the latter type are patient borrowers. As we shall see, in some cases it also allows lenders to screen out borrowers who are more likely to default strategically over time.

We first show that under full information about the borrower types and no arbitrage, the lender charges a relatively lower interest rate to the myopic borrowers as compared to the patient types. This is so because the patient borrowers value their future returns more than their myopic counterparts. As a result, the patient borrowers are willing to pay a higher interest rate than the impatient or myopic ones. For the myopic types, on the other hand, the lender would require a lower interest rate as a device to induce repayment. It must be reiterated that such contracts with different interest rates across borrower types can only be used if there is no arbitrage. With pre-contract informational asymmetry regarding the true nature of a borrower and a single instrument, the interest rate, the lender can only offer *pooling contracts*. We show that the interest rate chosen is determined by the nature of the distribution of borrowers according to types in the credit market. Our principal result is that if a credit market has a proportion of risky borrowers greater than a critical level, then the equilibrium interest rate here will be lower than in a market where the proportion of risky borrowers is lower than the critical level. This is diametrically opposite to the lender's risk hypothesis explanation in the sense that where the probability of strategic default is on the average higher, and interest rate turns out to be lower. This is in line with the empirical evidence that in close village societies, where it is difficult for agents to migrate away from their current locale, or find other lenders who would be willing to lend to them when they have a history of default, interest rates are normally high. Viewed in this way, our result provides an alternative theoretical argument to support the empirical observations.[14]

The paper is organized as follows. In Sect. 18.2, we present the basic multi-period lending–borrowing model with a single lender to uncover the incentive for strategic

[13] Refer to Fudenberg and Maskin (1986).

[14] Refer to Bell (1990).

default built in the story. In Sect. 18.3, we introduce different types of borrowers, myopic and patient in the model and explore the credit market equilibrium under full information. In Sect. 18.4, we introduce adverse selection and derive our principal result that the existence of high proportion of myopic borrowers in the credit market turns out to be beneficial for the few good ones present in the market in that they pay lower interest rate than the maximum they would be willing to pay. In Sect. 18.5, we do some comparative static exercises to explore the impact of parametric changes on the market interest rate. Finally, we conclude in Sect. 18.6.

18.2 The Model

Let us consider a basic principal-agent framework. There is one lender and a large number of identical risk neutral borrowers. Each potential borrower (agent) has a project for which he needs to borrow L units of money, $L > 0$ for which the lender (principal) charges an interest rate r, $r \geq 0$. The borrower then invests this capital in some project which yields, either a return Y with probability p, or 0, with probability $(1 - p)$, $0 < p < 1$. Both the borrower and the lender know this, but the actual state, once uncertainty is resolved in any period, can only be observed by the borrower and cannot be verified by the lender. For the borrowers to have a non-negative non-default pay-off in the good state, we need, $Y \geq L(1 + r)$. Assume further that in the bad state $Y < L(1 + r)$. Without loss of generality, we also assume that the lender does not have any capacity constraint, and the cost of providing such credit by the lender is zero. After the output is realized, the borrower decides whether to pay back the loan or not. To keep matters simple, we assume that there is no debt renegotiation in case of strategic default. If a borrower fails to repay the lender, irrespective of the state of the world, the lender stops lending to the borrower forever. The timeline of the model is given in Fig. 18.1.

In a finite horizon model, where the lender and the borrowers interact repeatedly, and the last period of interaction is known with certainty to the lender and the borrower, any rational borrower will not repay the lender in the last period. Thus, a rational lender will not offer credit in the last period; hence, no lending will take place in that period. A backward induction argument reveals that no lending actually takes place in any period if interaction is limited to a fixed, commonly known, finite number ofperiods. We, therefore, assume that the lender and the borrowers interact over an infinite number of periods, or the last period is not known with certainty.[15] Given such specifications, a borrower is expected to repay his loan, if his gain from strategically defaulting on the loan in any period is less than his gain from repayment. That is, repayment will occur only in a good state and that too if and only if:

[15] Refer to Fudenberg and Maskin (1986).

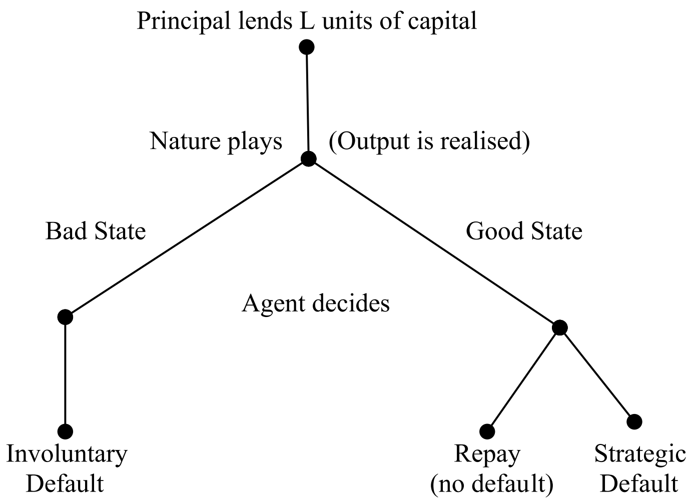

Fig. 18.1 Game form of the lender–borrower game

$$Y \leq [Y - L(1+r)] + \delta p[Y - L(1+r)] + \delta^2 p^2 [Y - L(1+r)] + \dots$$
$$\text{or } Y \geq \frac{L(1+r)}{p\delta} \tag{18.1}$$

where $0 < \delta < 1$ is the discount factor.

Lemma 18.1 *The highest rate of interest that can be charged by the lender to avoid strategic default in a good state is*

$$r_M = \frac{Y}{L} p\delta - 1. \tag{18.2}$$

Proof Follows trivially from Eq. (18.1). ■

18.3 Variation in Borrower Types: Full Information

Let the credit market comprise two types of otherwise identical borrowers, Type P[16] (patient) and Type M[17] (myopic), who differ in their valuation of future income. Let the probability of getting an credit from an alternative source in any period by the

[16] The forward-looking borrowers who value their long-term relationship with the lender more than the myopic borrowers (who has access to alternative credit sources) are identified as Type P borrowers.

[17] Refer to Mukherjee (2013) for discussions on alternative credit sources.

myopic borrower be α, where $\alpha \in (0, 1)$ and the probability of finding an alternative source of credit for the patient borrower be zero. Thus, $(1 - \alpha)$ can be identified as a myopic borrower's probability of not getting credit from an alternative source in any given period. Let δ be the common discount factor of the two borrower types. Hence, if δ_P and δ_M are the effective discount factors for the Type P and Type M borrowers, respectively, then we can say that, $\delta_P = \delta > \delta_M = (1 - \alpha)\delta$.

In this section, we characterize the full information contracts that the lender will offer. By full information, we mean that the lender can identify a borrower's type before a contract is offered to him.[18] We assume throughout the rest of this paper that arbitrage is not posssible, i.e. a borrower who is offered a loan of size L cannot lend the amount to another borrower who is willing to pay a higher rate of interest. From Eq. (18.2), there is a threshold value of interest rate r_M, above which a Type M borrower will choose to default strategically in a good state:

$$r_M = \frac{Y}{L} p\delta_M - 1 \tag{18.3}$$

Analogously, the upper bound of the interest rate r_P that can be charged to Type P is

$$r_P = \frac{Y}{L} p\delta_P - 1 \tag{18.4}$$

Proposition 18.1 *In the infinitely repeated lending game with strategic default (ex post moral hazard) and no adverse selection, the maximum interest rate at which Type P borrowers will not default strategically in a good state, r_P, is higher than r_M, the maximum interest rate at which Type M borrowers will not strategically default.*

Proof Comparing (18.3) and (18.4),

$$r_P = \frac{Y}{L} p\delta_P - 1 > r_M = \frac{Y}{L} p\delta_M - 1, \quad \text{since, } \delta_M < \delta_P \tag{18.5}$$

■

A borrower who values his future income less than another borrower is less likely to be concerned about maintaining his reputation as a good borrower than the latter. In credit markets where reputation acts as the sole bond, borrowers who are less concerned about maintaining their reputation than others would be considered a greater credit risk and would be asked to pay a higher interest rate. To us, this is the intuitive heart of the lender's risk hypothesis. Proposition 18.1 demonstrates that this is incorrect under some circumstances. In particular, charging a high interest rate to myopic borrowers who value their reputations less may actually trigger strategic default. It is the set of good borrowers who value their reputations who are willing to pay more and can, therefore, be charged a higher rate without triggering

[18] There is no adverse selection problem here.

strategic default. Hence, if there is no adverse selection problem, a monopolistic lender can charge two different interest rates to the two types of borrowers, r_M and r_P, without triggering strategic default in the good state. Default (involuntary) will only occur in a bad state of the world. Thus, in an infinitely repeated credit market game without adverse selection, the problem of strategic default can be resolved by charging appropriate interest rates.

18.4 Different Types of Borrowers: Adverse Selection

Suppose borrowers know their discount factors, i.e. a Type M borrower knows that he is a Type M borrower and a Type P borrower knows that he is a Type P borrower, but the lender cannot identify the true nature of any borrower prior to lending. However, he knows the proportion of each borrower type in the market. Let the number of potential borrowers in the market be N, which is constant over time, and let the proportion of Type M borrowers in the population be f, with $0 \leq f \leq 1$.

Let us now look at the exercise from the lender's point of view. With a single instrument (interest rate) in this model, and no feasible screening device, the lender with informational asymmetry has to offer the same interest rate to both borrower types. Therefore, it is not possible for the lender, to offer the incentive compatible contract to each type of borrower, to make them reveal their true nature. The monopolist lender has no other option, but to charge a uniform interest rate to both types of borrowers in the credit market, i.e. either $r = r_M < r_P$ or, $r_M < r_P = r$.[19] If the lender charges the lower of the two rates, i.e. $r = r_M < r_P$, he can guarantee a repayment from all the debtors (in a good state of nature) irrespective of their types, eliminating the problem of strategic default. Under this situation, the expected net profit of the lender in the first period becomes

$$\begin{aligned}\pi_M &= -NL + p[fNL(1 + r_M) + (1 - f)NL(1 + r_M)] \\ &= NL[p(1 + r_M) - 1] \end{aligned} \tag{18.6}$$

In the second period, fraction $1 - p$ of the N borrowers who involuntarily default in the first period are no longer eligible borrowers. Thus, only fraction p of the N original borrowers from the first period apply for loan and repay under a good state. The expected net profit of the lender in this period is

$$\begin{aligned}\pi_M &= -pNL + p^2NL[f(1 + r_M) + (1 - f)(1 + r_M)] \\ &= pNL[p(1 + r_M) - 1] \end{aligned} \tag{18.7}$$

[19] It is easy to see that the lender will never charge an interest rate r in the range (r_M, r_P). For any $r \in (r_M, r_P)$, Type M will strategically default and Type P will be charged less than its valuation.

Proceeding this way, the present value of the expected net profit of the lender over a lifetime by charging $r = r_M < r_P$ is given by[20]

$$\begin{aligned}\pi_M^* =& A + \delta_L pA + \delta_L^2 p^2 A + \ldots \\ =& \frac{A}{1-\delta_L p}\end{aligned} \tag{18.8}$$

where $A = NL[p(1+r_M) - 1] = NL\left[p(\frac{Y}{L}p\delta_M) - 1\right]$ and, $0 < \delta_L < 1$ is the discount factor of the lender.

If the lender, on the other hand, charges $r_M < r_P = r$, he will be repaid by Type P borrowers only, while Type M borrowers are sure to strategically default. Hence, the lender's expected profit in the first period is given by

$$\pi_P = -NL + p(1-f)NL(1+r_P) \tag{18.9}$$

However, from second period onwards, the lender can discriminate against Type M borrowers by offering credit only to Type P borrowers, since the screening of good and bad borrowers has already occurred in the first period. Given this, the expected net profit of the lender in second period is given by

$$\pi_P = -(1-f)pNL + p^2(1-f)NL(1+r_P) \equiv B(say) \tag{18.10}$$

Proceeding this way, the expected net profit of the lender over a lifetime by charging $r_M < r_P = r$ is given by

$$\begin{aligned}\pi_P^* =& NL[p(1-f)(1+r_P) - 1] + \delta_L B + \delta_L^2 pB + \ldots \\ =& NL[p(1-f)(1+r_P) - 1] + \frac{\delta_L B}{1-\delta_L p}\end{aligned} \tag{18.11}$$

since $B = p(1-f)NL[p(1+r_P) - 1] = (1-f)NL[p\{\frac{Y}{L}p\delta_P\} - 1]$.

Proposition 18.2 *The lender will charge the interest rate correspoding to Type P borrowers, i.e.* $r_M < r_P = r = \frac{Y}{L}p\delta_P - 1$[21] *if and only if,* $f < \frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L}$.

Proof Comparing the two profit functions in Eqs. (18.8) and (18.11), we find that, $\pi_M^* < \pi_P^*$ if and only if,[22]

20 A positive profit level of the lender requires $r_M > \frac{1}{p} - 1$.

21 As opposed to Stiglitz and Weiss (1981), we show that the same interest rate is charged to all the borrowers irrespective of their types, and in this case we do not use any credit rationing.

22 Refer to Appendix "Determination of Critical Level of Population Proportion".

$$f < \frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L} \tag{18.12}$$

■

From Proposition 18.2, it follows that with $f < \frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L}$, the lender charges the higher of the two interest rates, i.e. $r_M < r_P = r = \frac{Y}{L}p\delta_P - 1$, to maximize his profit. In such a situation, Type P borrowers repay the loan, while the myopic ones (Type M) strategically default. This is so because, with a greater proportion of population consisting of the Type P borrowers, it is beneficial for the lender to charge the highest feasible interest rate to the patient ones. This shows that, in a good state, the gain from a debt repayment from the Type P borrowers by charging a higher rate offsets the loss arising out of strategic default of the myopic types (Type M). It is easy to check that with $f < \frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L}$, $r_M < r_P = r = \frac{Y}{L}p\delta_P - 1$ is the sub-game perfect Nash equilibrium interest rate.[23]

On the other hand, if the fraction of Type M borrowers in the credit market exceeds $\frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L}$, then it is better for the lender to charge the lower of the two interest rates ($r = r_M < r_P$). Since most of the debtors in the market comprise the myopic borrowers, it is easier for the lender to charge an interest rate, custom-made for them. If the lender deviates from $r = r_M$, by charging any higher interest rate, i.e. $r_P > r > r_M$, then the loss incurred from credit default of the Type M borrowers will surpass the total repayment from the patient types (Type P). Since the interest rate $r = r_M < r_P$ is derived from Eq. (18.2), hence, in a good state, strategic default becomes dearer to repayment for all borrowers, Type M and Type P alike, as only debt repayment sanctions future credit access. Hence, $r = r_M < r_P$, is the sub-game perfect Nash equilibrium in interest rate for $f < \frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L}$.

Hence from Proposition 18.2, we can say that if the proportion of myopic borrowers exceeds a threshold level, independent of by how much this happens, the market interest rate will be lower than otherwise.

Corollary 18.1 *The presence of large number of myopic borrowers (Type M) in the credit market compared to the patient type (Type P) lowers the interest rate faced by the patient ones (Type P).*

Since, in credit contracts with adverse selection problem, the lender cannot distinguish between the borrower types, he charges a uniform interest rate to both types of borrowers. Since, only interest rate *pooling contracts* can be offered, both types of borrowers can free-ride by deceiving the lender, by not disclosing their true types in the first period. Hence, with $f < \frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L}$, when the lender charges $r_M < r_P = r$, the myopic borrowers can pretend to be forward looking to get access to credit and strategically default thereafter. However, when the credit market is dense with large number of myopic borrowers, i.e $f \geq \frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L}$, the lender will find it wise to charge

[23] The result does not change even under a credit market with growing population as is shown in Appendix "Determination of Critical Level of Population Proportion with Growing Population of Borrowers".

$r = r_M < r_P$, the interest rate at which it pays for the myopic borrowers not to default strategically. In the latter case, due to the presence of numerous myopic (Type M) borrowers in the market, the patient (Type P) types can get credit at a lower rate than what they are willing to pay. Thus, in this case, contrary to our general belief, the existence of large number of risky borrowers in the credit market turns out to be beneficial for the few good ones (Type P).

18.5 Comparative Statics

In this section, we look at the impact on the interest rates of changes in the return from a successful project, default probability, loan size, discount factor of the lender and discount factors of the borrowers. Let $f^* = \frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L}$, at which $\pi_M^* = \pi_P^*$. Thus, if the proportion of Type M borrowers in the market is f^*, then the lender is indifferent between charging r_M and r_P. Notice, $0 \leq f^* \leq 1$, provided, $r_M \geq \delta_L - 1$ which automatically guarantees $r_P > \delta_L - 1$.[24] As we notice in Fig. 18.2, f^* is the threshold population fraction of Type M borrowers.

The profit schedule π_M^* corresponding to the market interest rate $r = r_M < r_P$, all borrowers repay their loans, irrespective of types, if the project is successful and hence the schedule is horizontal implying that it is independeent of the proportion of patient type borrowers in the credit market. However, the profit schedule π_P^* corresponding to market interest rate $r = r_P$ is download sloping since the larger is the fraction of myopic borrowers f in the credit market, the lesser will be the profit of the lender if he charges $r = r_P$, since in this case all the myopic borrowers will strategically default on their loans. Hence, for $f > f^*$, the lender can secure a repayment from both types of borrowers by charging $r = r_M < r_P$. Hence, in Fig. 18.3 we can present a distribution of population proportion on the basis of which the lender decides his optimal lending strategy.

The proportion of myopic borrowers f^* is a population parameter which is a function of the basic parameters of the model, i.e.

$$f^* = g(Y, p, L, \delta_L, \delta_M, \delta_P) \tag{18.13}$$

Proposition 18.3 *Following Eq. (18.12), the interest rate charged by the lender is* $r = r_M < r_P$ *if* $r_M \geq \delta_L - 1$,[25] *and any one of the following is true: (i) Y is large, (ii) probability of success of any project is high, (iii) loan size is small, (iv) discount factor of the lender is low, (v) discount factor of the myopic borrower is high, and (vi) the lesser is the weightage attached to future pay-offs by the patient borrower.*

[24] Refer to Appendix "Sufficiency Condition of $0 \leq f^* = \frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L} \leq 1$".

[25] If $r_M \geq \delta_L - 1$, then, under condition (vi), $r_M < r_P = r$, and $r = r_M < r_P$, otherwise.

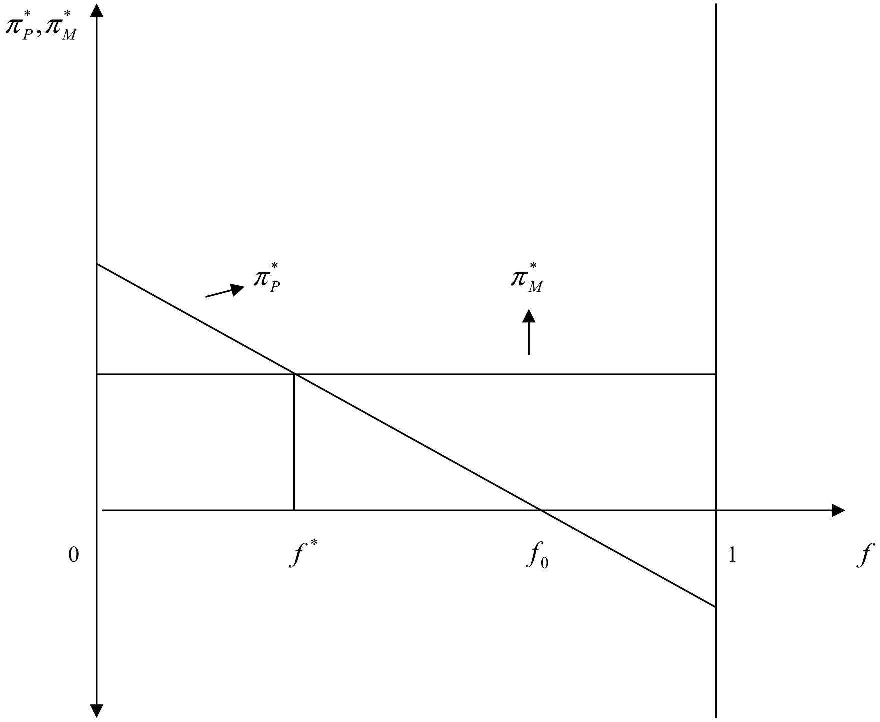

Fig. 18.2 Critical level of population proportion in the credit market

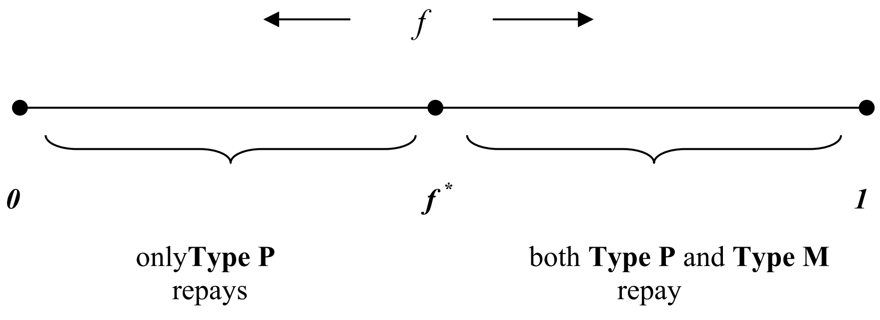

Fig. 18.3 Repayment based on population distribution

Proof From Eq. (18.12), it can be derived that,[26] $\frac{\partial f^*}{\partial Y} < 0$, $\frac{\partial f^*}{\partial p} < 0, \frac{\partial f^*}{\partial L} > 0$, $\frac{\partial f^*}{\partial \delta_L} > 0$, $\frac{\partial f^*}{\partial \delta_M} < 0$ and $\frac{\partial f^*}{\partial \delta_P} \geq 0$ provided, $r_M \geq \delta_L - 1$. ■

Changes in the value of the parameters in Eq. (18.13) result in the variation of f^*. This will, in turn, alter the rates offered by the lender and his corresponding pay-offs.

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[26] The derivations are given in Appendix "Derivatives of f^* with Respect to Different Parameters".

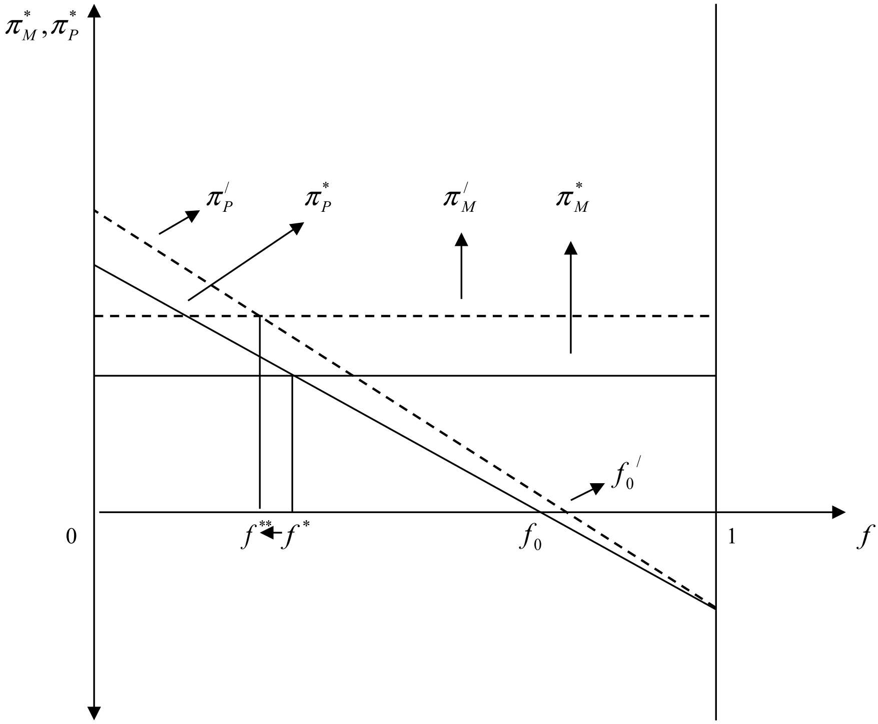

Fig. 18.4 Effects of changes in Y and p

The decision on the interest rate structure thus depends on all the paramters of this credit market via f^*.

With an increase in the return from any successful project (Y), even the Type M borrowers become more future oriented and want a regular access to loan in the following period. Similarly, an increase in p indicates a congenial state of the nature, which guarantees a good return from a project for all the borrowers. Both of these factors lower the threshold level of f below f^* and allow the lender to earn $\pi_M^* > \pi_P^*$ for a considerable range of f. Here the lender charges $r = r_M < r_P$ and gets loan repayment from both types of borrowers. However, it is interesting to note that if the credit market, to begin with, has fraction of myopic borrowers $f > f^*$ or $f < f^{**}$, then their equilibrium market interest rate increases unambiguously (since both $r_M < r_M^*$ and $r_P < r_P^*$ increase), whereas, for $f^{**} \leq f \leq f^*$, the market interest rate increases (i.e. $r_P < r_M^*$) if and only if $\frac{(\delta_P - \delta_M)}{\delta_M} < \frac{\Delta p}{p}$[27] and $\frac{(\delta_P - \delta_M)}{\delta_M} < \frac{\Delta Y}{Y}$.[28] This is shown in Fig. 18.4.

Again, a lender with high degree of future orientation will always try to establish long-term lending relationships with borrowers who are patient in nature. Hence,

[27] Refer to Appendix "Impact of Change in p on Market Interest Rate".

[28] Refer to Appendix "Impact of Change in Y on Market Interest Rate".

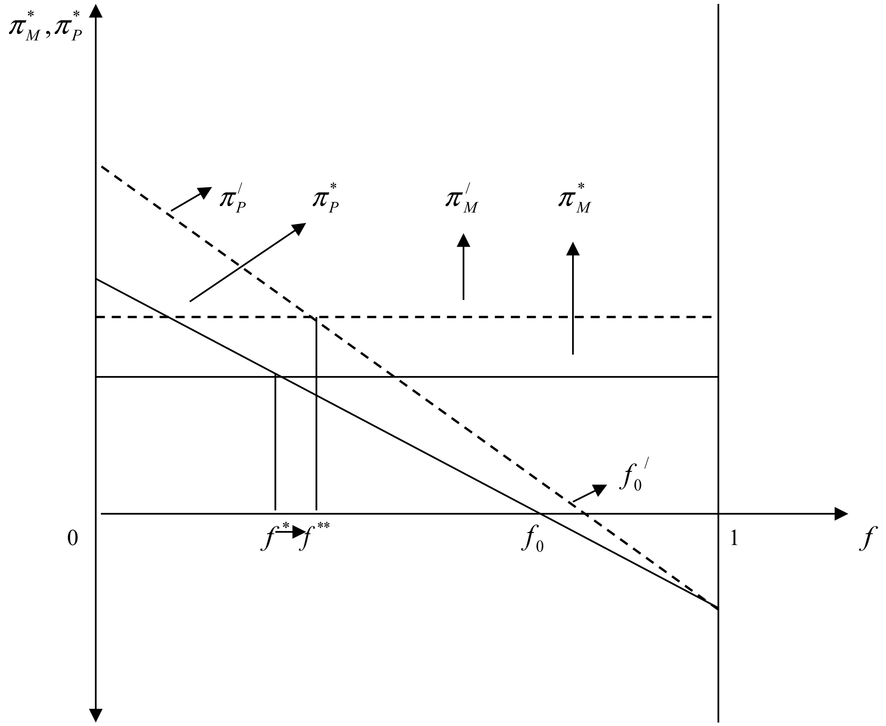

Fig. 18.5 Effects of changes in δ_L

the lender will charge an interest rate typical to the patient borrowers and try to concentrate more on long-term untainted credit relationships. However, this has no effect on the equilibrium value of either $r = r_M$ or $r = r_P$. This can be seen in Fig. 18.5.

On the other hand, as the loan size increases, i.e. at higher values of L, the risky borrowers are less likely to stay disciplined and will have more incentive to strategically default. Hence, it is beneficial for the lender to concentrate on the patient borrowers only.[29] Also in this case, the market interest rate falls if the proportion of myopic borrowers in the market is either $f < f^*$ or $f > f^{**}$, since, $r_M^* < r_M$ and $r_P^* < r_P$. For those lying between $f^{**} \geq f \geq f^*$, the interest rate also falls, i.e. $r_F^* < r_M$ iff, $\frac{(\delta_P - \delta_M)}{\delta_M} < \frac{\Delta L}{L}$.[30] This is shown in Fig. 18.6.

However, while framing a credit contract, the lender is primarily concerned about the change in the values of δ_M and δ_P. The behaviour of the myopic borrowers will be more reserved in the current period if they start valuing their future more (with

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[29] Refer to Besley and Coate (1995), Morduch (1999) and Tedeschi (2006). These literatures show that future guarantees in the form of increasing loan size can help in disciplining the risky borrowers. This is done by the lender offering dynamic incentive schemes.

[30] Refer to Appendix "Impact of Change in L on Market Interest Rate".

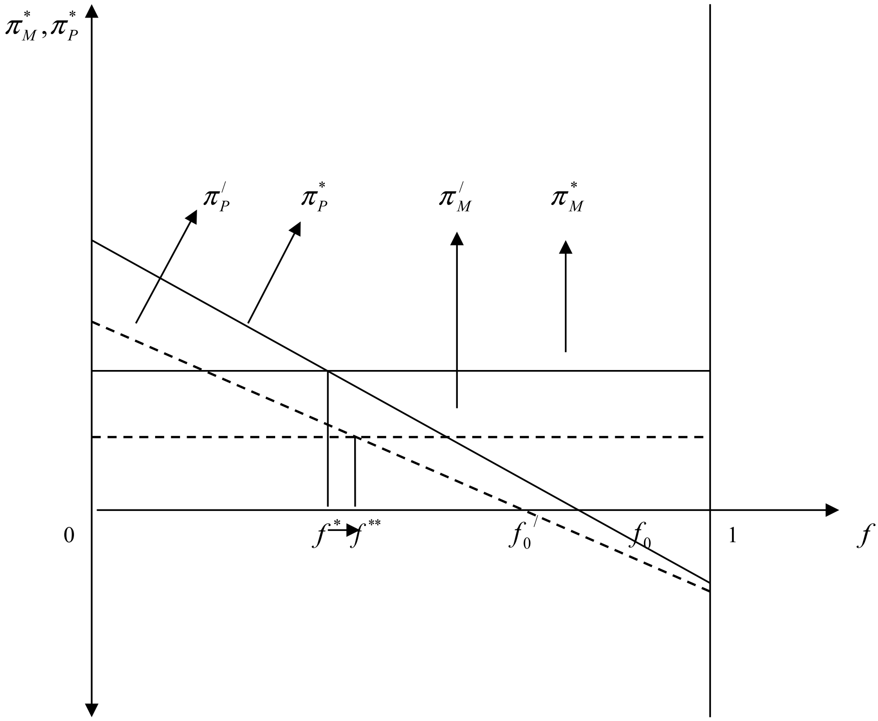

Fig. 18.6 Effects of change in L

high values of δ_M), whereby the lender can charge $r = r_M < r_P$ and get loan repayment from both types of borrowers. In this case if the proportion of myopic borrowers in the market is $f < f^{**}$, then the lender continues to charge the interest rate corresponding to the patient forward-looking type $r = r_P$. If the proportion of myopic borrowers $f > f^*$, then they face $r = r^*_M > r_M$. However for those $f^{**} \leq f \leq f^*$, the interest rate increases iff $\frac{(\delta_P - \delta_M)}{\delta_M} < \frac{\Delta\delta_M}{\delta_M}$.[31] This is shown in Fig. 18.7.

Again, Fig. 18.8 shows that if the forward-looking patient borrowers assign a higher value to their future income streams (with higher values of δ_P), it allows the lender to raise the interest rate typical to this type, i.e. $r = r_P = \frac{Y}{L} p\delta_P - 1$. In this case, the monopoly rent derived from charging a peak rate targeting only the Type P borrowers can be high enough in order to compensate for the loss accrued from the strategic defaults of the myopic ones.[32] Thus, a lower valuation of future pay-off by the patient borrowers will equilibriate the market interest to $r = r_M < r_P$. Here if the credit market, to begin with, has the proportion of myopic borrowers given

[31] Refer to Appendix "Impact of change in δ_M on market interest rate".

[32] Bottomley (1964) relates monopoly rent to higher interest rates in rural areas in underdeveloped countries.

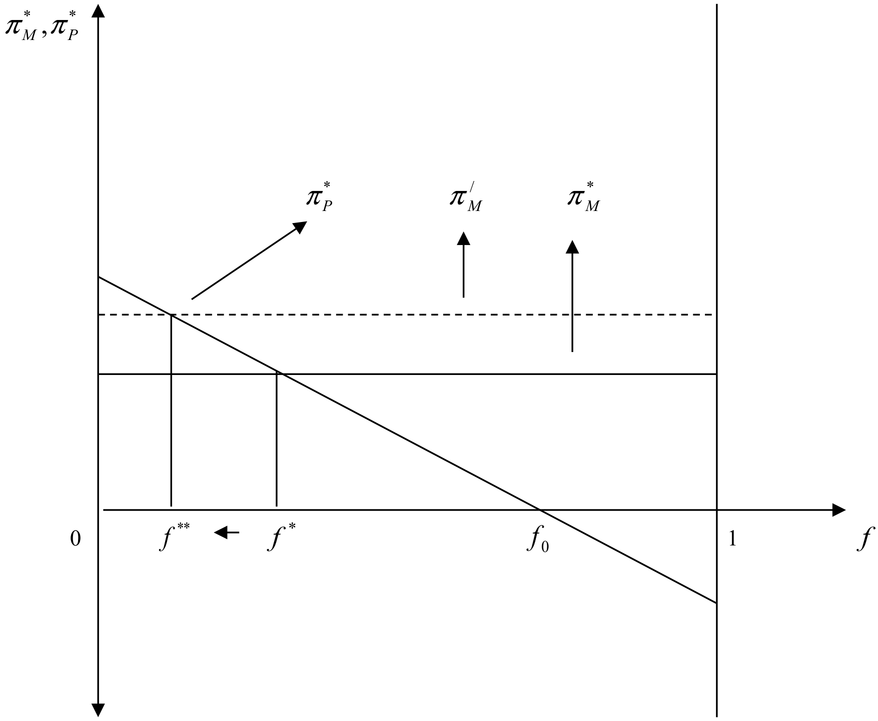

Fig. 18.7 Effects of changes in δ_M

by $f > f^{**}$, they continue to face the same unchanged interest rate $r = r_M$. For $f < f^*$, they face $r = r^*_P > r_P$. However for those $f^{**} \geq f \geq f^*$, they now face r^*_P where $r = r^*_P > r_M$.

18.6 Conclusion

The lender's risk hypothesis asserts that interest rates will be higher for groups of borrowers for whom the chance of individual default is perceived to be higher than the interest rates for cohorts in which lending to individual borrowers is thought to be less risky to cover for the higher expected loss from default. Basu (1997) uses this idea to construct an explanation for relatively higher rural interest rates compared to urban interest rates and then argues that this is an unsatisfactory explanation because lenders in rural areas typically lend to those whom they know well and can enforce repayment.

In this paper, we show that interest rates are higher when default risks are smaller. Our result does not depend on the differences in abilities of lenders to enforce repayment. Our borrowers invest in identical risky projects, and all borrowers require the

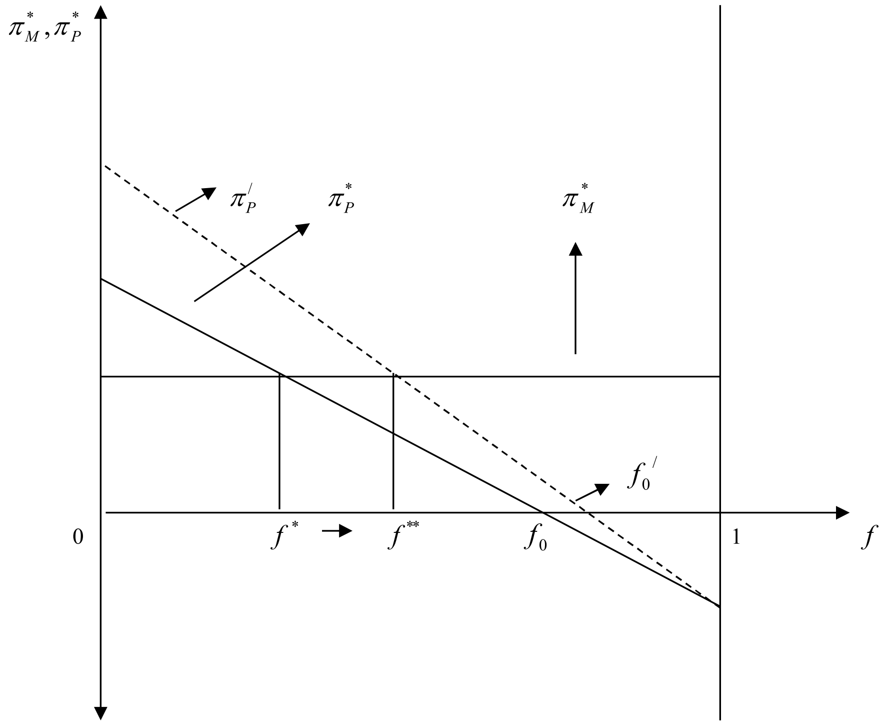

Fig. 18.8 Effects of changes in δ_P

same amount of loan from the lender. What drives the result is the differences in valuation of maintaining unblemished credit records among borrowers. We show that if lenders are unable to distinguish between patient and myopic borrowers a priori, a cohort of borrowers that has a sufficiently high proportion of patient borrowers will be charged a higher interest rate than if the proportion falls below a critical level. In the repeated game framework that we use, the myopic borrowers will default in the first period and will be disbarred from all future borrowing in this case. If the proportion of patient borrowers falls below a critical level, then the lender will charge a lower interest rate at which no one defaults, and the patient borrowers end up paying a lower interest than what they would be willing to pay.

We completely characterize this critical proportion of patient borrowers in the population and show that it depends on the output if the project is successful, the probability of success, size of the loan, and the discount factors of the patient and myopic borrowers, and the discount factor of the lender. We show that a rise in the pay-off of a successful project (Y), as also a rise in the probability of a project being successful (p), leads to a rise in the market interest rate irrespective of the proportion of patient borrowers in the population if the percentage change in Y (respectively p) lies above a critical level. Otherwise, for a range of values of the proportion of patient borrowers in the population, the market interest rate falls if the actual value of the proportion lies within it and rises otherwise. In a similar fashion, we can also show that if either the lender (δ_L) or each type of borrowers (δ_P and δ_M) become more future oriented thereby valuing their future pay-offs more, then the market interest will rise as long as the rate of change of the concerned parameter is more than a critical value. With respect to a change in the size of the loan (L), also a similar result is shown.

In related work, we are exploring the role played by social networks in the credit market. Networks are viewed as informal institutions that use reputation devices to enforce compliance and, hence, explore the implications that network may have for the pattern of credit contracts.

Appendix

Determination of Critical Level of Population Proportion

Comparing the two profit functions in Eqs. (18.8) and (18.11), we find that $\pi_M^* < \pi_P^*$ provided

$$\Rightarrow \frac{NL[p(1+r_M)-1]}{1-\delta_L p} < NL[p(1-f)(1+r_P)-1] + \frac{\delta_L p(1-f)NL[p(1+r_P)-1]}{1-\delta_L p}$$

$$\Rightarrow [p(1+r_M)-1] < [p(1-f)(1+r_P)-1](1-\delta_L p) + \delta_L p(1-f)[p(1+r_P)-1]$$

$$\Rightarrow [p(1+r_M)-1] < p(1-f)(1+r_P) - \delta_L p^2(1-f)(1+r_P) - 1$$
$$+ \delta_L p + \delta_L p^2(1-f)(1+r_P) - \delta_L p(1-f)$$

$$\Rightarrow p(1+r_M) < p(1-f)(1+r_P) + \delta_L p - \delta_L p(1-f)$$

$$\Rightarrow (1+r_M) - (1+r_P) < -f(1+r_P) + \delta_L(1-1+f)$$

$$\Rightarrow (r_M - r_P) < -f(1+r_P) + f\delta_L$$

$$\Rightarrow (r_P - r_M) > f[(1+r_P) - \delta_L]$$

$$\Rightarrow f < \frac{(r_P - r_M)}{1 + r_P - \delta_L}$$

$$\Rightarrow f < \frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L} \tag{18.14}$$

Determination of Critical Level of Population Proportion with Growing Population of Borrowers

Let us consider that the population grows at the rate k of the previous period population. Given this if the lender charges the lower of the two interest rates, i.e. $r = r_M < r_P$, then in the first period the lender's net profit is given by

$$\begin{aligned}\pi_M =& - NL + pNL(1 + r_M)\\ =& NL[p(1 + r_M) - 1]\end{aligned}$$

In the second period, the total pool of borrower comprises pN number of old borrowers and kN number of new entrants in the market. Given that the lower of the two interest rates is charged, in a good state both types repay. Thus, the lender's net profit in this period is

$$\begin{aligned}\pi_M =& - [pNL + kNL] + pNL[p(1 + r_M) + k(1 + r_M)]\\ =& NL(p + k)[p(1 + r_M) - 1]\end{aligned}$$

In the third period, the borrower pool comprises p^2N number of borrowers from the first period, pkN from the second period and $k(1 + k)N$ number of new third period entrants. Given this the net profit of the lender is

$$\begin{aligned}\pi_M =& - [p^2NL + pkNL + k(1 + k)NL] + pNL\big[p^2(1 + r_M)\\ &+ pk(1 + r_M) + k(1 + k)(1 + r_M)]\\ =& NL\big[p^2 + pk + k(1 + k)\big][p(1 + r_M) - 1]\end{aligned}$$

Proceeding this way, the present value of the expected lifetime profit of the lender is given by

$$\begin{aligned}\pi_M^* =& NL[p(1 + r_M) - 1] + \delta_L[NL(p + k)\{p(1 + r_M) - 1\}]\\ &+ \delta_L^2\big[NL\{p^2 + pk + k(1 + k)\}\{p(1 + r_M) - 1\}\big] + \ldots\\ =& NL[p(1 + r_M) - 1]\big[1 + \delta_L(p + k) + \delta_L^2\{p^2 + pk + k(1 + k)\} + \ldots\big]\\ =& NL[p(1 + r_M) - 1]\big[(1 + \delta_L p + \delta_L^2 p^2 + \ldots)\\ &+ \delta_L k(1 + \delta_L p + \delta_L^2 p^2 + \ldots) + \delta_L^2 k(1 + k)(1 + \delta_L p + \delta_L^2 p^2 + \ldots) + \ldots\big]\\ =& NL[p(1 + r_M) - 1]\left[\frac{1}{1 - \delta_L p} + \frac{\delta_L k}{1 - \delta_L p} + \frac{\delta_L^2 k(1 + k)}{1 - \delta_L p} + \ldots\infty\right]\\ =& NL[p(1 + r_M) - 1]\left[\frac{1}{1 - \delta_L p} + \frac{\delta_L k}{1 - \delta_L p}\{1 + \delta_L(1 + k) + \ldots\}\right]\\ =& NL[p(1 + r_M) - 1]\left[\frac{1}{1 - \delta_L p} + \frac{\delta_L k}{(1 - \delta_L p)\{1 - \delta_L(1 + k)\}}\right]\\ =& NL[p(1 + r_M) - 1]\left[\frac{1 - \delta_L}{(1 - \delta_L p)\{1 - \delta_L(1 + k)\}}\right] \qquad (18.15)\end{aligned}$$

On the other hand, if the lender charges the higher of the two interest rates, i.e. $r_M < r_P = r$, then only Type P repays while in every period Type M will strategically default after applying for credit pretending to be a Type P borrower. Given this the net profit of the lender in the first period is

$$\pi_P = -NL + p(1-f)NL(1+r_P)$$

From second period onwards, every period only Type P will repay their credit even though both types of new entrants in the market will apply for fresh credit. However, once a Type M borrower has strategically defaulted the lender in any period, he will have a credit embargo in the succeeding periods. Given this the net pay-off of the lender in the second period is

$$\pi_P = -NL[p(1-f)+k] + p(1-f)NL(1+r_P)(p+k)$$

Similarly, in the third period the net profit of the lender is

$$\begin{aligned}\pi_P = & -NL\left[p^2(1-f) + p(1-f)k + k(1+k)\right] \\ & + p(1-f)NL(1+r_P)\left\{p^2 + pk + k(1+k)\right\}\end{aligned}$$

Proceeding this way, the present value of the expected lifetime profit of the lender is

$$\begin{aligned}\pi_P^* = & NL[p(1-f)(1+r_P)-1] + \delta_L NL[\{p(1-f)\{p(1+r_P)-1\} \\ & +k\{p(1-f)(1+r_P)-1\}] + \delta_L^2 NL\left[\{p^2(1-f)\right. \\ & +p(1-f)k\}\{p(1+r_P)-1\} + k(1+k)\{p(1-f)(1+r_P)-1\}] + \dots \\ = & NL[p(1-f)(1+r_P)-1]\left\{1 + k\delta_L + k(1+k)\delta_L^2 + \dots\right\} \\ & + \frac{\delta_L pNL(1-f)\{p(1+r_P)-1\}}{1-\delta_L p} + \frac{\delta_L^2 pkNL(1-f)\{p(1+r_P)-1\}}{1-\delta_L p} \\ & + \frac{\delta_L^3 pk(1+k)NL(1-f)\{p(1+r_P)-1\}}{1-\delta_L p} + \dots \\ = & NL[p(1-f)(1+r_P)-1]\left\{1 + \frac{k\delta_L}{1-(1+k)\delta_L}\right\} \\ & + \frac{\delta_L pNL(1-f)\{p(1+r_P)-1\}}{1-\delta_L p}\left\{1 + \frac{k\delta_L}{1-(1+k)\delta_L}\right\} \\ = & [NL\{p(1-f)(1+r_P)-1\} \\ & + \frac{\delta_L pNL(1-f)\{p(1+r_P)-1\}}{1-\delta_L p}\Bigg]\left[\frac{1-\delta_L}{1-(1+k)\delta_L}\right]\end{aligned} \tag{18.16}$$

Comparing the two profit functions in π_M^* and π_P^*, we find that $\pi_M^* < \pi_P^*$ provided

$$\Rightarrow NL[p(1+r_M)-1]\left[\frac{1-\delta_L}{(1-\delta_L p)\{1-\delta_L(1+k)\}}\right] < [NL\{p(1-f)(1+r_P)-1\}$$
$$+\frac{\delta_L pNL(1-f)\{p(1+r_P)-1\}}{1-\delta_L p}\Bigg]\left[\frac{1-\delta_L}{1-(1+k)\delta_L}\right]$$
$$\Rightarrow [p(1+r_M)-1] < [p(1-f)(1+r_P)-1](1-\delta_L p)$$
$$+\delta_L p(1-f)[p(1+r_P)-1]$$
$$\Rightarrow [p(1+r_M)-1] < p(1-f)(1+r_P)-\delta_L p^2(1-f)(1+r_P)-1$$
$$+\delta_L p+\delta_L p^2(1-f)(1+r_P)-\delta_L p(1-f)$$
$$\Rightarrow p(1+r_M) < p(1-f)(1+r_P)+\delta_L p-\delta_L p(1-f)$$
$$\Rightarrow (1+r_M)-(1+r_P) < -f(1+r_P)+\delta_L(1-1+f)$$
$$\Rightarrow (r_M-r_P) < -f(1+r_P)+f\delta_L$$
$$\Rightarrow (r_P-r_M) > f[(1+r_P)-\delta_L]$$
$$\Rightarrow f < \frac{(r_P-r_M)}{1+r_P-\delta_L}$$
$$\Rightarrow f < \frac{Yp(\delta_P-\delta_M)}{Yp\delta_P-L\delta_L} \tag{18.17}$$

Sufficiency Condition of $0 \le f^* = \frac{Yp(\delta_P-\delta_M)}{Yp\delta_P-L\delta_L} \le 1$

$f^* = \frac{Yp(\delta_P-\delta_M)}{Yp\delta_P-L\delta_L} \ge 0$ if both the numerator and denominator are of the same sign. Since $\delta_M < \delta_P$ by our model specification, hence, the numerator becomes positive. Thus, in order to make the denominator positive, we need

$$Yp\delta_P-L\delta_L > 0$$
$$\Rightarrow Yp\delta_P > L\delta_L$$
$$\Rightarrow \frac{Yp\delta_P}{L} > \delta_L$$
$$\Rightarrow \frac{Yp\delta_P}{L}-1 > \delta_L-1$$
$$\Rightarrow r_P > \delta_L-1 \tag{18.18}$$

The above condition is always true since, $r_P > 0 > -(1-\delta_L)$.

Similarly, in order to guarantee $f^* = \frac{Yp(\delta_P-\delta_M)}{Yp\delta_P-L\delta_L} \le 1$, we need the numerator to be lesser than the denominator, i.e.

$$
\begin{aligned}
& Yp(\delta_P - \delta_M) \leq Yp\delta_P - L\delta_L \\
\Rightarrow & - Yp\delta_M \leq -L\delta_L \\
\Rightarrow & Yp\delta_M \geq L\delta_L \\
\Rightarrow & \frac{Yp\delta_M}{L} \geq \delta_L \\
\Rightarrow & \frac{Yp\delta_M}{L} - 1 \geq \delta_L - 1 \\
\Rightarrow & r_M \geq \delta_L - 1
\end{aligned} \tag{18.19}
$$

The above condition is always true since, $r_M > 0 > -(1 - \delta_L)$.

Derivatives of f^* with Respect to Different Parameters

The critical value of population proportion of myopic borrowers in the credit market below which it is always beneficial for the lender to charge the interest rate corresponding to Type P borrower is given by $f^* = \frac{Yp(\delta_P - \delta_M)}{Yp\delta_P - L\delta_L}$. We notice that the proportion of myopic borrowers f^* is a population parameter which is a function of the basic parameters of the model, i.e. $f^* = g(Y, p, L, \delta_L, \delta_M, \delta_P)$. The signs of the derivatives are as follows:

$$
\begin{aligned}
\frac{\partial f^*}{\partial Y} &= \frac{p(\delta_P - \delta_M)(Yp\delta_P - L\delta_L) - p\delta_P\{Yp(\delta_P - \delta_M)\}}{(Yp\delta_P - L\delta_L)^2} \\
&= \frac{(Yp^2\delta_P^2 - pL\delta_P\delta_L - Yp^2\delta_P\delta_M + pL\delta_M\delta_L) - (Yp^2\delta_P^2 - Yp^2\delta_P\delta_M)}{(Yp\delta_P - L\delta_L)^2} \\
&= \frac{-pL\delta_L(\delta_P - \delta_M)}{(Yp\delta_P - L\delta_L)^2} < 0 \quad \text{since } \delta_P > \delta_M
\end{aligned} \tag{18.20}
$$

$$
\begin{aligned}
\frac{\partial f^*}{\partial p} &= \frac{Y(\delta_P - \delta_M)(Yp\delta_P - L\delta_L) - Y\delta_P\{Yp(\delta_P - \delta_M)\}}{(Yp\delta_P - L\delta_L)^2} \\
&= \frac{(Y^2p\delta_P^2 - YL\delta_P\delta_L - Y^2p\delta_P\delta_M + YL\delta_M\delta_L) - (Y^2p\delta_P^2 - Y^2p\delta_P\delta_M)}{(Yp\delta_P - L\delta_L)^2} \\
&= \frac{-YL\delta_L(\delta_P - \delta_M)}{(Yp\delta_P - L\delta_L)^2} < 0 \quad \text{since } \delta_P > \delta_M
\end{aligned} \tag{18.21}
$$

$$
\begin{aligned}
\frac{\partial f^*}{\partial L} &= - \frac{Yp(\delta_P - \delta_M)}{(Yp\delta_P - L\delta_L)^2}(-\delta_L) \\
&= \frac{Yp\delta_L(\delta_P - \delta_M)}{(Yp\delta_P - L\delta_L)^2} > 0 \quad \text{since } \delta_P > \delta_M
\end{aligned} \tag{18.22}
$$

$$\begin{aligned}\frac{\partial f^*}{\partial \delta_L} &= -\frac{Yp(\delta_P - \delta_M)}{(Yp\delta_P - L\delta_L)^2}(-L)\\ &= \frac{YpL(\delta_P - \delta_M)}{(Yp\delta_P - L\delta_L)^2} > 0 \quad \text{since } \delta_P > \delta_M \end{aligned} \tag{18.23}$$

$$\frac{\partial f^*}{\partial \delta_M} = \frac{-Yp}{Yp\delta_P - L\delta_L} < 0 \quad \text{as long as } r_P > -(1-\delta_L) \tag{18.24}$$

$$\begin{aligned}\frac{\partial f^*}{\partial \delta_P} &= \frac{Yp(Yp\delta_P - L\delta_L) - Yp\{Yp(\delta_P - \delta_M)\}}{(Yp\delta_P - L\delta_L)^2}\\ &= \frac{(Y^2p^2\delta_P - YpL\delta_L) - (Y^2p^2\delta_P - Y^2p^2\delta_M)}{(Yp\delta_P - L\delta_L)^2}\\ &= \frac{Yp(Yp\delta_M - L\delta_L)}{(Yp\delta_P - L\delta_L)^2} > 0 \quad \text{as long as } r_M > -(1-\delta_L)\end{aligned} \tag{18.25}$$

Impact of Change in *p* on Market Interest Rate

Let the new interest rate paid by Type M borrowers is $r_M^* = \frac{(p+\Delta p)\delta_M Y}{L} - 1$ and the old one paid my Type P borrowers is $r_P = \frac{Y\delta_P p}{L} - 1$. For the proportion of myopic borrowers lying within the range, the equilibrium market interest rate increases iff

$$\begin{aligned}& r_P < r_M^*\\ \Rightarrow & \frac{Y\delta_P p}{L} - 1 < \frac{(p+\Delta p)\delta_M Y}{L} - 1\\ \Rightarrow & \frac{(\delta_P - \delta_M)}{\delta_M} < \frac{\Delta p}{p}\end{aligned}$$

Impact of Change in *Y* on Market Interest Rate

Let the new interest rate paid by Type M borrowers is $r_M^* = \frac{(Y+\Delta Y)\delta_M p}{L} - 1$ and the old one paid my Type P borrowers is $r_P = \frac{Y\delta_P p}{L} - 1$. For the proportion of myopic borrowers lying within the range, the equilibrium market interest rate increases iff

$$\begin{aligned}& r_P < r_M^*\\ \Rightarrow & \frac{Y\delta_P p}{L} - 1 < \frac{(Y+\Delta Y)\delta_M p}{L} - 1\end{aligned}$$

$$\Rightarrow \frac{(\delta_P - \delta_M)}{\delta_M} < \frac{\Delta Y}{Y}$$

Impact of Change in L on Market Interest Rate

Let the new interest rate paid by Type M borrowers is $r_M^* = \frac{Y\delta_M p}{(L+\Delta L)} - 1$ and the old one paid my Type P borrowers is $r_P = \frac{Y\delta_P p}{L} - 1$. For the proportion of myopic borrowers lying within the range, the equilibrium market interest rate increases iff

$$\begin{aligned} & r_P < r_M^* \\ \Rightarrow & \frac{YVp}{L} - 1 < \frac{Y\delta_M p}{(L+\Delta L)} - 1 \\ \Rightarrow & \frac{(\delta_P - \delta_M)}{\delta_M} < \frac{\Delta L}{L} \end{aligned}$$

Impact of change in δ_M on market interest rate

Let the new interest rate paid by Type M borrowers is $r_M^* = \frac{Y(\delta_M+\Delta\delta_M)p}{L} - 1$ and the old one paid my Type P borrowers is $r_P = \frac{Y\delta_P p}{L} - 1$. For the proportion of myopic borrowers lying within the range, the equilibrium market interest rate increases iff

$$\begin{aligned} & r_P < r_M^* \\ \Rightarrow & \frac{Y\delta_P p}{L} - 1 < \frac{Y(\delta_M + \Delta\delta_M)p}{L} - 1 \\ \Rightarrow & \frac{(\delta_P - \delta_M)}{\delta_M} < \frac{\Delta\delta_M}{\delta_M}. \end{aligned}$$

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Chapter 19
Financial Inclusion in India: An Intertemporal Study

Papita Dutta

19.1 Introduction

Financial inclusion refers to the bringing of unbanked section of population under the purview of formal banking system in a sustainable manner. It implies the provision of timely, adequate, affordable, and sustainable formal financial services like saving, credit, insurance services, equity, and access to remittance facilities to the unbanked people. RBI defines financial inclusion as '*The process of ensuring access to financial services and timely and adequate credit where needed by vulnerable groups such as weaker sections and low income groups at an affordable cost*.' Unbanked people are those who are beyond the reach of formal financial institutions. Financial inclusion is recognized as an easy and cost-effective instrument to achieve the goal of inclusive development across the world. The sustainable development goal will remain unattainable, until maximum people come under formal banking system. Financial inclusion not only protects the vulnerable and deprived population, who borrow from spurious village money lenders at a higher borrowing cost, it also direct their liquid asset in productive channel with some interest earning rather than keeping it under a mattress. It helps rural poor people by making them self-sufficient and better financial decision taker. The easy availability of financial services such as savings and payment account, credit and credit insurance, pensions, etc. helps individuals and firms to invest maximum amount in business opportunities, education, save for retirement, insurance against risks, save for unpredictable situations, etc. It helps the poor to receive appropriate and timely payments of several social security measures through the Direct Cash Transfer program. Thus, it plays a crucial role in preventing concentration of economic power with a few individuals and corruption. Financial inclusion is also recognized as a tool to alleviate income poverty and inequality from the country and accelerate the economic growth (Banerjee & Newman, 1993; Beck, et al., 2009; Nanda, 2019; World Bank, 2008). A report of Reserve Bank of India

P. Dutta (✉)
Gushkara Mahavidyalaya, Gushkara, Purba Bardhaman, West Bengal, India

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prepared by Chattopadhyay (2011) claims that financial exclusion in India leads to the loss of one percentage of GDP. Keeping in view the potentiality of financial inclusion for socio-economic development, providing institutional financial services to the excluded population is, now, become an area of concern for policymakers. Across the world, different initiatives have been taken towards complete financial inclusion. The government of India has long focused on financial inclusion as a means of development and the most recent effort Prime Minister Jan DhanYojana (PMJDY) has been working since August 28, 2014. The basic objective of this Yojana is to ensure the access to basic financial services at an affordable cost to the deprived section of population, i.e., households belonging to lower castes, minority religion, and communities, low income groups, and unbanked women. The basic financial services include the access to formal savings facilities, need based credit, remittances facilities, micro insurance, pension facilities, and financial literacy. In order to smooth the provision of the services, PMJDY emphasizes on financial literacy and centrally addresses the problems of IT network and effective use of the technology by the target population. In this scheme, a person belonging to disadvantaged section open a bank account even with zero balance producing a valid photo identity card. With this account, the holder gets a RuPay debit card which covers accidental insurance benefit of one lakh rupees and life insurance of rupees thirty thousands. Holding the account for at least six months, the holder's household preferably a woman can avail a need based formal credit up to Rs. 5000.00. The account holder can also enjoy the mobile banking facility and Rupay Kisan Credit Card facility under this scheme. Nowadays through the PMJDY, poor people get government payment, access to pension, and other insurance products. RBI has also taken several initiatives like relaxation of KYC norms, 'no-frills' accounts, Kisan Credit Cards, 'General Credit Cards,' etc. to accelerates the financial inclusion. Moreover, in recent times, remarkable development in the field of internet-based information technology empowers banking sector to provide services beyond the official hours and the customers to get hassle free access to most of the financial services.

Despite the development of high tech banking infrastructure, a large section of population in the world manage their personal finance beyond the coverage of banking network. Refer to Table 19.1. In 2011, half of the world's adult population did not have any type of bank account. In 2017, almost one-third of world's adult population (31.5%) did not have a bank account. The situation is more precarious in respect of access to credit. Only, 22.5% of the adult population in the world borrowed from a financial institution or used a credit card in 2017. In India, eighty percent of population aged above 15 years holds at least one bank account in 2017 which was 35 (52)% in 2011(2014). Moreover, the numbers of bank branches and ATMs per thousand populations have increased considerably during the last decades. But it is not surprising that 38.7% of the bank accounts were inactive in India during the 2017. Thus, opening a bank account is not really enough to understand the extent and sustainability of financial inclusion. Only 8.1% of the adult people in India get access to formal credit or used credit card in 2017 although 42% of the adult population borrowed from any source during the same period. Moreover, the status of the access to formal credit is unchanged during the period 2011–2017. The position of India compared to world

Table 19.1 Basic indicators of financial inclusion of India, South Asia, and lower middle income groups

Indicators	India	South Asia	Lower middle income group
Account (% age 15+)			
All adults, 2017	79.9	69.6	57.8
All adults, 2014	53.1	46.5	41.9
All adults, 2011	35.2	32.4	28.9
Inactive account in the past year (% age 15+)			
No deposit and no withdrawal from an account, 2017	38.5	31.2	21.6
Saving in the past year (% age 15+)			
Saved at a financial institution, 2017	19.6	17.2	15.9
Saved at a financial institution, 2014	14.4	12.7	14.4
Saved using a savings club or person outside the family, 2017	8.4	10.2	13.0
Saved any money, 2017	33.6	33.2	39.7
Credit in the past year (% age 15+)			
Borrowed from a financial institution or used a credit card, 2017	8.1	7.8	9.8
Borrowed from a financial institution or used a credit card, 2014	9.1	8.6	10.0
Borrowed from family or friends, 2017	32.7	31.3	30.4
Borrowed any money, 2017	42.4	41.5	42.9

Source World Bank (2018)

average the South Asian average and average of lower middle income countries is better in terms of account holding, access to formal savings. However, in respect of the access to formal credit and sustainability of the account, holding the position of India lies below the world average, the averages of South Asian countries, and lower middle income countries. Therefore, the question is why the position of India in respect of the extent of financial inclusion is below the averages of South Asian countries and lower middle income countries despite the tremendous development of financial drivers and government initiatives.

19.2 Literature Review and Measures of Financial Inclusion

Financial inclusion at the macrolevel has been initially measured by the unidimensional indicators like the number of bank accounts per lakh population, number of bank branches and ATM counters per lakh population, savings–income ratio, credit–

income ratio, credit–deposit ratio (Beck et al., 2009; Conrad et al., 2009; Peachy & Roe, 2006). However, any one of these individual indicators is not enough to explore the true nature of the financial inclusion of a community. There indicators collectively should be used to measure the extent of financial inclusion of a community or of a country. There has also been attempts for measuring financial inclusion index using multiple indicators and dimensions (Arora, 2010; Bagli & Adhikary, 2013; Gupte et al., 2012; Kumar & Mishra, 2009; Sarma, 2008). Sarma (2008) has computed FII of the 49 countries applying inverse of Euclidian distance method. She has and found the value of FII 0.194 for India in 2004 which belongs to the category of low level financial inclusion. Kumar and Mishra (2009) have estimated the FII index for banking outreach using distance-from-average method. Arora (2010) has computed the FII for 60 countries covering wide range of dimension and indicators. He has computed the arithmetic mean of the dimension index and found that the rank of India is 29 with the value of FII 0.062 for the year 2008. Gupte et al. (2012) compute the financial inclusion index as geometric mean of four dimensions, namely outreach (penetration and accessibility), usage, ease of transactions, and cost of transactions. This study shows that financial inclusion index for India has increased from the year 2008 to the year 2009. Bagli and Dutta (2012) have computed the FII for the Indian states applying principal component analysis and revealed a low mean high variance of financial inclusion across the states in 2010. Bagli and Adhikary (2013) covering three dimensions of financial inclusion—diffusing, widening, and deepening—have computed the FII for the states and reported a simultaneous relation between human development and financial inclusion in 2010. Sing et al. (2014) have identified that in India people in the unbanked areas do not understand the need of a bank account at all and the benefits of formal loans over the loans from informal sources. Lack of a strong network and unsuitable financial instruments (for rural people) hinders the objective of achieving financial inclusion. They suggest that by giving more incentives for the BCs, utilizing existing network for banking such as post offices, creating awareness for the use of modern banking technologies like mobile may create a big difference in the economy. Garg and Agarwal (2014) explain how financial inclusion is important for overall economic development of a country by focusing on various approaches adopted by different Indian banks. They found that the different endeavors of financial inclusion are not yielding expected result. According to them, a suitable regulatory environment is needed to maintain the interest of all the stakeholders. Ananth and SabriÖncü (2013) explain challenges and problems faced by the attempts of financial inclusion in the state of Andhra Pradesh (AP), India. The study recommend that efforts to expanding inclusion should be taken as long-term future investment rather than a capital cost or as a charitable expense. The time series analysis of FII and economic growth data for the 17 states in India for the period 1994–95 to 2015–16 conducted by Nanda (2019) explores a bidirectional and positive relationship between financial inclusion and economic growth, in the long as well as in the short run.

Therefore, the majority of the study has computed the FII for India as a whole covering different set of indicators. So far with this aggregate indicator, we cannot realize the distribution and dynamics of financial inclusion in India at the sub-national levels. No one study exclusively examines the intertemporal change of the extent of financial inclusion for the states and UTs in India and study the similarity of the sub-national units in respect of the selected indicators of financial inclusion. This study analyzes the achievement/failure in financial inclusion of the Indian states and union territories during the last decade.

This study has two objectives. First, this study illustrates the nature of distribution of financial inclusion across the states and union territories and its intertemporal change during the period 2011–12–2018–19. We thus compare the distribution of financial inclusion of the states and union territories before and after introduction of PMJDY. Second objective of the study is to investigate the similarity or dissimilarity of the states/UTs in respect of the selected indicators of financial inclusion for the same time points 2011–12, 2014–15, and 2018–19. It explores whether any change occurs or not in the clusters during the period.

19.3 Methodology and Data Sources

Usually, the extent of financial inclusion at the macrolevel is reported in respect of number of bank account per lakh population at a certain time. However, this unidimensional figure fails to report the true extent of financial inclusion. Financial inclusion is multidimensional phenomenon where dimensions are highly associated. There are two sides of the dimensions namely supply side and demand side. In order to cover these two sides, this study following the existing literature (Bagli & Adhikary, 2013; Chattopadhyay, 2011; Sarma, 2008) has considered three dimensions, namely availability of formal financial service centers, accessibility of the formal financial services and depth of utilization or applicability of the services. The dimensions are not perfectly substitutes rather they are very much interconnected. The availability of the banking infrastructure is not enough to ensure the accessibility of this service by the common people. But the availability is a primary condition for accessibility. Moreover, accessibility to financial infrastructure by the common people ensure the incidence of financial inclusion. It fails to capture the extent of utilization of the banning facilities. Thus, in addition to availability and accessibility, we should cover the nature of utilization or applicability of the banking facilities for measuring the degree of financial inclusion. Therefore, the three dimensions are important to explore the extent of financial inclusion of the sub-national units in India. Ignoring any one of them, the measure misleads the true degree of financial inclusion. We have taken two indicators for each dimension as mentioned in Table 19.2.

As FII is an achievement index, all the selected indicators are progressive in the sense that higher value of the indicators indicates the greater achievement. The goalpost values of an indicator, i.e., the best value and the worst value, are the maximum value and the minimum value of the indicator observed among the sub-national units for all three time points 2011–12, 2014–15, and 2018–19. In order to construct the FII for the sub-national units in India at three different time points, first we normalize the indicators applying range equalization method so that the values

Table 19.2 Dimensions and indicators along with their goalpost values of financial inclusion in India for the years 2012, 2015, and 2019

Dimension	Indicator	Goalposts Values of the Indicator	
		Best Value	Worst value
Availability	Number of ATM counters per lakh adult population (I_1)	90.50 (Chandigarh,2019)	3.85 (Manipur, 2012)
	Number of bank branches per lakh adult population (I_2)	59.41 (Goa, 2015)	5.10 (Manipur, 2012)
Accessibility	Number of deposit account per thousand adult population (I_3)	5239.84 (Chandigarh,2019)	420.66 (Manipur, 2012)
	Number of credit account per thousand adult population(I_4)	718.24 (Chandigarh,2019)	49.87 (Manipur, 2012)
Applicability	Amount of savings to net state domestic product (%) (I_5)	234.27 (Chandigarh,2015)	35.21 (Manipur, 2015)
	Amount of credit outstanding to net state domestic product (%) (I_6)	268.67 (Chandigarh,2012)	10.81 (Sikkim,2015)

Source Author's computation based on secondary data

of the indicators are unit free and lie between zero and one. Thus, the formula for normalization of an indicator,

$$A_{ijt} = \frac{I_{ijt} - \text{Worst value of } I_i}{\text{Best value of } I_i - \text{Worst value of } I_i} \tag{19.1}$$

where A_{ijt} denotes the achievement index of ith indicator for jth state/UT at time point t and I_{ijt} denotes the observed value of ith indicator for jth state/UT at time point t, $i = 1, 2, \ldots, 6$, for six indicators, $j = 1, 2, \ldots, 33$ for thirty three sub-national units, i.e., states and UTs, and $t = 1, 2, 3$ for three time points 2011–12, 2014–15, and 2018–19.

The second task is to determine the weightage for the indicators for constructing the composite index. Most of the previous studies has used equal weights for the dimensions/indicators. But the indicators are definitely interrelated so application of principal component analysis (PCA) for searching the weight for the indicators would be judicious. Thus, for each time point, this study has conducted PCA of the selected indicators for deriving the relative weights of the indicators with respect to the highest factor loadings on the respective indicators. The weighted arithmetic mean of the achievement index of the indicators for a sub-national unit at time point may be considered as a composite financial inclusion index. However, the arithmetic mean considers indicators as perfect substitutes and disregards inequality in the distribution. Extreme values affects considerably. With this end in view and following the UNDP methodology to measure HDI since 2010, we have computed weighted geometric mean of the achievement indexes of the indicators. The geometric mean reports the arithmetic mean reduced by the inequality in the distribution. Moreover, geometric mean does not consider the indicators as perfectly substitutes. Therefore, we compute the weighted geometric mean of the normalized values of the indicators for reporting the extent of financial inclusion index. The formula thus is as follows

$$FII_{jt} = \prod_{i=1}^{6} (I_{ijt})^{w_{it}} \tag{19.2}$$

where FII_{jt} indicates the financial inclusion index for jth state/UT for time point t and w_{it} stands for the relative weight of ith indicator at time t, i.e., $\sum_{i=1}^{6} w_{it} = 1$

The FII is an achievement index which lies between zero indicating complete financial exclusion and one indicating complete financial inclusion. With reference to the value of FII of the states at each time point, the states/UTs are ranked in descending order to identify the position of a sub-national unit.

The closeness of the value of FII of two states does ensure the similarity of the states in terms of the selected indicators of financial inclusion. In order to assess the closeness of the sub-national units, cluster analysis has been used for the indicators of financial inclusion. Cluster analysis is an exploratory data analysis technique which categorizes the subjects in our case the sub-national units, into groups where subjects are relatively homogeneous within the group and heterogeneous across the groups, on the basis of a defined set of variables. These groups are called cluster. The clusters are determined maximizing the homogeneity of the sub-national units in respect of the indicators within the clusters and their heterogeneity across the clusters. It is done by estimating the Euclidean distance matrix which is known as proximity matrix. As the indicators of financial inclusion are highly correlated first, we apply PCA and determine the factors. Finally, we have standardized the factors and apply cluster analysis based on the standardized factors to measure the closeness of the selected sub-national units based on the selected indicators of financial inclusion in India. Although there are several methods of clustering, we apply hierarchical clustering method as the indicators are quantitative and sample of states/UT is relatively small.

Hierarchical clustering method first computes the Euclidean distance among the states/UTs or centroids of the clusters to measure the similarity or dissimilarity among the states/UTs within the cluster and outside the cluster.

$$d_{ij} = \sqrt{\sum_{k=1}^{n} (D_{ik} - D_{jk})^2} \tag{19.3}$$

where d_{ij} is the Euclidian distance between the point 'i' and point 'j' and D_k is the kth indicator of financial inclusion of the state/UT and 'n' stands for number of indicator. The formula for the coordinates of the centroid of a cluster is

$$Y_k = \frac{\sum_{i=1}^{a} D_{ik}}{a} \tag{19.4}$$

Y_k is the coordinate of the centroid of the cluster along the axis k; D_{ik} is the coordinate of the point 'i' along the axis 'k'; and 'a' is the total number of states/UTs in the cluster.

The centroid linkage method has been applied to draw the dendrograms showing the possible clusters of the states/UTs in India. The average distance between two clusters is the mean of the Euclidian distance from one cluster to another cluster of the states/UTs. In cluster analysis, a numbers of groups are not predefined. At each stage of clustering, a pair of subjects is identified on the basis of the minimum distance which is termed as agglomeration coefficient at this stage. These two objects at this stage and the old cluster(s), if any, formed by any one of these two form a new cluster and replace the old cluster(s). The process continues until we find all objects in a single cluster. Number of clusters can be selected as per requirement. But the rule of thumb is that we stop at the stage where agglomeration coefficient changes extremely. This classification thus help us to compare the geographical clusters of the sub-national units which already exists in nature with the clusters formed on the basis of the indicators of FII. Thus, the analysis provides a clear message to the policymakers identifying the effectiveness or ineffectiveness of the regional specific financial inclusion policies.

Data Sources

We have constructed the financial inclusion index for 29 states and four major union territories in India for the years 2011–12, 2014–15, and 2018–19 to examine the intertemporal change in the extent of financial inclusion. The study has excluded the union territories Dadra and Naga Haveli, Daman and Diu, and Lakshadweep due to lack of data on net state domestic product. As the state of Telangana comes in picture in 2014, our sample size is 32 for the year 2011–12 and 33 for the rest two time points. The data for the study have been sourced from basic statistical returns annually published by Reserve Bank of India, (Reserve Bank of India (2020) Economic Survey, 2020-21 (Government of India, 2021)and Population Census 2011 (Government of India, 2011). We have computed adult population size, i.e., aged 18+ from census data 2011. Then using the projected growth rate of population of India for different years from the website of macrotrends, we have computed estimated adult population for the years 2011–12, 2014–15, and 2018–19. Finally, the values of the indicators have been calculated for selected states and union territories for three time points.

19.4 Findings and Discussion

The study is designed to assess the impact of PMJDY on the extent of financial inclusion of the states/UTs in India. For this purpose, this study has selected three time points: 2011–12 which is referred to as the time point prior to the implementation of PMJDY, 2014–15 the time of the implementation of the project, and 2018–19 the time of the post PMJDY. First, we discuss the nature of financial inclusion in India

Table 19.3 State of financial inclusion and its intertemporal change in India in respect of the selected indicators

Dimensions	Availability of banking Infrastructure		Accessibility to the banking infrastructure		Applicability of the banking infrastructure	
Year/Growth rate	No. of ATM per lakh adult population	No. of bank branches per lakh adult population	No. of deposit A/C per 1000 adult population	No. of credit A/C per 1000 adult population	Bank deposit relative to NSDP (%)	Bank credit relative to NSDP (%)
2011–12	12.33	12.99	1163.70	168.63	77.74	61.43
2014–15	24.95	16.25	1792.71	179.58	80.19	61.83
2018–19	27.09	17.36	2355.48	277.37	74.38	58.25
2011–12–2014–15	102.36	25.08	54.05	6.50	3.16	0.64
2014–15–2018–19	8.57	6.85	31.39	54.45	−7.25	−5.78
2011–12–2018–19	119.70	33.65	102.41	64.49	−4.31	−5.18

Source Author's computation based on secondary data

and its change during the last decade in respects of the selected indicators. Table 19.3 displays that in the beginning of the decade there were twelve ATM counters per lakh adult population which reaches twenty-seven per lakh adult population in 2018–19. The number of ATM per lakh population grew102% during 2011–12 to 2014–15, whereas the growth rate of ATM per lakh population was only 8.5% during the PMJDY era. However, the number of ATM per lakh population has growth at 119% rate during the last decade. The number of bank branches per lakh adult population increased from 13 in 2011–12 to 17 in 2018–19. Growth rate of this indicator is 33.6% during the decade but growth rate reduces during the post PMJDY. Therefore, the indicators under the dimension of the availability of banking infrastructure have grown considerable throughout the selected period irrespective of the introduction of the PMJDY in India as shown in Fig. 19.1. We have found the similar trend for the number of deposit accounts per 1000 adult population and for the number of credit accounts per 1000 adult population as shown in Fig. 19.2. The growth rate of

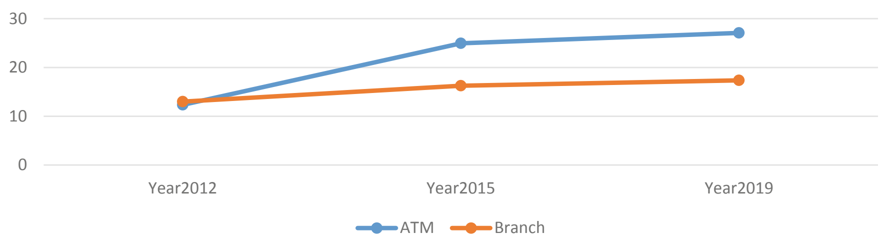

Fig. 19.1 Trend of the availability of basic banking facilities in India. *Source* Author's computation based on secondary data

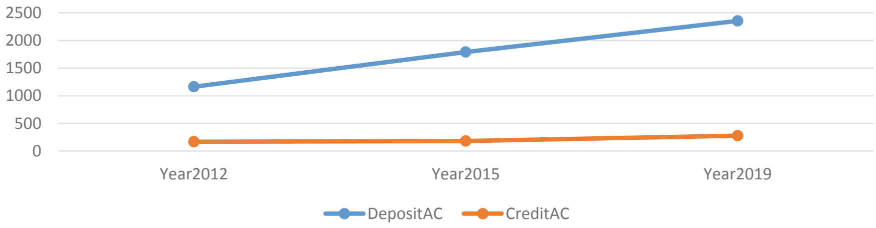

Fig. 19.2 Trend of the penetration of basic banking facilities in India. *Source* Author's computation based on secondary data

the number of credit accounts per 1000 adult population during PMJDY period is more than eightfold of the growth rate of the same for the pre PMJDY period. It says that PMJDY accelerates the access to formal credit of the adults in India. However, if we look at the indicators of the dimension of the utilization or applicability of the banking infrastructure, we find savings to net state domestic product (NSDP) grew at 3.16% during 2011–12 to 2014–15, but it shrank at 7.25% during 2014–15 to 2018–19. Moreover, the percentage of credit outstanding in NSDP increased one percent in the pre PMJDY era while it decreased at 5.7% in the post PMJDY era. The volumes of the indicators under the applicability of the banking infrastructure fall during our entire selected period as shown in Fig. 19.3. One plausible reason behind the fall is the complete demonetization in India in 2016. Thus, during the selected period of analysis, indicators of the financial inclusion did not change uniformly. So, unidimensional analysis is not enough to discuss the extent of financial inclusion and its intertemporal change.

Table 19.4 reports the descriptive statistics of the indicators for the sub-national units, i.e., states and union territories in India for the year 2011–12, 2014–15 and 2018–19. Average value of the number of ATM counter and bank branches is relatively very low in respect of the best value of the indicators but relative disparity across the sub-national units in India irrespective of the time points is very high. However, the mean values are increasing, and coefficient of variation is reducing over time. The good sign is that average value of the number of deposit and credit

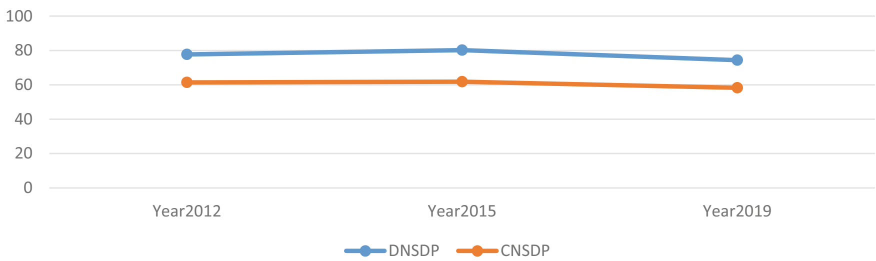

Fig. 19.3 Trend of the utilization of basic banking facilities in India. *Source* Author's computation based on secondary data

Table 19.4 Basic statistics of the indicators of financial inclusion in India

	Mean			Std. deviation			CV		
	2011–12	2014–15	2018–19	2011–12	2014–15	2018–19	2011–12	2014–15	2018–19
No. of ATM per lakh adult population	17.14	32.26	33.70	16.52	20.15	18.74	96.38	62.46	55.61
No. of bank branches per lakh adult Population	16.79	21.06	22.50	9.73	11.49	11.15	57.95	54.56	49.56
No. of deposit A/C per 1000 adult Population	1313.3	1955.6	2495.10	715.3	850.86	851.60	54.47	43.51	34.13
No. of credit A/C per 1000 adult population	157.56	174.31	281.97	102.2	105.67	161.49	64.85	60.62	57.27
Bank deposit relative to NSDP (%)	71.95	75.03	71.58	44.00	42.38	32.43	61.15	56.48	45.31
Bank credit relative to NSDP (%)	46.68	47.68	45.76	55.48	51.40	42.90	118.8	107.8	93.75

Source Author’s computation based on secondary data account per lakh adult across the states/UTs was low but has increased commendably in recent past. Disparity of saving accounts is reducing drastically whereas the disparity of the credit accounts per lakh adults is high and reducing slowly. The average value of the savings–income ratio and credit–income ratio remains more or less unchanged during the selected time frame. However, the inequality across the sub-national units in India in respect of the indicators under the dimension of applicability of banking infrastructure is reducing.

Tables 19.5, 19.6, and 19.7 show that the selected indicators are highly correlated. The correlation coefficients are positive and statistically significant. Therefore, all indicators are unidirectional. So averaging the indicators, we get the composite index of financial inclusion. However, all the indicators should not have equal weight, and weights should not be attached arbitrarily. This study has conducted PCA to derive the weight of the indicators for computing FII of the states and UTs in India at different time points. Tables 19.8, 19.9, and 19.10 depict factor loading of the indicators in rotated PCA of the indicators. With these factor loadings, we have determined the highest squared loading corresponding to the indicators and then relative value of it is considered the weight of the corresponding indicator. In 2011–12, indicator

Table 19.5 Bivariate correlations among the indicators of financial inclusion in India in 2011–12

	I_1	I_2	I_3	I_4	I_5	I_6
I_1	1	0.880**	0.933**	0.663**	0.810**	0.806**
I_2		1	0.939**	0.481**	0.606**	0.550**
I_3			1	0.607**	0.736**	0.678**
I_4				1	0.558**	0.665**
I_5					1	0.944**
I_6						1

** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed)
Source Author's computation based on secondary data

Table 19.6 Bivariate correlations among the indicators of financial inclusion in India in 2014–15

	I_1	I_2	I_3	I_4	I_5	I_6
I_1	1	0.912**	0.943**	0.471**	0.739**	0.687**
I_2		1	0.906**	0.325	0.610**	0.484**
I_3			1	0.494**	0.747**	0.674**
I_4				1	0.208	0.353*
I_5					1	0.914**
I_6						1

** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed)
Source Author's computation based on secondary data

Table 19.7 Bivariate correlations among the indicators of financial inclusion in India in 2018–19

	I_1	I_2	I_3	I_4	I_5	I_6
I_1	1	0.888**	0.912**	0.729**	0.652**	0.645**
I_2		1	0.871**	0.493**	0.556**	0.424*
I_3			1	0.681**	0.740**	0.693**
I_4				1	0.459**	0.665**
I_5					1	0.844**
I_6						1

** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed)
Source Author's computation based on secondary data

Table 19.8 Factor loading matrix and estimated weights for the indicators in 2011–12

Indicators	Component						Weight of the indicators 2011–12
	1	2	3	4	5	6	
I_1	0.742	0.520	0.330	0.267	0.006	0.012	0.038
I_2	0.950	0.241	0.171	−0.023	−0.096	0.012	0.480
I_3	0.860	0.380	0.284	0.011	0.184	−0.023	0.018
I_4	0.267	0.303	0.914	0.025	0.010	0.000	0.445
I_5	0.382	0.891	0.203	−0.006	0.044	−0.130	0.009
I_6	0.291	0.877	0.351	0.063	−0.018	0.140	0.010

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization. Rotation converged in five iterations
Source Author's computation based on secondary data

Table 19.9 Factor loading matrix and estimated weights for the indicators in 2014–15

Indicators	Component						Weight of the indicators 2014-15
	1	2	3	4	5	6	
I_1	0.832	0.438	0.257	−0.007	−0.010	0.223	0.017
I_2	0.962	0.230	0.109	−0.067	0.013	−0.076	0.321
I_3	0.822	0.433	0.283	0.236	0.020	−0.006	0.019
I_4	0.202	0.115	0.972	0.012	−0.004	0.012	0.328
I_5	0.419	0.886	0.022	0.038	0.192	−0.005	0.013
I_6	0.264	0.933	0.197	0.004	−0.143	0.033	0.302

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization. Rotation converged in five iterations
Source Author's computation based on secondary data

Table 19.10 Factor loading matrix and estimated weights for the indicators in 2018–19

Indicators	Component						Weight of the indicator 2018-19
	1	2	3	4	5	6	
I_1	0.793	0.340	0.432	0.044	0.008	0.260	0.024
I_2	0.963	0.203	0.165	−0.004	−0.029	−0.059	0.327
I_3	0.759	0.451	0.353	0.022	0.310	0.006	0.034
I_4	0.304	0.255	0.917	0.018	0.036	0.018	0.297
I_5	0.366	0.907	0.128	−0.157	0.038	0.017	0.290
I_6	0.197	0.838	0.419	0.283	0.036	0.042	0.028

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization, Rotation converged in 5 iterations
Source Author's computation based on secondary data

bank branches per lakh adult population receives 48% of the weightage and number of credit account per lakh adult population receives 44% weights. In 2014–15 and 2018–19, equal and highest weights are attached with the bank branches per lakh adult population, number of credit account per lakh adult population and credit–income ratio. We have considered different sets of weights for different years because the importance of the indicators is changing over time due to technological and economic change in the country and across the sub-national units.

Finally, we have constructed the FII computing the weighted geometric mean of the normalized values of the indicators to make sure the FII ranges from zero to one. Table 19.11 displays that the value of FII for the three time points. In 2011–12, the value of FII ranges from 0 to 0.637 with mean value 0.172 across the states and union territories. The value of FII ranges 0–0.659 with mean 0.176 in 2014–15, and the mean value of FII is 0.252 with range 0.055–0.889 in 2018–19. Therefore, in average, FII of the states and union territories increases marginally during the selected time period. Moreover, the inequality of FII across the states reduces remarkable during the last decade. Thus, initiatives toward financial inclusion are concentrated in backward regions in respect of financial inclusion. As a result, inequality in access to financial services has declined. However, the average improvement of the status of financial inclusion is not at a commendable rate and uniform level across the states and UTs. It would be clear from the discussion of the positions of the states/UTs in respect of the value of FII. The highest position goes to the union territory Chandigarh irrespective of the time points and among the selected sub-national units. On the other side, the state of Manipur occupies the worst position among the sub-national units in India across the selected time points. The state of Goa received the second position in 2011–12, but it could not keep its position in 2014–15 and in 2018–19. The Delhi has got the second position in 2014–15, and it maintains its position during 2018–19. Irrespective of the time, the states of western region except Gujarat and the states/UTs of southern region perform better compared to the others. Note that Andhra Pradesh including Telangana performed better in 2011–12 but excluding

Table 19.11 Financial inclusion index across the states/union territories in India

States/Union Territories	FII 2011–12	Rank in 2011–12	FII 2014–15	Rank in 2014–15	FII 2018–19	Rank in 2018–19
Andaman & Nicobar Islands	0.151	14	0.135	17	0.220	15
Andhra Pradesh	0.220	9	0.226	11	0.145	26
Arunachal Pradesh	0.084	23	0.055	30	0.155	24
Assam	0.061	28	0.074	28	0.136	29
Bihar	0.047	31	0.072	29	0.149	25
Chandigarh	0.637	1	0.659	1	0.885	1
Chhattisgarh	0.050	30	0.077	27	0.133	30
Delhi	0.395	3	0.436	2	0.595	2
Goa	0.454	2	0.313	4	0.556	3
Gujarat	0.108	19	0.136	16	0.180	22
Haryana	0.163	13	0.195	12	0.286	9
Himachal Pradesh	0.194	10	0.153	14	0.261	13
Jammu and Kashmir	0.110	18	0.169	13	0.281	10
Jharkhand	0.079	25	0.088	26	0.182	21
Karnataka	0.223	8	0.236	10	0.297	8
Kerala	0.305	5	0.287	6	0.356	4
Madhya Pradesh	0.079	26	0.114	20	0.141	27
Maharashtra	0.230	7	0.287	7	0.332	5
Manipur	0.000	32	0.000	33	0.055	33
Meghalaya	0.104	21	0.100	24	0.213	18
Mizoram	0.135	16	0.104	23	0.196	19
Nagaland	0.066	27	0.051	31	0.093	32
Odisha	0.119	17	0.122	19	0.216	16
Puducherry	0.323	4	0.288	5	0.319	7
Punjab	0.190	11	0.239	9	0.326	6
Rajasthan	0.099	22	0.125	18	0.139	28
Sikkim	0.139	15	0.000	32	0.120	31
Tamil Nadu	0.293	6	0.336	3	0.280	11
Telangana	NA	NA	0.270	8	0.268	12
Tripura	0.108	20	0.111	21	0.213	17
Uttar Pradesh	0.079	24	0.107	22	0.166	23

(continued)

Table 19.11 (continued)

States/Union Territories	FII 2011–12	Rank in 2011–12	FII 2014–15	Rank in 2014–15	FII 2018–19	Rank in 2018–19
Uttarakhand	0.190	12	0.142	15	0.248	14
West Bengal	0.059	29	0.092	25	0.183	20
Max	0.637		0.659		0.885	
Min	0.000		0.000		0.055	
Mean	0.172		0.176		0.252	
SD	0.135		0.134		0.162	
CV	78.814		76.244		64.179	

Source Author's computation based on secondary data

Telangana its position fall drastically. The position of undivided Andhra Pradesh occupies Telangana since its birth.

The states of Punjab, Haryana, Jammu and Kashmir, Tripura, West Bengal, Bihar, and Jharkhand have remarkably improved their ranks, while the ranks of the states of Gujarat, Rajasthan, Sikkim, and Nagaland fall during the last decade among the states and UTs. Following Sarma (2008), we categories the states as high, medium and low FII states/UTs defining on whether FII is greater than 0.5, between 0.3 and 0.5, and less than 0.3. With this specification, we find majority of the states/UTs falls under the category of low level of financial inclusion. Only Chandigarh reached at high level of financial inclusion in 2011–12 and in 2014–15. In 2018–19 Chandigarh, Goa, and Delhi among the states/UTs enter the range of high level of financial inclusion. Thus, the achievement in financial inclusion is highly uneven across the states/UTs in India during the last decade.

Table 19.12 represents the achievement index of the indicators for India as a whole. It shows that the values of the achievement index for the indicators of the dimension of availability and accessibility increase remarkably during the pre- and post-period of the launch of PMJDY in India. But values of achievement indices of indicators of the dimension of applicability deteriorate during the post-PMJDY

Table 19.12 Achievement index of the selected indicators and FII for India as a whole

Year	No. of ATM per lakh adult population	No. of bank branches per lakh adult population	No. of deposit A/C per 1000 adult population	No. of credit A/C per 1000 adult population	Bank deposit relative to NSDP (%)	Bank credit relative to NSDP (%)	FII India as a whole
2011–12	0.098	0.145	0.154	0.178	0.214	0.196	0.158
2014–15	0.243	0.205	0.285	0.194	0.226	0.198	0.201
2018–19	0.268	0.226	0.401	0.340	0.197	0.184	0.249

Source Author's computation based on secondary data

era in India. It thus indicates that PMJDY improves the accessibility of the banking services but depth of the accessibility did not improve. Therefore, PMJDY fails to accelerate the financial inclusion in India at the level which significantly contributes to economic growth and reduce poverty and inequality. However, the composite FII for India as a whole changes positively during the entire period due to significant improvement of the availability and accessibility of the banking services. However, value of FII reaches at only at 0.249. Thus, India is still belonging to the countries with low level of financial inclusion (below 0.3).

The close value of the FII of the states does not necessarily imply the closeness of the states in respect of the indicators of the FII. In this study using the exploratory data analysis technique, we have determined the clusters of the states and union territories at three different time points. Figures 19.4, 19.5, and 19.6 depict the dendrograms showing the possible clusters of the Indian states and union territories for the time points 2011–12, 2014–15, and 2018–19. In the dendrogram, the vertical axis indicates the subjects in our case states and UTs. The horizontal axis measures dissimilarity of the subjects. The maximum dissimilarity is rescaled in to 25. The state of Goa, union territories Chandigarh and Delhi with their outstanding performance in financial inclusion are identified as influential outliers for each year. In addition to these three, if we allow one-fifth of the maximum dissimilarity detected among the states and UTs in 2011–12, Puduchchery, Maharashtra were also distinct from the states and UTs. Kerala and Tamil Nadu were similar. Sikkim and Mizoram formed a distinct cluster. The remaining 23 states and UTs with low level of financial are very much close with each in respect of the indicators of financial inclusion. In 2014–15, outliers remain intact, Tamil Nadu catches the cluster of Puducherry. After bifurcation, Andhra Pradesh has become distinct while Telangana part remains in the same group. Meghalaya has been separated from its initial cluster. Let us now look at the major changes in the clusters in 2018–19. In the year with the 20% of dissimilarity, we find that in addition to the all-time outliers, Maharashtra, Meghalaya, Sikkim, Mizoram have become separated from the other states and UTs. Tamil Nadu and Puducherry form a new cluster. Tripura catches the cluster of Kerala. Arunachal Pradesh, Nagaland, Manipur, and Andaman Nicobar come to each other and form a separate cluster. The remaining states and UTs keep unchanged themselves during the last decade in respect of the nature of financial inclusion.

19.5 Concluding Remarks

No doubt the penetration banking infrastructure along with the improved IT in banking system have been flourished tremendously. The introduction of PMJDY effectively ensures the basic financial services like access to savings facilities, remittance facilities, and credit and insurance facility during the last five–six years. However, the disappointing point is that during the post era of PMJDY the propensity to formal savings as well credit–income ratio decreases. The fact is also true for most of the major states. It is a cause and a consequence of great slowdown of the

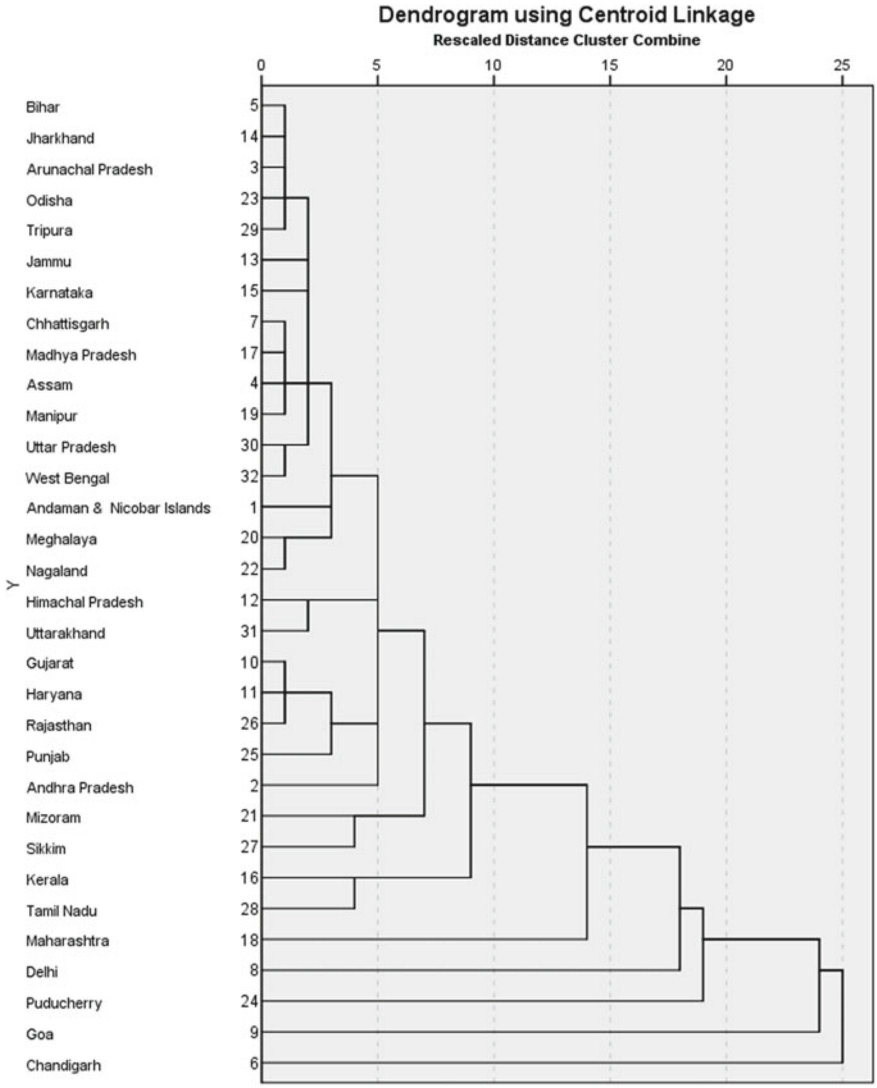

Fig. 19.4 Dendrogram showing the relevant clusters of the Indian states/UTs in respect of the indicators of financial inclusion in 2011–12. *Source* Author's computation based on secondary data

Indian economy in recent times. It is a structural as well as a cyclical predicament of India. The lack of effective demand for Indian goods and services across the world reduces the private and foreign investment and thereby employment and income. It reduces savings and loan demand. The situation of bankruptcy arises. Thus, India fails to improve the extent of financial inclusion particularly in the dimension of applicability. It concludes that the government initiatives like PMJDY can ensure the

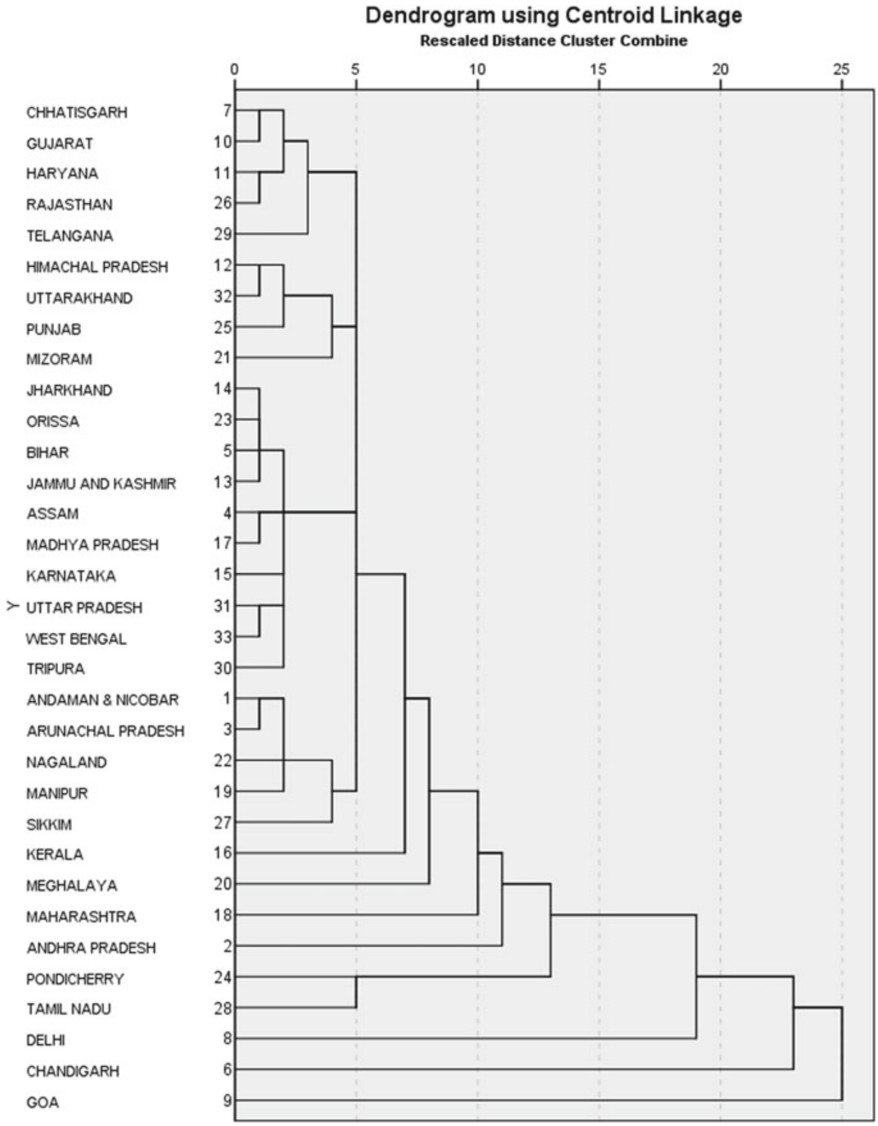

Fig. 19.5 Dendrogram showing the relevant clusters of the Indian states/UTs in respect of the indicators of financial inclusion in 2014–15. *Source* Author's computation based on secondary data

availability and accessibility drivers of financial inclusion and even can help to reduce the inequality in availability and accessibility to the formal financial services, but cannot ensure the sustainable applicability of the services. Public investment, particularly, in infrastructure, in health sector, and in agriculture, improvement of financial

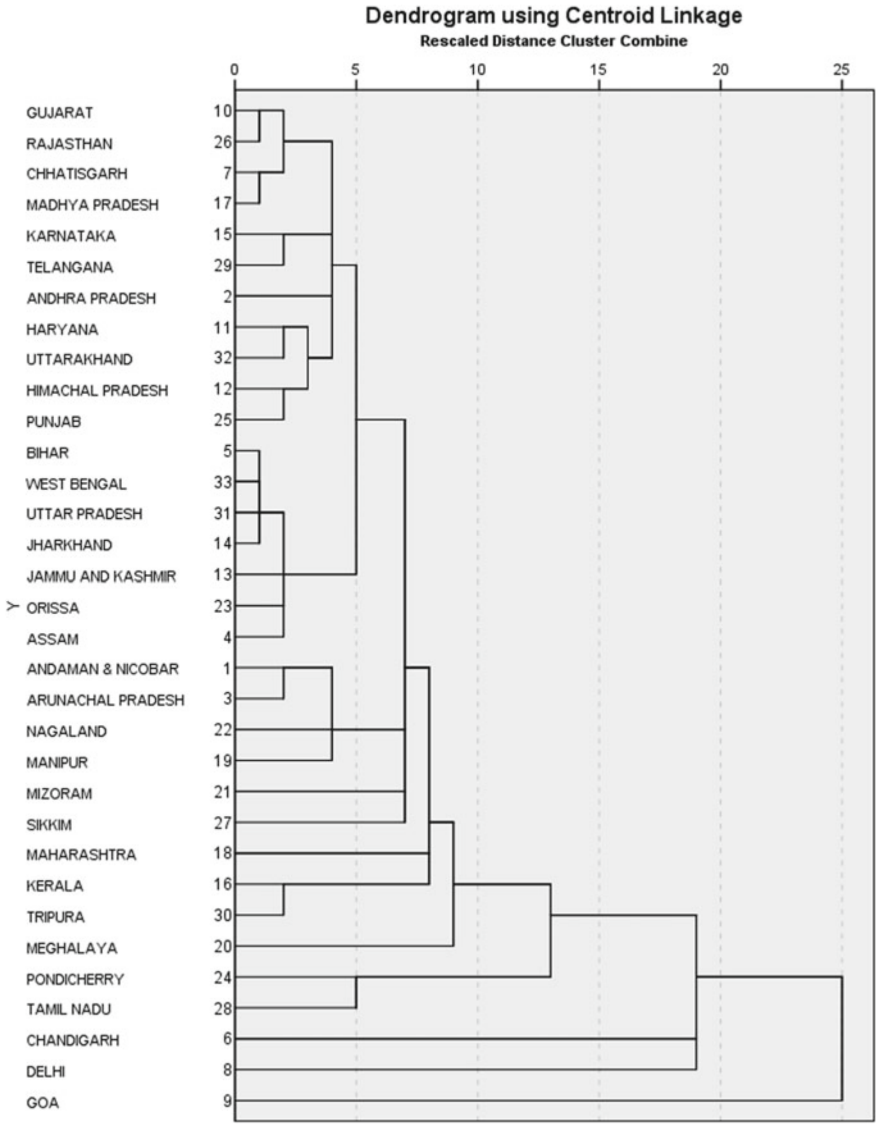

Fig. 19.6 Dendrogram showing the relevant clusters of the Indian states/UTs in respect of the indicators of financial inclusion in 2018–19. *Source* Author's computation based on secondary data

literacy, enhancement of entrepreneurial skill, and business-friendly political environment may play important role to achieve the applicability goal of financial inclusion. The status of financial inclusion of India still has low mean and high variance. It is worthy to mention that the disparity among the states and UTs reduces slightly during the study period. Most of the southern and western states have performed relatively better while the north-eastern states lie behind the states and union territories in India. It proves that financial literacy, business-friendly political environment, improved infrastructure ensures the relatively better financial inclusion in southern states compared to eastern and north-eastern states. The cluster analysis reveals that with respect to the indicators of financial inclusion the state of Goa, union territories Chandigarh and Delhi are recognized as powerful outliers for each year. The southern states are, however, not similar in respect of the indicators of financial inclusion. For example, recently, we find Kerala similar to the position of Tripura. On the other hand, with respect to the financial inclusion, the north-eastern states have been separating from the cluster in 2011–12. Therefore, for framing the future policies toward complete financial inclusion in India, the governments and the banking authorities should study the nature of changing clusters over times in respect to the indicators.

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