New Frontiers in Regional Science: Asian Perspectives 61

Cuong Le Van
Van Pham Hoang
Makoto Tawada *Editors*

International Trade, Economic Development, and the Vietnamese Economy

Essays in Honor of Binh Tran-Nam

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New Frontiers in Regional Science: Asian Perspectives

Volume 61

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International Trade, Economic Development, and the Vietnamese Economy

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Introduction

Cuong Le Van, Van Pham-Hoang, and Makoto Tawada

Abstract We preview the contents of the book *International Trade, Economic Development, and the Vietnamese Economy: Essays in Honor of Binh Tran-Nam* with a dedication to Professor Binh Tran-Nam.

Keywords International trade · Productivity · Taxation · Economic Development · Growth · Environment · Immigration · Networks · Vietnam

A successful academic could be a prolific scholar, or a master teacher, or an accessible public intellectual, or an able leader, or a generous colleague. Professor Binh Tran-Nam is a rare person who is all those things. His career over four decades has seen him in each of these roles, most often simultaneously. This book is a collection of chapters in honor of Professor Binh Tran-Nam's scholarly contributions and also a celebration of his other achievements as an academic economist.

Professor Tran-Nam was born in Hai Phong and grew up in Sai Gon, Vietnam. He came to Australia to study economics at James Cook University on a Colombo Plan scholarship receiving first-class honors and a university medal. He received his master's degree in economics from the Australian National University and obtained his doctorate in economics from the University of New South Wales (UNSW) under a Commonwealth Postgraduate Research Award. Professor Tran-Nam would spend

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most of his academic career on the faculty at UNSW but has also held positions at universities around the world, including the University of Auckland, University of Technology Sydney, Deakin University, Nagoya City University, University of California Santa Barbara, Vietnam National University of Agriculture, Ton Duc Thang University, and RMIT University Vietnam. He has taught many subjects in economics and taxation and successfully advised numerous doctoral and master's research theses. Professor Tran-Nam is a founding coeditor of the *eJournal of Tax Research* and *International Journal of Development and Conflict*, an associate editor of *Asia-Pacific Journal of Regional Science*, and an editorial board member of the *Journal of Chinese Tax and Policy*, *New Zealand Journal of Taxation Law and Policy*, and *Public Sector Economics*.

Professor Tran-Nam is a prolific scholar publishing close to 200 academic papers over four decades. He has made important contributions in the areas of taxation, international trade, and economic development. His papers are widely cited in the academic community and have also had policy impact having been cited in federal parliamentary debates and in the High Court of Australia. His work on compliance costs of federal taxes in Australia has resulted in tax administration changes such as more frequent income tax reporting. In 2007, recommendations from his joint study on the personal income tax system about the tax-free threshold and lower top marginal personal income tax rate were adopted by the federal government. In January 2015, he received the Hill Medal from the Australasian Tax Teachers Association (ATTA) recognizing his "outstanding contributions to tax teaching and tax policy in Australasia." In January 2018, he was awarded lifetime membership by ATTA.

As a former Colombo Plan scholarship recipient, Professor Tran-Nam has also devoted much time and effort to the development of Vietnam. His activities in this area include collaborations with and mentoring of Vietnamese researchers, teaching at various institutions in Vietnam, organizing conferences and other academic activities, and policy advice and consultancy on tax to the Ministry of Finance and on university reform to the Ministry of Education and Training. He is a founding member of the International Society of Vietnam Economists and was elected its inaugural secretary in 2013 and president in 2019. For his service, he was awarded VietnamNet's Achievement Award for contribution to Vietnam's development in 2006 and Vietnamese Foreign Affairs Minister's Certificate of Commendation for effective contributions to scientific, economic research, and international economic integration of Vietnam in 2007. Since 2015, he has been a director of Vietnam Foundation, an Australia-based charitable organization that aims to build schools and assist poor students in Vietnam.

Over his long and distinguished career, Professor Tran-Nam has touched and influenced many, including scores of classmates, colleagues, students, and collaborators. Among these are the contributors to this volume, who in some way have benefited from their interactions with Professor Tran-Nam and would like to honor their teacher, colleague, and friend. The chapters are organized by subject areas that Professor Tran-Nam has worked on in his career. We preview each chapter below.

1 Chapters in This Volume

The first part of the volume contains two chapters on taxation, an area in which Professor Tran-Nam has made numerous and important contributions. His many writings have been widely cited by academics and have made an impact on tax policy and tax administration in Australasia. His work on compliance costs has resulted in tax administration changes in Australia. Professor Ngo Van Long's chapter relates to this topic of tax compliance in a behavioral economics model. In his chapter, Van Long considers an optimal tax scheme when part of the population is "Kantian" and part is traditional "Nashian." Kantians follow the norm that any deviation from a possible equilibrium would be taken only if, when all members of the community adopted the same deviation, all would achieve a higher level of welfare. A Nashian follows traditional individual rationality deviating if assuming all others do not deviate, she can be made better off. For example, in a Prisoner's Dilemma, the socially optimal outcome is a Kantian equilibrium while the Pareto inferior outcome is a Nashian equilibrium. When all of society are Nashian, a tax credit can offset the externality of tax contribution and achieve the socially optimal contribution level. When all of society are Kantian, no such tax credit is necessary to achieve the social optimum. When society is a mixture of the two types, it is no longer possible to achieve the first-best outcome where each individual contributes the same amount because Nashians will want to free-ride on the Kantians. But it is possible to design a tax scheme to achieve the first best in the aggregate. This behavioral theme was also explored by Professor Tran-Nam and his coauthors in a recent paper "The effects of emotion, trust and perception on tax compliance: empirical evidence from Vietnam."

We are especially grateful for this contribution by Professor Ngo Van Long, who had taken ill during the preparation of his chapter but persevered and completed the chapter. Professor Van Long passed away on January 15, 2022. We mourn his loss and deeply appreciate his contribution to this volume, which is a heroic act.

In the second chapter, Professors Masayuki Okawa and Tatsuya Iguchi show that when reducing tariffs on imported intermediate goods governments can offset the loss in revenue by raising the tax on profits of domestic firms. The profit tax increase can raise the welfare of both domestic firms and consumers only when initial tariff levels are higher than the threshold levels. This chapter analyzes taxation in the international trade context that brings together two of the main bodies of work by Professor Tran-Nam.

The second part of this book covers the field of international trade in goods and the movement of factors. Professor Tran-Nam's earliest contributions are in the area of international trade, particularly the pure theory of international trade. This is the approach of Professor Makoto Tawada's contribution to this volume. Tawada analyzes the shape of a country's production possibility frontier (PPF) in the presence of one pure public intermediate good. The shape of the PPF is a key determinant of specialization patterns and gains from trade. Tawada investigates the

cases where the PPF has both convex and concave portions in the economy of one primary factor.

In a theoretical analysis of exports in an industrial organization model, Professors Thanh Tam Nguyen-Huu and Med Kechidi argue that because of fixed costs of exporting, tariff-jumping, and setting up an export platform, the size of the destination market will determine which of these strategies is undertaken by a small or medium enterprise (SME). Furthermore, because of the capacity constraint of the SME, if the destination market is too large, supplying this market will be prohibitive.

In his chapter, Professor Shigemi Yabuuchi notes that today many developing countries are imposing higher environmental standards instead of being pollution havens when industrialized economies impose higher standards. He analyzes the effects of increasing environmental standards in a dual economy with wage differentials. Consistent with the Rybczynski effect and Stolper–Samuelson effect from international trade theory, the effect of higher standards on the outputs of polluting and nonpolluting sectors depends on the relative capital intensity of the abatement industry. Interestingly, in the dual economy model, higher environmental standards can reduce unemployment because the expansion of the abatement activity increases labor demand for the rural nonpolluting sector.

Motivated by recent stances with respect to immigration on the part of the United States and European countries, Professors Kenji Kondoh and Kiyoshi Matsubara undertake a provocative analysis of strategic policies on the immigration of skilled labor by two countries. Stricter restrictionist policies by the host country can reduce the total number of illegal immigrants from the source country, but because of the reaction by the source country to stem the outflow of skilled labor (i.e., reduce the brain drain), the average quality of immigrants to the host country may not necessarily increase. The topic of immigration is of particular relevance to Professor Tran-Nam and is the subject of some of his scholarly work on the Vietnamese diaspora.

Some of the previous papers cover topics at the intersection of international trade and economic development. Development economics is the third area in which Professor Tran-Nam has made many contributions. In recent years, he has written numerous papers, both theory and empirical analyses, on taxation, international trade, education, foreign aid, foreign direct investment, and innovation in the context of developing countries. The next few chapters cover these topics.

Professors Ngoc-Sang Pham and Thi Kim Cuong Pham survey the evidence on the allocation of foreign aid and its effectiveness on recipient country outcomes. The authors complement the empirical analysis with a theoretical discussion of recipient characteristics and donors' preferences for optimal aid allocation.

Professors Nadir Altinoka and Phu Nguyen-Van write on education. They analyze data from six African countries and find that teacher subject knowledge does not affect student outcomes. The authors attribute this lack of association to high teacher absenteeism and poor pedagogical skills.

Drs. Nguyen Ngoc Minh and Nguyen Ngoc Anh study the relationship between social capital and subjective as well as objective measures of well-being. They find

heterogeneous associations between different measures of social capital and each measure of well-being.

In the modern context of fragmented production across borders, development and industrialization often mean integrating into the global supply chain. Dr. Duc-Anh Dang and Professor Ngoc-Anh Tran study the effect of an industry's participation in global value chains (GVCs) on employment and wages in small manufacturing firms in Vietnam. For a developing economy, increased integration into GVCs can increase the demand for labor and investment in human capital to complement the more advanced technologies. The effect would be higher employment, higher productivity, and higher wages. But, on average, smaller firms are less able to participate in GVCs but could be affected by increased competition for labor and thus higher labor costs. Less productive firms will exit while surviving firms increase the relative demand for skilled labor. Using the Trade in Value Added (TiVA) database from OECD and the WTO matched by industry to Vietnam's enterprise survey data from 2005 to 2011, the authors find that increased foreign value added in exports resulted in higher wages, increased productivity, and a greater share of production workers in domestic small- and medium-sized enterprises while higher domestic value added in the export of intermediate products increases wages and lowers employment, particularly in medium-sized firms. The results suggest that increasing integration in the form of GVC participation increases efficiency but also has distributional consequences.

The final three chapters in this book focus on productivity, technology, trade, innovation, and economic growth in Asia. These topics are of particular interest to Prof. Tran-Nam in the context of the Vietnamese economy as exemplified in his professional life and in his edited book *The Vietnamese Economy: Awakening the Dormant Dragon*, exploring the factors contributing to the industrialization of Vietnam.

Professors Cuong Le-Van and Ngoc-Sang Pham show in a series of growth models that total factor productivity matters for growth and competitiveness. Although this message is not new, it is an important reminder since in recent discussions in Vietnam policymakers have emphasized labor productivity as the key to sustaining growth and avoiding a middle-income trap. Their explanation of labor productivity is consistent with Baumol et al. (1989):

> Historically, labor productivity growth has been driven by innovation, better education, and investment in physical capital. Innovation and investment by private sector require a growth-friendly environment, with supportive institutions and policies, including policies that promote macroeconomic stability and the rule of law.

Total factor productivity gains for a developing country can come from interactions with the outside world. Steven Kauffman and Professor Van Pham-Hoang explore the hypothesis that the destination of a firm's exports is an important source of production knowledge for a developing country and that this production knowledge can then spread to other firms in the country. The authors find evidence for this mechanism through an explicit network analysis of firms in Vietnam. They construct networks based on geography and industry classification and calculate

alpha centrality for each firm to capture both the external influence of the export destination and the spillover effect influenced by the firm's position in the network. They find that exporting to Japan and the United States and being more centrally located is associated with higher TFP growth for the firm.

The final chapter of this volume by Professors An-Chi Tung and Henry Wan takes stock of the industrialization experiences of East Asian economies to draw lessons to apply to other late industrializers. While countries have entertained the possibility of replicating the fast growth of China, the authors argue that the conditions for China's growth are quite unique. China's enormous size allows economies of scale important for launching new advanced industries. And by historical accident, Taiwan and Hong Kong became crucial to the rapid industrialization of China as export windows, sources of capital, and production knowledge. India possesses a similar size but does not have partners similar to Taiwan and Hong Kong. Tung and Wan note the importance of Township and Village Enterprises in the Chinese experience that are harder to replicate in India. The authors also contrast the experiences of Korea and Taiwan, particularly firm size determining the industries of specialization. Tung and Wan give historical examples of technology leapfrogging in the case of Japan in silk weaving after technology was transferred from China and a similar example of Vietnam leapfrogging China in canon-making in the fifteenth century. The examples of leapfrogging were meant to emphasize that technology emulation is more than just imitation, but through "strategic intent" and "redesign," innovation can occur in the later industrializer. And finally, that it is innovation that matters for sustained growth.

In these chapters, the contributors honor Professor Binh Tran-Nam, an influential economist, teacher, and a great person, whose legacy will live on through his work and the people who are fortunate to know him.

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Efficiency-Inducing Tax Credits for Charitable Donations when Taxpayers Have Heterogeneous Behavioral Norms

Ngo Van Long

Abstract We consider an economy in which some taxpayers behave in a Kantian way in their donation behavior while others are Nash players. A Kantian taxpayer holds the norm that any suggested deviation from a proposed equilibrium profile would be adopted by him only if, when all members of their community adopted the same deviation, they would all achieve a higher level of welfare. In contrast, a Nash player follows the individual rationality criterion: he would deviate if, assuming all others do not deviate, he would improve his own payoff. We show that if all taxpayers are Nash players, then there is an efficiency-inducing tax credit scheme for charitable contributions. In contrast, if all taxpayers are Kantian, the optimal tax credit for charity is zero. If both types of taxpayers coexist, and the government does not know who is of what type, then it is not possible for the government to induce the first-best outcome, but it must rely on a second-best tax credit scheme.

Keywords Categorical imperative · Kantian behavior · Kantian equilibrium · Kant–Nash equilibrium · Voluntary contributions to a public good · Tax credits

JEL Codes: H21, H31, H41

1 Introduction

The standard model of the behavior of taxpayers relies on the assumption that individuals maximize their expected utility, taking as given the action of other taxpayers. Recently, that model has been criticized for its failure to explain some empirical facts regarding taxpayers' responses to incentives such as penalties for tax avoidance; for a survey, see Hashimzade et al. (2013). As a result, alternative

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models have been developed to explain taxpayers' behavior. Some of the new models abandon the expected utility framework by adopting the nonexpected utility approach. Other models assume that individuals' utility contains elements such as concerns about fairness, social norms, and the like while retaining the assumption that each behaves in a Nash fashion. In this chapter, we suppose that some taxpayers behave in a Kantian way (so that they do not behave in a Nash fashion) and explore how the concept of Kantian equilibrium (introduced by Laffont, 1975; Roemer, 2010, 2015) and the associated concept of Kant–Nash equilibrium (introduced by Van Long, 2016, 2020a, b) may shed light on how different groups of taxpayers respond differently to tax credits for charitable donations. We then explore how the government may be able to design a tax credit scheme that would induce an efficient outcome.

The concept of Kantian norm was first applied to economics by Laffont (1975). He asked a simple question. Why is it that in some countries people do not leave their beer cans on the beach, contrary to individual rationality (in the Nashian sense)? His answer was that individuals in these countries are aware of their collective responsibility toward the environment; their behavior is collectively rational though not individually rational in the Nashian sense. Laffont's work has inspired Roemer (2010, 2015) to formulate the concept of a Kantian equilibrium in an economy where everyone is Kantian. According to Roemer, a Kantian holds a norm that say: I would deviate from a proposed equilibrium profile only if I would be better off when all other individuals deviate likewise. As Roemer points out, as parents we teach our children the Kantian norm. We tell our children: Do not throw rubbish in the park; how would you like it if everyone throws their rubbish in the park? This is clearly Kantian reasoning, not Nashian reasoning.

Van Long (2016) and Grafton et al. (2017) explored the concept of Kant–Nash equilibrium in an economy where some agents follow the Kantian norm while others are Nashian in their behavior. Van Long (2020b) argued that through moral education individuals derive a warm glow from adhering to the Kantian norms and that parents collectively have an incentive to provide collective moral education to their offspring.

We proceed in Sect. 2 to describe the basic elements of the model. Section 3 analyzes the model under three different scenarios. Brief concluding remarks are provided Sect. 4.

2 Basic Elements of the Model

Consider an economy consisting of m taxpayers. Each of them has an additively separable utility function, $U = u(c_i) + v(G)$, where $u(c_i)$ is the individual's satisfaction derived from consuming c_i units of a private good, and $v(G)$ is the individual's satisfaction derived from knowing that a public good project, for example, *conservation of wildlife,* is receiving an aggregate budget G. For simplicity, we assume that G is equal to the sum of charitable donations from

the taxpayers. (Each taxpayer knows that if she donates a dollar then her private consumption level will be reduced by exactly a dollar unless the government reduces her income tax by granting her a tax credit for her donation.)

We assume that there are two groups of taxpayers with different behavioral characteristics. The first group consists of n taxpayers who adopt the standard Nash behavior. We call them the Nashians. Each Nashian agent i takes as given the sum of donations of the other $m-1$ taxpayers (denoted by G_{-i}) and chooses her donation level g_i to maximize her utility, knowing that $G_{-i}+g_i=G$. The second group of taxpayers consists of the remaining $k \equiv m-n$ individuals, indexed by $j=n+1, n+2, \ldots, n+k$. We call these individuals Kantians. Assume that Kantian individuals behave according to a Kantian norm, which is formulated as follows: I would deviate from my equilibrium donation level g_j^* if and only if my utility level would increase when all other members of the Kantian group would deviate in the same way. This Kantian norm was proposed by Roemer (2010) in a model where everyone is Kantian. In our model, there is an important difference: the Kantians know that there are Nashian taxpayers who do not share the Kantian norm. Consequently, Kantians do not consider Nashians as members of the Kantian community.

3 A Model of Donations by Kantians and Nashians

In order to focus on the consequence of differences in behavior, we assume that Kantians and Nashians have the same utility function and the same income level, denoted by Y. An individual's consumption is equal to her income minus her donation: $c_i = Y - g_i$. As a preliminary step, let us find out what is the socially optimal aggregate donation G if there is a social planner in North that can dictate how much each resident of North must donate to the wildlife fund. The social planner's objective is to maximize the sum of utility levels of Northern residents. Assume that u and v are concave and increasing functions. Then, the social planner will make sure that all residents enjoy the same level of utility. Therefore, the planner chooses a common donation level $g \in [0, Y]$ to maximize the social welfare function $S \equiv mu(Y-g)+mv(mg)$. Let us assume that (1) $mv'(0) > u'(Y)$, so that the socially optimal g is strictly positive, and that (2) $u'(0) > mv'(mY)$, so that the socially optimal g is smaller than Y. Then, the socially optimal donation is the unique g_{so} that satisfies the first-order condition $u'(Y-g_{so}) = mv'(mg_{\text{so}})$. This condition can also be expressed in the familiar Samuelsonian rule on efficient provision of a public good: the marginal rate of transforming a private good into a public good is equated to the sum (across all individuals) of the individual marginal rates of substitution of between the public good and the private good:

$$1 = \sum_{i=1}^{m} \frac{v_i'(G_{\text{so}})}{u_i'(Y-g_{\text{so}})}$$

Example 1 Assume that $u(c) = Alnc$ and $v(G) = \ln(B + G)$, with $A > 0$, $B > 0$, $Y > AB$. It follows that $mv'(0) > u'(Y)$ and $u'(0) > mv'(mY)$, so that at the social optimum we have $g_{so} \in (0, Y)$. (The subscript denotes that this is the social optimal solution.) Indeed, the first-order condition gives

$$\frac{A}{Y - g_{so}} = \frac{m}{B - mg_{so}}$$

Solving, we get the social optimal solution

$$g_{so} = \frac{Y - (AB)/m}{A + 1} > 0.$$

Example 2 Assume $u(c) = c$ and $v(G) = \beta \ln G$. Assume $Y > \beta > 0$. The First Order Conditions (FOC) is $-1 + m\beta\frac{1}{mg_{so}} = 0$, which yields $g_{so} = \beta$, an interior solution.

In the following subsections, we compare the benchmark outcome under the social planner with the outcomes under private contributions to a public good and show how the socially efficient outcome can be decentralized by taxation schemes where individuals are awarded tax credits for their charitable donations. We will consider three cases. In case 1, all individuals are Nashian, that is, $n = m$, which means $k = 0$. In case 2, all individuals are Kantian, that is, $k = m$, which means $n = 0$. In case 3, there is a mixture of Kantians and Nashians in the population.

3.1 Case 1: Optimal Tax Credits for Charitable Donations When All Individuals Are Nashian

Consider now the case in which all individuals are Nashian, that is, $n = m$ and $k = 0$. Each individual i takes the aggregate donation of all other individuals, G_{-i}, as given and chooses g_i to maximize her own utility, $u(Y - g_i) + v(g_i + G_{-i})$. The FOC is

$$u'(Y - g_i) + v'(g_i + G_{-i}) = 0$$

In a symmetric Nash equilibrium, the Nash contribution of each individual is $g^N$and aggregate contribution is mg^N, so that $u'(Y - g^N) = v'(mg^N)$. Compared with the social optimum solution, the Nash contribution level is too low.

Example 1 **(Continued)**

With $=m, k = 0$, the Nash equilibrium contribution is the solution of the equation

$$\frac{A}{Y - mg^N} = \frac{1}{B + mg^N}$$

Solving, we get

$$g^N = \frac{Y - AB}{Am + 1} > 0$$

It is easy to see that $g_{so} - g_N > 0$.

Example 2 **(Continued)**

Each Nashian agent i takes G_{-i} as given and chooses g_i to maximize $Y - g_i + \beta ln(g_i + G_{-i})$. With $n = m$, $k = 0$, the Nash equilibrium contribution is $g^N = \frac{\beta}{m}$.

In both examples, the aggregate contribution is below the social optimum. To achieve the socially optimal outcome, consider the following taxation scheme. Each taxpayer is charged an income tax tY, but can deduct from that an amount sg_i. Each also receives from the government a lumpsum transfer amount L. The government's balanced budget constraint is $mtY - mL - s\sum_{i=1}^{m} g_i = 0$. Individuals take the income tax rate, the tax credit rate s, and the lumpsum transfer L as given. Individual i takes the aggregate contribution of other individuals, G_{-i}, as given and chooses g_i to maximize her utility

$$u\left[Y\left(1-t\right)+L-\left(1-s\right)g_i\right]+v\left(g_i+G_{-i}\right)$$

Note that her consumption level is $c_i = Y(1 - t) + L - (1 - s)g_i$.

The FOC is

$$\frac{du}{dc_i}\frac{dc_i}{dg_i} + v'\left(g_i + G_{-i}\right) = 0$$

Let g^{N*} denote the symmetric Nash equilibrium contribution that results from this tax scheme. Then,

$$-\left(1-s\right)u'\left[Y\left(1-t\right)+L-\left(1-s\right)g^{N*}\right]+v'\left(mg^{N*}\right)=0$$

This equation yields the equilibrium contribution as a function of the taxation parameters t, s, and L

$$g^{N*} = \varphi\left(t, s, L\right)$$

The government then chooses a vector (t, s, L) such that $\varphi(t, s, L) = g_{\text{so}}$. There are many such (t, s, L). The simplest one is achieved by setting $L = 0$, which implies that the gross tax revenue is equal to the tax credit:

$$Yt^* = s^*\varphi\left(t^*, s^*, 0\right)$$

Now, to induce Nashian taxpayers to donate the amount that is exactly equal to the socially optimal donation g_{so}, the parameters t^* and s^* must be chosen such that $\varphi(t^*, s^*, 0) = g_{so}$. Proposition 1 characterizes $s^*$and t^* that would achieve that objective.

Proposition 1 *When all individuals are Nashian, the government can induce them to achieve the social optimum by setting (1)* $s^* = 1 - \frac{1}{m}$ *and (2)* $t^* = \frac{g_{so}}{Y} s^*$.

Proof Recall that g_{so} is defined by the social planner's FOC equation $\frac{1}{m} u'(Y - g_{so}) = v'(m g_{so})$ and that g^{N*} is defined by

$$(1-s)\, u'\left[Y(1-t) + L - (1-s)\, g^{N*}\right] = v'\left(m g^{N*}\right)$$

By setting $(1-s) = \frac{1}{m}$, $L = 0$, $tY = s g_{so}$, the second equation becomes

$$\frac{1}{m} u'\left[(Y - s g_{so}) + 0 + s g^{N*} - g^{N*}\right] = v'\left(m g^{N*}\right)$$

Clearly, this equation and the social planner's FOC equation are identical when $g^{N*} = g_{so}$

To illustrate Proposition 1, let us return to Example 1 and show that, given that the government sets $(1-s) = \frac{1}{m}$, $L = 0$, $tY = s g_{so}$, the Nash equilibrium contribution indeed equals g_{so}. Given s, t, the condition that characterizes the symmetric Nash equilibrium is

$$A(1-s)\left[B + m g^{N*}\right] = Y - tY - (1-s)\, g^{N*}$$

This equation gives g^{N*} as a function of the taxation parameters s, t and other parameters:

$$g^{N*} = \frac{Y\left[(1-t)/(1-s)\right] - AB}{Am + 1}$$

It is easy to verify that when we set $s = \frac{m-1}{m}$ and $tY = s g_{so} = \frac{m-1}{m} g_{so} = \frac{m-1}{m}\left[\frac{Y - AB/m}{A+1}\right]$, then $g^{N*} = g_{so}$. □

3.2 Case 2: Optimal Tax Credits for Charitable Donations When All Individuals Are Kantian

In this subsection, we show that when all individuals are Kantian then their charitable donations are socially optimal and therefore there is no need to introduce a tax credit system. Let us recall that Kantians do not behave like Nashians. Instead,

they obey a behavior norm. As in Roemer (2015, p. 46), we take it that each Kantian would affirm the following. *I hold the norm that says: If I want to deviate from a contemplated action profile (of my community's members), then I may do so only if I would have all other deviate in like manner.* It is as if each Kantian believes that when she increases (or decreases) her donation amount by a factor $\lambda > 0$, then other Kantians will do likewise. Formally, when all individuals are Kantian, that is, when $k = m$ and $n = 0$, a vector of contributions $\left(g_1^K, g_2^K, \ldots, g_m^K\right) > (0, 0, \ldots, 0)$ is a Kantian equilibrium if for each i it holds that the utility level

$$u\left(Y - \lambda g_i^K\right) + v\left(\lambda g_i^K + \lambda G_{-i}^K\right)$$

attains its maximum with respect to λ at the value $\lambda = 1$, where $G_{-i}^K \equiv \sum_{j \neq i}^m g_j^K$.

We now can prove Proposition 2.

Proposition 2 *When all individuals are Kantian, the vector* $\left(g_1^K, g_2^K, \ldots, g_m^K\right) > (g_{\text{so}}, g_{\text{so}}, \ldots, g_{\text{so}})$ *is the symmetric Kantian equilibrium. It follows that there is no need to introduce a tax credit scheme to achieve the social optimum.*

Proof If $\left(g_1^K, g_2^K, \ldots, g_m^K\right)$ is a Kantian equilibrium, then for each person it must hold that the derivative of her utility function with respect to λ, when evaluated at $\lambda = 1$, is equal to zero. That is, for each i, the FOC is

$$-g_i^K u'\left(Y - g_i^K\right) + G^K v'\left(G^K\right) = 0.$$

Under symmetry, $G^K = m g_i^K$. Therefore, the FOC for a Kantian equilibrium is identical to the FOC for a social optimum. The SOC is satisfied because of the concavity assumption. □

3.3 Case 3: Voluntary Contributions when Nashians and Kantians Coexist

Now, we turn to the more realistic case where Nashians and Kantians coexist. In this case, there is the possibility that the Nashians completely free-ride on the Kantians by contributing nothing. Whether complete free ride is individually rational from the point of view of the Nashians depends on the parameters of the model. Let us illustrate this by considering a continuation of Example 1 under the assumption that an economy with m agents, n of which behave in a Nashian way while k are Kantians.

Example 1 **(Continued)**

Let us show that under certain parameter values the Nashians find it individually rational to contribute nothing while the Kantians' contributions are strictly positive. Let $\mathcal{N} \equiv \{1, 2, \ldots, n\}$ denote the set of Nashians and

$\mathcal{K} \equiv \{n+1, n+2, \ldots, n+k\}$ denote the set of Kantians. We assume that $k \geq 2$, so that the community of Kantians has at least two members.

Each Nashian agent i takes as given the aggregate contributions of the Kantians, $G^K \equiv \sum_{h\in\mathcal{H}} g_h^K$, and the sum of contributions of all other Nashians, G_{-i}^N, and chooses her own contribution $g_i \geq 0$ to maximize her utility

$$u\left(Y - g_i\right) + v\left(g_i + G_{-i}^N + G^K\right)$$

Her FOC for a maximum is $-u'\left(Y - g_i^N\right) + v'\left(g_i^N + G_{-i}^N + G^K\right) \leq 0$ (with strict equality holding if $g_i > 0$). Each Kantian agent h is in a Kantian equilibrium with strictly positive contributions if, given the Nashians' aggregate contribution G^N, the strictly positive contribution pair $\left(g_h^K, G_{-h}^K\right)$ is such that the utility level $u\left(Y - \lambda g_h^K\right) + v\left(\lambda g_h^K + \lambda G_{-h}^K + G^N\right)$ attains its maximum with respect to λ at $\lambda = 1$. The FOC is

$$-g_h^K u'\left(Y - g_h^K\right) + \left(g_h^K + G_{-h}^K\right) v'\left(g_h^K + G_{-h}^K + G^N\right) = 0$$

Let us find a symmetric Kant–Nash equilibrium where the Nashians find it strictly optimal to contribute nothing, that is, $g_i^N = 0$, and all the Kantians contribute each the same amount $g^K > 0$. That is, we seek parameter values under which the following two conditions hold simultaneously. First, $v'(kg^k) < u'(Y)$, that is, given that the Kantians collectively donate the amount kg^K, each Nashian would incur a utility loss if she were to donate, because from her point of view the marginal valuation of conservation is already too low relative to her marginal valuation of consumption. Second, $u'(Y - g^K) = kv'(kg^K)$, that is, given that the Nashians contribute nothing, the Kantians are in equilibrium if their marginal evaluation of private consumption, $u'(Y - g^K)$, just equals the sum of their individual marginal evaluations of wildlife conservation, $kv'(kg^K)$. Applying these conditions to the functions $u(Y - g) = A \ln (Y - g)$ and $v(G) = \ln (B + G)$, we find that if both the inequality $\frac{1}{B+kg^K} < \frac{A}{Y}$ and the equality $\frac{A}{Y-kg^K} = k\frac{1}{B+kg^k}$ are satisfied, then the Nashians contribute nothing while each Kantian contributes the amount $g^K = \frac{kY-AB}{(A+1)k}$, which is strictly positive provided that $kY > AB$, that is, the number of Kantians is sufficiently large. Substituting for g^K into the Nashian's inequality condition for noncontribution, we obtain the following result.

Proposition 3 *Assume* $[A(1-k)+1]Y < AB < kY$. *Then, there exists a Kant–Nash equilibrium such that the Nashians do not donate and each Kantian contributes a positive amount,* $g^K = \frac{kY-AB}{(A+1)k}$.

Remark If $k = 1$, then it is not possible to satisfy condition $[A(1-k)+1]$ $Y < AB < kY$.

Proposition 4 *Assume* $[A(1-k)+1]Y < AB$ *and* $kY > AB$. *Then, there exists a Kant–Nash equilibrium such that the Nashians make positive contributions, with*

$g^N = \frac{1}{An+A+1}\{Y[A(1-k)+1]-AB\}$ *and* $g^K = \frac{Y[k+A(n+2)(k-1)-AB]}{k(An+A+1)}$. *Each Kantian contributes more than each Nashian.*

Corollary If Nashians and Kantians face the same tax scheme, it is not possible to achieve the social optimum where everyone contributes the same amount, $g_{\text{so}} = \frac{Y-(AB)/m}{A+1}$.

While the first-best social optimum cannot be achieved, it is possible to design a tax scheme such that the total donation, $ng^N + kg^K$, is equal to mg_{so}. The proof of this result is straightforward and is not supplied here for lack of space.

4 Conclusion

Using a simple model where some taxpayers follow the Kantian behavioral norm while others follow the Nashian concept of individual rationality, we first showed that if all taxpayers are Nashian then a tax credit system for charitable donation will achieve the socially optimal outcome. In contrast, when all taxpayers are Kantian, there is no need for giving tax credit for charitable donation. In the third scenario, we show that it is not possible to achieve the first-best utilitarian outcome where all individuals contribute the same amount of donation to a charitable cause because Nashians tend to free-ride on Kantians. However, it is possible to design a tax scheme such that the aggregate donation is equal to the sum of first-best donations.

Extension of the model to the case where no Kantian has the same characteristics is a challenging topic. Another possible extension is to introduce an intertemporal model in which Kantians and Nashians interact (see Grafton et al., 2017).

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Trade Liberalization and Profit Tax Reform Under Oligopolistic Vertical Trade

Masayuki Okawa and Tatsuya Iguchi

Abstract This chapter studies the welfare effects of trade liberalization and the accompanied domestic profit tax reform in a vertical trading economy where oligopoly firms in a domestic final good market import intermediate good from a foreign monopolist and compete in either a Cournot or a Bertrand fashion. We show that if the initial protection level is relatively high, governments can ensure higher welfare for consumers and producers by raising profit taxes compensating for a decrease in a government's revenue caused by a reduction of the tariff on the intermediate good. When the import tariff is already at a low level, the government may not be able to meet that policy goal.

Keywords Trade liberalization · Oligopoly · Vertical trade · Profit tax

1 Introduction

As a result of globalization, a number of countries, including developing and transitional nations, have liberalized their markets by reducing import tariffs and eliminating other nontariff barriers. As many of these countries obtain a relatively large share of their government revenues from tariffs, the question of how governments accommodate domestic tax reforms to substitute for the losses caused by a reduction in tariff revenues is an urgent domestic policy issue.

The theoretical literature has analyzed this issue in various settings. Hatzipanayatou et al. (1994) and Keen and Ligthart (2002) set up a perfectly competitive small country trading model that focused on the relationship between tariff reduction and domestic consumption tax reforms. Keen and Ligthart (2005), Naito and Abe

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(2008), and Okawa and Iguchi (2016, 2018) studied these issues in international oligopoly settings.

Mujumdar (2004) and Haque and Mukherjee (2005) set up vertical small country trading models in which domestic oligopoly firms import an intermediate good from the world market at a constant price and sell their final goods to domestic consumers. They examined whether a government can raise the consumer surplus (CS) and firms' total profits while keeping government revenue unchanged by adjusting profit taxes levied on the domestic firms' profits when reducing import tariffs. Mujumdar (2004) showed that a government can attain its goal only when an industry is a monopoly. Haque and Mukherjee (2005), by setting up a differentiated downstream oligopoly market, argued that, when products are differentiated, there always exists a degree of product differentiation such that the government can always find a profit tax to achieve its objective.

This chapter also examines whether a government can ensure higher welfare for both consumers and producers by raising profit taxes to compensate for a shortfall in government tax revenues caused by tariff reductions. We extend earlier settings in two ways. (1) Though earlier studies just focused on the case where domestic oligopolists compete in the Cournot fashion, we analyze two cases in which domestic oligopolists compete in the Cournot and Bertrand ways. (2) We assume that the intermediate good that domestic oligopolists import is supplied by an upstream foreign monopolist.

We show that a government cannot always ensure higher welfare for both consumers and producers through such policies. We show that the results depend on the threshold values of the initial tariff levels and the magnitude of the tariff reduction.

Our model consists of three stages. In stage 1, a government sets the profit tax on domestic downstream firms and the import tariff rate on the key input supplied by a foreign monopoly. In stage 2, a foreign monopolist determines the price of the key input. In stage 3, domestic downstream firms compete in either the Cournot or the Bertrand fashion and supply differentiated goods to consumers.

This chapter is organized as follows. Section 2 sets up the model. Section 3 derives the revenue-maximizing and welfare-maximizing tariffs under both the Cournot and Bertrand competitions in a domestic downstream market. Section 4 analyzes the welfare effects of domestic profit tax reforms, accommodated by reductions in import tariffs on the intermediate goods supplied by a foreign monopoly.

2 The Model

We set up a simple vertically trading model. In a country, there are n oligopoly firms with symmetric technologies producing differentiated final goods to domestic consumers by using an imported intermediate good from a foreign monopolist. The monopolist sets the price of the intermediate good. We assume that one unit of final good requires one unit of the intermediate good. The government imposes a specific tariff on the imported intermediate good.

The preferences of domestic consumers are represented by a quasi-linear quadratic utility function: $U(q_1, \ldots q_n, m) = a\sum_{i=1}^{n} q_i - (1/2)\sum_{i=1}^{n} q_i^2 - \theta\sum_{j\neq i}^{n-1} q_i q_j + m$, where $a > 0$ denotes a positive parameter and q_i denotes the consumption of the final good i, $(i = 1, .., n)$. We assume that all final goods are substitutes and are only horizontally differentiated. $\theta \in [0, 1]$ denotes the parameter of the degree of product differentiation. If $\theta = 0$, final products are isolated, and if $\theta = 1$, products are either homogeneous or perfect substitutes. m denotes the consumption of the numeraire good, whose price is normalized to 1. The budget constraint for domestic consumers is represented as follows: $\sum_{i=1}^{n} P_i q_i + m = I$, where P_i denotes the price of final good i, and I denotes consumers' budget. From the first-order conditions (FOCs) for utility maximization, the inverse demand function for good i is[1]

$$P_i = a - q_i - \theta\sum_{j\neq i}^{n-1} q_j, (i, j = 1, 2, \ldots, n; i \neq j) \tag{1}$$

Summing up all the FOCs in Eq. 1, we obtain the direct demand function for domestic oligopolist i:

$$q_i = \left\{(1-\theta)a - [1+\theta(n-2)]P_i + \sum_{j\neq i}^{n-1} P_j\right\} / \{(1-\theta)[1+\theta(n-1)]\}\,(i, j = 1, 2, \ldots, n; i \neq j) \tag{2}$$

The consumer surplus (CS) can be written as $CS = (1/2)\sum_{i=1}^{n} q_i^2 + \theta\sum_{j\neq i}^{n-1} q_i q_j$.

The domestic oligopolists compete in either the Cournot or the Bertrand fashion. The net profit after subtracting the profit tax for a downstream firm i is represented as follows:

$$\pi_i = (1-T)(P_i - c - w)\, q_i \tag{3}$$

where $T \in (0, 1)$ denotes a profit tax imposed by the domestic government, $c > 0$ denotes the constant processing cost, and w denotes the intermediate good price. Thus, $c + w$ is the oligopolist's combined marginal cost. In our setting, a profit tax is a policy measure that affects only the distribution of income between domestic industries and the government. Any change in the tax does not affect equilibrium. Thus, we define the industry's gross profit (before subtracting the profit tax) as

$$\Pi = (1-T)^{-1}\sum_{i=1}^{n} \pi_i = \sum_{i=1}^{n} (P_i - c - w)\, q_i. \tag{4}$$

[1] We normalize the marginal utility of the numeraire good to unity.

These domestic firms import the intermediate good from a foreign monopolist. The profit of the foreign monopolist is represented by the following:

$$\pi_M = (w - c_M - t)\, q_M. \tag{5}$$

where $c_M > 0$ denotes the constant marginal cost of producing the intermediate input, q_M is the supply of the intermediate good, and t denotes a specific import tariff set by the government. The domestic government revenue from the tariffs and the domestic welfare are respectively represented by the following: $R = T\Pi + tq_M$ and $W = \mathrm{CS} + (1 - T)\Pi + R$.

3 Cournot and Bertrand Equilibria

In stage 3, downstream firms compete in either the Cournot or the Bertrand fashion for a given price of imported inputs, import tariffs on the input (t) and profit taxes (T).

3.1 Cournot Equilibrium

When domestic firms compete in the Cournot fashion, we obtain from Eq. 3 the FOCs for the profit maximization of oligopolist i:

$$\partial \pi_i / \partial q_i = (1 - T)\left(a - 2q_i - \theta \sum_{j \neq i}^{n-1} q_j - w - c\right) = 0, \quad (i, j = 1, 2, \ldots, n; i \neq j) \tag{6}$$

Applying the symmetry $q_i (i = 1, 2, \ldots, n) \equiv q$ for Eq. 6, we obtain the equilibrium output of each oligopolist and the industry's total output:$q = (a - c - w)/[2 + \theta(n - 1)]$ and $Q \equiv nq$. Therefore, the equilibrium price for each good and the profits of both each oligopolist and the total industry can be written as follows:

$$P = \{a + [1 + \theta\,(n - 1)]\,(c + w)\}\,/\beta \tag{7}$$

$$\pi = (1 - T)\,[(a - c - w)\,/\beta]^2 \tag{8}$$

$$\Pi = n\,[(a - c - w)\,/\beta)\,\Big]^2 \tag{9}$$

where $\beta \equiv 2 + \theta(n - 1) > 0$.

In stage 2, the foreign monopolist sets the price of intermediate good for a given import tariff and profit tax. Letting q_M be the foreign monopolist's output of the intermediate good, the market-clearing condition for the intermediate good is

$$Q \equiv q_M \tag{10}$$

From Eq. 5, the FOC for the profit maximization of the foreign monopolist is as follows:

$$\partial \pi_M / \partial w = q_M - n\left(w - c_M - t\right)/\beta = 0 \tag{11}$$

We obtain an equilibrium under the Cournot competition in the downstream market as follows:

$$w_M^C = \left(a - c + c_M + t\right)/2 \tag{12}$$

$$q_M^C = n\left(\alpha - t\right)/\beta \tag{13}$$

$$\pi_M^C = n(\alpha - t)^2/4\beta \tag{14}$$

$$q^C = \left(\alpha - t\right)/2\beta \tag{15}$$

$$Q^C = n\left(\alpha - t\right)/2\beta \tag{16}$$

$$P^C = \left\{\left[3 + \theta\left(n - 1\right)\right]a + \left[1 + \theta\left(n - 1\right)\right]\left(c + c_M + t\right)\right\}/2\beta \tag{17}$$

$$\pi^C = \left(1 - T\right)\left[\left(\alpha - t\right)/2\beta\right]^2 \tag{18}$$

$$\Pi^C = n\left[\left(\alpha - t\right)/2\beta\right]^2 \tag{19}$$

where $\alpha \equiv a - c - c_M > 0$ and the variables with superscript C denote those under the Cournot equilibrium.

3.2 Bertrand Equilibrium

We next turn to the case where domestic oligopolists compete in the Bertrand fashion for a given intermediate good price. The FOCs for the profit maximization

are given by the following:

$$\partial \pi_i / \partial P_i = (1-T)\left\{(1-\theta)\, a - [1+\theta\,(n-2)]\, P_i + \theta \sum_{j \neq i}^{n-1} P_j - [1+\theta\,(n-2)\,(P_i - c - w)]\right\} / (1-\theta)\,\gamma, \quad (i, j = 1, 2, \ldots, n; i \neq j) \tag{20}$$

where $\gamma \equiv 1 + \theta(n-1) > 0$.

Applying the symmetry, we obtain the equilibrium price of a final good under the Bertrand competition:

$$P = (1-\theta)\, a + [1+\theta\,(n-2)]\,(c+w)\,/\delta \tag{21}$$

where $\delta \equiv 2 + \theta(n-3) > 0$.

Therefore, the oligopolist's output and profit under the Bertrand equilibrium in stage 3 can be written as follows:

$$q = [1+\theta\,(n-2)]\,(a-c-w)\,/\gamma\delta \tag{22}$$

$$\pi = (1-T)\,(1-\theta)\,[1+\theta\,(n-2)]\,(a-c-w)^2/\gamma\delta^2 \tag{23}$$

We now turn to stage 2. In stage 2, the foreign monopolist maximizes its profit by setting the price of the intermediate good. From Eq. 5 and Eq. 10, the FOC for the foreign upstream monopolist is

$$\partial \pi_M / \partial w = q_M - n\,[1+\theta\,(n-2)]\,(w - c_M - t)\,/\gamma\delta = 0 \tag{24}$$

Thus, we obtain the equilibrium under the Bertrand competition as follows:

$$w_M^B = (a - c + c_M + t)\,/2 \equiv w_M^C \tag{25}$$

$$q_M^B = n\,[1+\theta\,(n-2)]\,(\alpha - t)\,/2\gamma\delta \tag{26}$$

$$\pi_M^B = n\,[1+\theta\,(n-2)]\,(\alpha - t)^2/4\gamma\delta \tag{27}$$

$$P^B = \{[3+\theta\,(n-4)]\,a + [1+\theta\,(n-2)]\,(c + c_M + t)\}\,/2\delta \tag{28}$$

$$q^B = [1+\theta\,(n-2)]\,(\alpha - t)\,/2\gamma\delta \tag{29}$$

$$Q^B \equiv nq^B = n\,[1+\theta\,(n-2)]\,(\alpha - t)\,/2\gamma\delta \tag{30}$$

$$\pi^B = (1-T)(1-\theta)[1+\theta(n-2)](\alpha-t)^2/4\gamma\delta^2 \tag{31}$$

$$\Pi^B = n(1-\theta)[1+\theta(n-2)](\alpha-t)^2/4\gamma\delta^2 \tag{32}$$

4 The Optimal Tariff

In stage 1, the government sets the import tariff and profit tax. We now examine revenue-maximizing and welfare-maximizing tariffs under both the Cournot and Bertrand competitions in the domestic market.

We first consider the revenue-maximizing tariff under the Cournot competition. Differentiating R, we obtain the FOC for revenue maximization with respect to import tariffs under the Cournot competition[2]:

$$\partial R^C/\partial t = T\left(\partial \Pi^C/\partial t\right) + Q^C + t\partial Q^C/\partial t = 0 \tag{33}$$

Upon solving Eq. 33, we obtain the revenue-maximizing tariff (t^{CR})[3]

$$t^{\mathrm{CR}} = \alpha(\beta - T)/(2\beta - T) > 0 \tag{34}$$

We find that t^{CR} is decreasing in T. The intuition is straightforward: If a government reduces the profit tax on domestic firms, it should subsequently raise revenue-maximizing tariffs to substitute for the loss of government revenues and adjust t^{CR} to the new lower tax revenues.

Turning to the welfare-maximizing tariff (t^{CW}), we obtain the FOC

$$\partial W^C/\partial t = \partial \mathrm{CS}^C/\partial t + \partial \Pi^C/\partial t + Q^C + t\left(\partial Q^C/\partial t\right) = 0 \tag{35}$$

which leads to the following:

$$t^{\mathrm{CW}} = \alpha\left[n + 2\theta(n-1)^2\right]/[5n + 2\theta(n-1)(2n-1)] > 0 \tag{36}$$

We find that $t^{\mathrm{CW}}$is independent of T. Comparing $t^{\mathrm{CW}}$and t^{CR}, since t^{CR} is monotonically decreasing in T, t^{CR} is lowest when $T = 1$. Comparing $t^{\mathrm{CW}}$and $t^{\mathrm{CR}}(T=1)$, we find that $t^{\mathrm{CW}} < t^{\mathrm{CR}}(T=1)$, implying that $t^{\mathrm{CW}} < t^{\mathrm{CR}}$ for $\forall T \in (0,1)$. Thus, suppose that governments that adopt revenue-maximizing tariffs reduce

[2] The level of the profit tax that maximizes the total revenue is infinitely close to 1. But we suppose that the role of the profit tax for the government is to make up the shortfall of the government revenue caused by the reduction of input tariff in order to keep the government revenue unchanged.

[3] The SOC is satisfied: $\partial^2 R^C/(\partial t)^2 = -(n/2)\{2[2+\theta(n-1)]-T\}[2+\theta(n-1)]^{-2} < 0$.

domestic firms' profit taxes, then the governments will adjust the tariffs and raise the input tariffs to a new revenue-maximizing level. However, this policy reform reduces social welfare.

We next turn to revenue-maximizing tariff (t^{BR}) and welfare-maximizing tariff (t^{BW}) under the Bertrand competition. From Eqs. 30 and 32, we obtain the following:

$$t^{BR} = \alpha \left[\delta - (1-\theta)\, T\right] / \left[2\delta - (1-\theta)\, T\right] > 0 \tag{37}$$

and

$$t^{BW} = \frac{[1+\theta(n-2)]\left[n+2\theta(n-1)^2\right]\alpha}{[1+\theta(n-2)][3n+2\theta(2n-1)(n-1)]+2n(1-\theta)[1+\theta(n-1)]} > 0 \tag{38}$$

Comparing t^{BR} witht^{CR}, we find that $t^{CR} < t^{BR}$. In an oligopolistic market with product differentiation, price competition is more competitive and more efficient than quantity competition (see Vives, 1985, among others).[4] Thus, the government can raise the tariffs that are higher for oligopolists competing in the Bertrand fashion than for oligopolists competing in the Cournot fashion.

Comparing t^{CW} and t^{BW}, we find the following:

$$t^{CW} - t^{BW} = -2\theta^2 n\,(n-1)\left[n + 2\theta(n-1)^2\right] / K < 0 \tag{39}$$

where $K \equiv [5n + 2\theta(2n-1)(n-1)]\{[1+\theta(n-2)][3n + 2\theta(2n-1)(n-1)] + 2n(1-\theta)[1+\theta(n-1)]\}$is positive. Thus, we have signified that (1) $t^{CR} < t^{BR}$ and (2) $t^{CW} < t^{BW}$. These results are summarized in Lemma 1.

Lemma 1
Both total revenue-maximizing and welfare-maximizing tariffs under the Bertrand competition are higher than that under the Cournot competition, that is, $t^{CR} < t^{BR}$ and $t^{CW} < t^{BW}$.

5 Welfare Effects of Trade Liberalization and Domestic Profit Tax Reform

We consider the welfare effects of trade liberalization and profit tax reform on government revenues and the welfare of domestic consumers and firms. We also examine whether or not a domestic government can compensate for a shortfall in

[4] Hackner (2000) pointed out that when goods are complements and quality differences are large, low-quality firms charge higher prices under a Bertrand competition than a Cournot competition. In our setting, however, final goods are horizontally differentiated only and substitutes.

input tariff revenue with a profit tax without decreasing domestic welfare under both the Cournot and Bertrand competitions in a domestic downstream market.

We restrict our attention to the cases where the tariff revenues decrease after tariff reductions under both the Cournot and Bertrand competitions. This condition can be written as follows:

$$t_b Q_b^j - t_a Q_a^j > 0, \quad j = B, C \tag{C-1}$$

where superscript j refers to the mode of competition, that is, Bertrand or Cournot, and subscript a (b) denotes the value of the variable after (before) trade liberalization. This expression can be rewritten as follows:

$$n\left(t_b^j - t_a^j\right)\left[\alpha - \left(t_b^j + t_a^j\right)\right]/2\left[2 + \theta\left(n-1\right)\right] > 0$$

Since tariff reduction implies $t_b^j - t_a^j > 0$, the tariff revenue decreases if $t_b^j + t_a^j < \alpha$. From Eqs. (15) and (29), consumer surplus (CS^j) can be written as follows:

$$\mathrm{CS}^C = \frac{[n+2\theta(n-1)]\left(\alpha - t^C\right)^2}{8\beta^2} \text{ and } \mathrm{CS}^B = \frac{[n+2\theta(n-1)][1+\theta(n-2)]^2\left(\alpha - t^B\right)^2}{8(\gamma\delta)^2}.$$

Thus, we observe that $\partial \mathrm{CS}^j/\partial t^j < 0$ and that an input tariff reduction unambiguously increases the consumer surplus.

The goal of a government's tax reform, conducted after reducing import tariffs, is to increase total industry profits without changing total government tax revenues. These respective conditions are formulated as follows:

$$\left(1 - T_a\right)\Pi_a^j > \left(1 - T_b\right)\Pi_b^j \tag{40}$$

$$T_a \Pi_a^j + t_a^j Q_a^j = T_b \Pi_b^j + t_b^j Q_b^j \tag{41}$$

By combining Eqs. (40) and (41), we obtain the following:

$$\Pi_a^j + t_a^j Q_a^j > \Pi_b^j + t_b^j Q_b^j \tag{42}$$

Equation 42 implies that if the sum of the industry profits and tariff revenues increases by the reduction of input tariffs, the two conditions in Eqs. 41 and 42 are satisfied.

For the Cournot competition, the condition in Eq. 42 can be rewritten from Eqs. 16–19 as

$$t_a^C > 2\alpha\left[1 + \theta\left(n-1\right)\right]/\left[3 + 2\theta\left(n-1\right)\right] - t_b^C \tag{43}$$

For the Bertrand competition, Eq. 42 can be rewritten from Eqs. 30–32 as

$$t_a^B > 2\alpha\left[1+\theta\left(n-2\right)\right]/\left[3+\theta\left(2n-5\right)\right]-t_b^B \tag{44}$$

Therefore, if Eq. 43 (Eq. 44) is satisfied under the Cournot (Bertrand) competition, we find that the government can meet the goal of tax reform (increasing domestic industry profits) by keeping total tax revenue unchanged after reducing tariff revenues. To examine the conditions in Eqs. 43 and 44 for both the Cournot and Bertrand cases, let $B^j(t) \equiv \Pi^j(t) + tQ^j(t)$ be the sum of the domestic industry profits and tariff revenues under the$j$ competition mode.

5.1 Cournot Equilibrium

Figure 1 illustrates the graphs of $B^C(t)$ and $tQ^C(t)$ in the Cournot case.

The curve ADO, which peaks at the tariff–revenue-maximizing tariff, $t^{\mathrm{CR}} = \alpha/2$, illustrates $t^C Q^C(t^C)$ while the curve ACE, which peaks at $\tilde{t}^C = [3+2\theta\,(n-1)]^{-1}[1+\theta\,(n-1)]\,\alpha$, illustrates $B^C(t^C)$. We observe that $t^C = \alpha$ is the prohibitive tariff. Let t^{C1} be a threshold level such that$B^C(t^{C1}) = B^C(0) = (1/4)n\alpha^2[2+\theta(n-1)]^{-2}$. Additionally, let t_b^C and t_a^C be the initial pre- and post-reduction tariffs, respectively. First, the case where $t_b^C \in \left[t^{C1}, \alpha\right]$ is considered. We observe that any tariff reduction will increase the sum of industry profits and tariff revenue, that is,$B^C\left(t_a^C\right) > B^C\left(t_b^C\right)$. Tariff revenue decreases only when t_b^C is reduced to $t_a^C \in \left[0, \alpha - t_b^C\right)$ while $B^C(t^C)$increases, that is, $B^C\left(t_a^C\right) > B^C\left(t_b^C\right)$. Reductions in import tariffs increase social welfare, whereas the tariff revenue decreases. Second, the case where $t_b^C \in \left(\tilde{t}^C, t^{C1}\right)$is

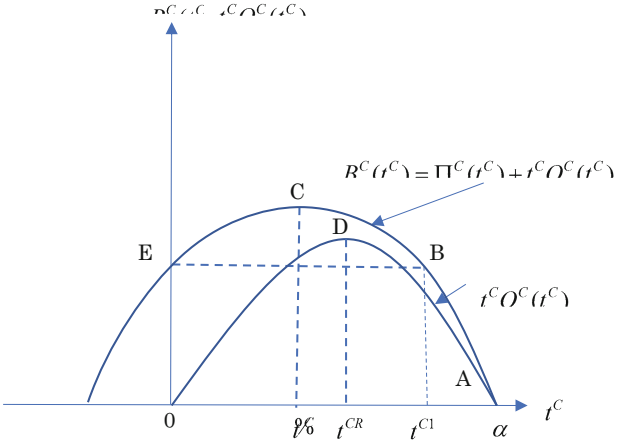

Fig. 1 $B^C(t^C)$ and $t^C Q^C(t^C)$ in Cournot equilibrium

considered. We find that if t_b^C is reduced to $t_a^C \in \left(2\tilde{t}^C - t_b^C, \alpha - t_b^C\right)$, then $B^C(t)$ increases while tariff revenue decreases, and the government can meet its policy goal. If the tariff is reduced to $t_a^C \in \left(0, 2\tilde{t}^C - t_b^C\right)$, then both $B^C(t^C)$ and tariff revenue decrease and the government fails to meet its goal. Third, if$t_b^C \in \left(0, \tilde{t}^C\right)$, then any tariff reduction decreases both $B^C(t^C)$ and tariff revenues. The above results are valid for any given value of parameters, $\theta \in [0, 1]$ and n.

5.2 Bertrand Equilibrium

Next, we examine the welfare effects of trade liberalization and domestic profit tax reform under the Bertrand competition. The results in the Bertrand equilibrium do not qualitatively differ from those under the Cournot competition. Once again, we assume that input tariff revenues decrease after input tariff reductions: $t_b^B Q_b^B - t_b^B Q_a^B > 0$. This expression can be formulated as follows:

$$n\left(t_b^B - t_a^B\right)[1 + \theta\,(n-2)]\left[\alpha - \left(t_b^B + t_a^B\right)\right]/2\gamma\delta > 0 \tag{45}$$

Since $t_b^B - t_a^B > 0$, the tariff revenue decreases if and only if $t_b^B + t_a^B < \alpha$.

Thus, to meet the goal under the Bertrand competition, two conditions—$t_b^B + t_a^B < \alpha$ and Eq. 44—must be satisfied simultaneously:

$$\alpha > t_b^B + t_a^B > \alpha - (1-\theta)/2\beta \tag{46}$$

Let $B^B(t^B) \equiv \Pi^B(t^B) + t^B Q^B(t^B)$ be the sum of domestic industry profits and tariff revenues under the Bertrand competition. The tariff revenue, $t^B Q^B(t^B)$, which is quadratic of t^B, peaks at the tariff–revenue-maximizing tariff, $t^{\mathrm{BR}} = \alpha/2$, and is zero at $t^B = 0$ and $t^B = \alpha$ while $B^B(t^B)$ peaks at $\tilde{t}^B = [3 + \theta\,(2n-5)]^{-1}[1 + \theta\,(n-2)]\,\alpha$. Let t^{B1} be a threshold level such that$B^B(t^{B1}) = B^B(0) = (1/4)n(\theta - 1)\alpha^2[1 + \theta(n-2)]\{[1 + \theta(n-1)][2 + \theta(n-3)]^2\}^{-1}$.

First, consider the case where $t_b^B \in \left[t^{B1}, \alpha\right]$. We observe that any tariff reduction, including when $t_a^B = 0$, will increase $B^B(t^B)$, that is, $B^C\left(t_a^B\right) > B^C\left(t_b^B\right)$. Tariff revenue decreases only when t_b^B is reduced to$t_a^B \in \left[0, \alpha - t_b^B\right)$. Second, consider the case where $t_b^B \in \left(\tilde{t}^B, t^{B1}\right)$. We find that if t_b^B is reduced to $t_a^B \in \left(2\tilde{t}^B - t_b^B, \alpha - t_b^B\right)$, then $B^B(t^B)$ increases, tariff revenues decrease, and the government can meet its policy goal. If the initial tariff is reduced to $t_a^B \in \left(0, 2\tilde{t}^B - t_b^B\right)$, then both $B^B(t^B)$ and tariff revenues decrease and the government fails to meet its goal. Third, if $t_b^B \in \left(0, \tilde{t}^B\right)$, any tariff reduction decreases both $B^B(t^B)$ and tariff revenues. The above results are valid for any given value of parameters, $\theta \in [0, 1]$ and $n \geq 2$.

We summarize our results for both the Bertrand and Cournot cases in Proposition 1.

Proposition 1
Suppose that n symmetrical domestic oligopolistic firms produce and supply only to domestic consumers differentiated goods using a fixed amount of imported intermediate good and compete in either the Cournot or the Bertrand fashion. Assume that the government imposes a profit tax on all domestic firms and a specific tariff on the imported input, and reduces the import tariff that causes a reduction of tariff revenues. Let $B^j(t^j)$ be the sum of industry profit and tariff revenues in j competition mode, $(j = C, B)$.

1. *Suppose that the initial tariff t_b^j is at the level, $t_b^j \in \left[t^{j1}, \alpha\right]$ and is reduced to $t_a \in [0, \alpha - t_b)$. Then, as the tariff revenues decrease, while $B^j\left(t_a^j\right) > B^j\left(t_b^j\right)$, consumers and firms are better-off.*
2. *Suppose that the initial tariff is $t_b^j \in \left(\tilde{t}^j, t^{j1}\right)$ and t_b^j is reduced to $t_a^j \in \left(2\tilde{t}^j - t_b^j, \alpha - t_b^j\right)$. Then, $B^j(t^j)$ increases and tariff revenues decrease.*
3. *Suppose that the initial tariff t_b^j at level $t_b^j \in \left(\tilde{t}^j, t^{j1}\right)$ is reduced to $t_a^j \in \left(0, 2\tilde{t}^j - t_b^j\right)$. Then, both $B^j(t^j)$ and tariff revenues decrease and the government fails to meet its policy goal.*
4. *Suppose that the initial tariff t_b^j is at the level $t_b^j \in \left(0, \tilde{t}^j\right)$. Then, any tariff reduction decreases both $B^j(t^j)$ and tariff revenues, implying that the government cannot meet its policy goal.*

In Proposition 1, we observe that, in cases (1) and (2), the government can attain its policy goal where domestic consumers and firms are better-off after partial trade liberalization and profit tax adjustment. In cases (3) and (4), however, the government cannot meet this policy goal. Since $W^j(t^j) = \mathrm{CS}^j(t^j) + B^j(t^j)$, where $d\mathrm{CS}^j(t^j)/dt^j < 0$, and $dB^j(t^j)/dt^j = 0$ at $\tilde{t}^j$, we find that $dW^j\left(\tilde{t}^j\right)/dt^j = d\mathrm{CS}^j\left(\tilde{t}^j\right)/dt^j < 0$. The implication is that $t^{jW} < \tilde{t}^j$, that is, the welfare-maximizing tariff is lower than $\tilde{t}^j$. Thus, in case (4) of Proposition 1, when t_b^j is at the level $t_b^j \in \left(t^{jW}, \tilde{t}^j\right)$, the government cannot meet its policy goal through tariff reductions and profit tax reforms only. However, if the government reduces the initial tariff to $t_a^j \in \left(t^{jW}, \tilde{t}^j\right)$ and includes a lump-sum income transfer from consumers to domestic producers, then the government can raise CS and domestic industry profits by keeping tariff revenues unchanged.

6 Concluding Remarks

We studied the welfare effect of reducing tariffs on imported intermediate goods and domestic profit tax reform in a simple, vertically trading oligopoly model. The domestic oligopoly firms competing in either the Cournot or the Bertrand fashion import the intermediate good from an upstream foreign monopolist. The tariff reduction would have two conflicting effects on domestic welfare: it reduces

domestic distortion and increases market efficiency by reducing marginal costs of oligopolists while it reduces a part of the rent shifted from the foreign monopolist to the government. We showed that the government cannot always ensure higher welfare for both consumers and producers by raising profit taxes to substitutes for the government's shortfall in tax revenues caused by a lower import tariff: the results depend on the initial tariff level or the degree of trade liberalization, and/or the magnitude of the tariff reductions.

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Properties of the Production Possibility Frontier of Generalized Ricardian Economy with a Pure Public Intermediate Good

Makoto Tawada

Abstract This chapter investigates the shape of the production possibility frontier (PPF) of an economy where three primary factors, two of which are sector specific, two final goods, and one pure public intermediate good, exist and derives the conditions for a convex portion to appear in the PPF under the Cobb–Douglas type of production functions. The economy considered here includes the Ricardian type of economy treated by Manning and McMillan (1979) and Ricardo and Viner's economy treated by Clarida and Findley (1992) and Tawada et al. (2020) as special cases in the present analysis.

Keywords Production possibility frontier · Pure public intermediate good · Ricardian economy · Comparative advantage

1 Introduction

In the theory of international trade, the properties of a country's production possibility set often play a significant role in determining the pattern of trade as well as the gains from trade. In a competitive economy, for any given price vector the production equilibrium point is usually revealed as the tangent point of the production frontier to its price line, so that, if the production set is convex and there are no market failures, the economy becomes efficient. Based on this, it is shown that the patterns of trade of any trading country obey the law of comparative advantage and the trade is beneficial to the country.

When a pure public intermediate good is introduced into the economy, however, the production set is not necessarily convex. Thus, even if the government of the economy implements the Lindahl type of taxation so as to attain an efficient economic state, the patterns of trade and the gains from trade are both ambiguous.

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The patterns of trade and the gains from trade are closely related to the shape of the production set in the economy with public intermediate goods since, at the production point, the price line is usually tangent to the production frontier under the Lindahl pricing. Therefore, it is important to investigate the shape of the production frontier particularly in the case where pure public intermediate goods exist, which is the aim of this chapter.

In an economy where two good, one primary factor, and one pure public intermediate good are accommodated, Manning and McMillan (1979) showed that the production frontier becomes convex to the origin under the constant returns to scale technology with respect to the primary factor. Recently, Tawada et al. (2021) argued the possibility that the frontier becomes concave–convex–concave in a Ricardo–Viner economy, which is considered to be a generalized version of the Manning and McMillan model. We treat a generalized version of the Ricardian model with a pure public intermediate good that accommodates both Manning and McMillan's and Ricardo–Viner's cases and investigate the properties of the production frontier.

It might seem to be interesting to treat this topic in the Heckscher–Ohlin model, and in fact much attention has been paid to that model. However, the recent trend of the theoretical development in trade theories seems to be directed to the Ricardian model rather than Heckscher–Ohlin's since the Ricardian model is simpler and more flexible enough to be able to cope with various interesting topics. For example, Jones and Weder (2017) discuss the importance of the Ricardian model in the modern trade analysis. A good application of the Ricardian trade model can be seen in Binh (2012).

Section 2 presents the basic model, and Sect. 3 provides the preliminary analysis. Then, we examine the properties of the production frontier in Sect. 4. In Sect. 5, we discuss the case of the Heckscher–Ohlin type of economy and the relationship between the shape of the frontier and international trade.

2 Model

We consider an economy where there are two final goods $\sim$. The two final goods are called goods 1 and 2.

Let the production function of good i be

$$X_i = A_i R^{\alpha_i} L_i^{\beta_i}, \quad i = 1, 2, \tag{1}$$

where X_i is the output of good i, A_i is the positive parameter, R is the public intermediate good, L_i is the labor used for production of good i, and α_i and β_i are the positive parameters.

The public intermediate good is produced under the linearly homogenous production function such that

$$R = L_R, \tag{2}$$

where L_R is the labor input for the production of the public intermediate good.

We assume that the economy is endowed with a constant and positive amount of labor, L. So, the labor constraint is expressed as

$$L_1 + L_2 + L_R \leq L. \tag{3}$$

Finally, we define the production possibility set S as

$$S \equiv \{(X_1, X_2) \geq 0 | (1), (2) \text{ and } (3) \text{ are satisfied}\}.$$

The upper boundary of S is called the production possibility frontier (PPF).

3 Preliminary Analysis

Because of (2), (3) is replaced by

$$L_1 + L_2 + R \leq L, \tag{4}$$

from which S becomes

$$S \equiv \{(X_1, X_2) \geq 0 | (1) \text{ and } (4) \text{ are satisfied}\}.$$

Therefore, the upper boundary of S is described by the solutions of the following problem:

$$(M) \underset{L_1, L_2, R}{\text{Max}} X_2 = A_2 R^{\alpha_2} L_2^{\beta_2}, \quad \text{subject to } X_1 = A_1 R^{\alpha_1} L_1^{\beta_1}, L_1 + L_2 + R = L, \tag{5}$$

where X_1 is given and fixed.

Let the Lagrangian function of the above problem be

$$\mathcal{L}(L_1, L_2, R, \lambda, \mu) = A_2 R^{\alpha_2} L_2^{\beta_2} + \lambda \left(A_1 R^{\alpha_1} L_1^{\beta_1} - x_1 \right) + \mu (L - L_1 - L_2 - R),$$

where λ and μ are the Lagrangian multipliers. The first-order conditions are

$$\frac{\partial \mathcal{L}}{\partial L_1} = \lambda \beta_1 A_1 R^{\alpha_1} L_1^{\beta_1 - 1} - \mu = 0 \tag{6}$$

$$\frac{\partial \mathcal{L}}{\partial L_2} = \beta_2 A_2 R^{\alpha_2} L_2^{\beta_2 - 1} - \mu = 0 \tag{7}$$

$$\frac{\partial \mathcal{L}}{\partial R} = \alpha_2 A_2 R^{\alpha_2 - 1} L_2^{\beta_2} + \lambda \alpha_1 A_1 R^{\alpha_1 - 1} L_1^{\beta_1} - \mu = 0. \tag{8}$$

In view of (6)–(8), we obtain

$$\frac{\alpha_1}{\beta_1} L_1 + \frac{\alpha_2}{\beta_2} L_2 = R, \tag{9}$$

which is the Samuelson and Kaizuka condition for the optimal supply of the public intermediate good.

Solve (5) and (9) with respect to L_1 and L_2. Then, under the assumption that $\alpha_1/\beta_1 \neq \alpha_2/\beta_2$, we have

$$L_1 = \frac{1}{\frac{\alpha_1}{\beta_1} - \frac{\alpha_2}{\beta_2}} \left[\left(1 + \frac{\alpha_2}{\beta_2} \right) R - \frac{\alpha_2}{\beta_2} L \right] \tag{10}$$

$$L_2 = \frac{1}{\frac{\alpha_1}{\beta_1} - \frac{\alpha_2}{\beta_2}} \left[\frac{\alpha_1}{\beta_1} L - \left(1 + \frac{\alpha_1}{\beta_1} \right) R \right] \tag{11}$$

so that, for $L_1 \geq 0$,

$$\frac{\alpha_1}{\beta_1} > (<) \frac{\alpha_2}{\beta_2} \iff R > (<) \frac{\alpha_2}{\alpha_2 + \beta_2} L$$

And, for $L_2 \geq 0$,

$$\frac{\alpha_1}{\beta_1} > (<) \frac{\alpha_2}{\beta_2} \iff R > (<) \frac{\alpha_1}{\alpha_1 + \beta_1} L.$$

These relations give the range of R in the PPF, where $L_1 > 0$ and $L_2 > 0$ as

$$\frac{\alpha_1}{\beta_1} > (<) \frac{\alpha_2}{\beta_2} \iff R^A \equiv \frac{\alpha_1}{\alpha_1 + \beta_1} L > (<) R < (>) \frac{\alpha_2}{\alpha_2 + \beta_2} L \equiv R^B. \tag{12}$$

Moreover, if $L_1 = 0$, then

$$\left(1 + \frac{\alpha_2}{\beta_2}\right) R = \frac{\alpha_2}{\beta_2} L.$$

This implies that $R = \frac{\alpha_2}{\alpha_2+\beta_2} L$. Similarly, if $L_2 = 0$, then $R = \frac{\alpha_1}{\alpha_1+\beta_1} L$. Thus, we have

Lemma 1
The range of R is
$\frac{\alpha_1}{\alpha_1+\beta_1} L \geq (\leq)\ R \geq (\leq) \frac{\alpha_2}{\alpha_2+\beta_2} L$ *according as* $\frac{\alpha_1}{\beta_1} >< \frac{\alpha_2}{\beta_2}$.

Making use of (6) and (7) yields

$$\lambda = \frac{\beta_2 A_2 R^{\alpha_2} L_2^{\beta_2 - 1}}{\beta_1 A_1 R^{\alpha_1} L_1^{\beta_1 - 1}} = \frac{\partial X_2 / \partial L_2}{\partial X_1 / \partial L_1} > 0. \tag{13}$$

While the slope of the PPF must be

$$\frac{dX_2}{dX_1} = -\lambda < 0,$$

by the envelope theorem. Therefore, if $d\lambda/dX_1 > (<)0$ at some point of PPF, the PPF is concave (convex) in the neighborhood of that point.

4 Main Analysis

In what follows, we investigate how λ reacts to a change in the level of X_1 in the optimization problem (M).

Differentiation of λ with respect to X_1 is calculated by the use of (7). Then, we have

$$\frac{d\lambda}{dX_1} = \frac{1}{(\partial X_1/\partial L_1)^2} \left[\left(\frac{\partial^2 X_2}{L_2^2} \frac{\partial L_2}{\partial X_1} + \frac{\partial^2 X_2}{\partial R \partial L_2} \frac{\partial R}{\partial X_1} \right) \frac{\partial X_1}{\partial L_1} - \left(\frac{\partial^2 X_1}{\partial L_1^2} \frac{\partial L_1}{\partial X_1} + \frac{\partial^2 X_1}{\partial R \partial L_1} \frac{\partial R}{\partial X_1} \right) \frac{\partial X_2}{\partial L_2} \right]. \tag{14}$$

Notice that

$$\frac{\partial X_i}{\partial L_i} = \beta_i A_i R^{\alpha_i} L_i^{\beta_i - 1}$$

$$\frac{\partial^2 X_i}{\partial L_i^2} = \beta_i (\beta_i - 1) A_i R^{\alpha_i} L_i^{\beta_i - 2}$$

$$\frac{\partial X_i}{\partial R} = \alpha_i A_i R^{\alpha_i - 1} L_i^{\beta_i}$$

$$\frac{\partial^2 X_i}{\partial L_i \partial R} = \beta_i \alpha_i A_i R^{\alpha_i - 1} L_i^{\beta_i - 1}.$$

By virtue of these equations, (14) can be written as

$$\begin{aligned}\frac{d\lambda}{dX_1} &= \frac{1}{\partial X_1/\partial L_1}\left[\beta_2(\beta_2-1)A_2R^{\alpha_2}L_2^{\beta_2-2}\left(\frac{\partial L_2}{\partial X_1}\right) - (\beta_2-1)\beta_2 A_2 R^{\alpha_2}L_2^{\beta_2-1}L_1^{-1}\left(\frac{\partial L_1}{\partial X_1}\right)\right.\\ &\qquad \left. + \beta_2 A_2 R^{\alpha_2-1}L_2^{\beta_2-1}\left(\frac{\partial L_R}{\partial X_1}\right)\right]\\ &= \frac{\beta_2 A_2 R^{\alpha_2-1}L_2^{\beta_2-1}}{\partial X_1/\partial L_1}\left[(\beta_2-1)\frac{R}{L_2}\frac{dL_2}{dX_1} - (\beta_1-1)\frac{R}{L_1}\frac{dL_1}{dX_1} + (\alpha_2-\alpha_1)\frac{dR}{dX_1}\right] \qquad (15)\end{aligned}$$

Our next task is to calculate dL_1/dX_1, dL_2/dX_1 and dR/dX_1. To do so, consider the following three equations that must hold in the PPF:

$$X_1 = A_1 R^{\alpha_1} L_1^{\beta_1}$$

$$L_1 + L_2 + R = L$$

$$\frac{\alpha_1}{\beta_1} L_1 + \frac{\alpha_2}{\beta_2} L_2 = R.$$

By the total differentiation of these equations, we have the following equation system of change:

$$\begin{bmatrix} A_1\beta_1 R^{\alpha_1}L_1^{\beta_1-1} & 0 & A_1\alpha_1 R^{\alpha_1-1}L_1^{\beta_1} \\ 1 & 1 & 1 \\ \alpha_1/\beta_1 & \alpha_2/\beta_2 & -1 \end{bmatrix} \begin{bmatrix} dL_1 \\ dL_2 \\ dR \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} dX_1. \qquad (16)$$

Let Δ be the determinant of the square matrix in (14). Then, Δ is calculated as

$$\begin{aligned}\Delta &= A_1 R^{\alpha_1-1}L_1^{\beta_1-1}\left[\alpha_1 L_1\left(\frac{\alpha_2}{\beta_2} - \frac{\alpha_1}{\beta_1}\right) - \beta_1 R\left(1 + \frac{\alpha_2}{\beta_2}\right)\right]\\ &= -A_1 R^{\alpha_1-1}L_1^{\beta_1-1}\left[(\alpha_1+\beta_1)R\left(1+\frac{\alpha_2}{\beta_2}\right) - \frac{\alpha_1\alpha_2}{\beta_2}L\right],\end{aligned}$$

by (10). In view of (12), it is clear that

$$(\alpha_1+\beta_1)R\left(1+\frac{\alpha_2}{\beta_2}\right) - \frac{\alpha_1\alpha_2}{\beta_2}L > 0,$$

which assures

$$\Delta < 0. \tag{17}$$

Now we solve (16) and obtain

$$\frac{dL_1}{dX_1} = \frac{-1}{\Delta}\left(1 + \frac{\alpha_2}{\beta_2}\right) > 0, \tag{18}$$

$$\frac{dL_2}{dX_1} = \frac{1}{\Delta}\left(1 + \frac{\alpha_1}{\beta_1}\right) < 0, \tag{19}$$

$$\frac{dR}{dX_1} = \frac{1}{\Delta}\left(\frac{\alpha_2}{\beta_2} - \frac{\alpha_1}{\beta_1}\right) > (<)\, 0 \; as \frac{\alpha_1}{\beta_1} > (<)\, \frac{\alpha_2}{\beta_2}, \tag{20}$$

because of (17). By these results, we can establish

Theorem 1

1. *In the PPF, the production expansion of good i is accompanied by an increase in labor input for that good.*
2. *In the PPF, if* $\alpha_i/\beta_i > (<)\alpha_j/\beta_j$, *for* $i, j = 1, 2$, *and* $i \neq j$, *the public intermediate good supply increases (decreases) as the production expansion of good i.*

It is easy to understand Theorem 1 intuitively. A change in the labor input plays a direct role in the change in the level of good production. But, from the production efficiency point of view, the public intermediate good supply shifts according to a change in the level of good production. If, for example, the technology of good 1 reveals to be relatively more dependent on the public intermediate good, then it is efficient to increase the public intermediate good with the expansion of good 1.

Putting (18)–(20) into (15), we have

$$\frac{d\lambda}{dX_1} = \frac{\beta_2 A_2 R^{\alpha_2 - 1} L_2^{\beta_2 - 1}}{(\partial X_1/\partial L_1)\Delta} \times \left[(\beta_1 - 1)\left(1 + \frac{\alpha_2}{\beta_2}\right)\frac{R}{L_1} + (\beta_2 - 1)\left(1 + \frac{\alpha_1}{\beta_1}\right)\frac{R}{L_2} + (\alpha_2 - \alpha_1)\left(\frac{\alpha_2}{\beta_2} - \frac{\alpha_1}{\beta_1}\right)\right] \tag{21}$$

Based on (21), we can establish.

Theorem 2

(a) *In the case where* $\alpha_1/\beta_1 \neq \alpha_2/\beta_2$, *the PPF is a straight line.*

(b) *Under the assumption that* $\alpha_1/\beta_1 \neq \alpha_2/\beta_2$, *suppose that* $\beta_1 \leq (\geq)1$, $\beta_2 \leq (\geq)1$ *and* $(\alpha_1 - \alpha_2)\left(\frac{\alpha_1}{\beta_1} - \frac{\alpha_2}{\beta_2}\right) \leq (\geq)\, 0$. *If at least one of the above inequalities holds with strict inequality, the PPF is strictly concave (convex).*

(c) *Under the assumption that* $\alpha_1/\beta_1 \neq \alpha_2/\beta_2$, *if* $\beta_1 < (>)1$, *the PPF is strictly concave (convex) in the neighborhood of* $X_i = 0$.

Proof. The assertion of (a) is clear from (1), (3), and (9). Concerning (b) and (c), they are straightforward from (21). □

The fact that the PPF is strictly convex in the Manning and McMillan case where $\beta_1 = \beta_2 = 1$ and $\alpha_1 \neq \alpha_2$ is obvious from Theorem 2 (b). Suppose the production functions (1) to be of the Cobb–Douglas type, so that $\alpha_i + \beta_i = 1$, $0 < \alpha_i < 1$, and $0 < \beta_i < 1$. Then, according to $\alpha_i > (<)\alpha_2$, $\alpha_1/\beta_1 > (<)\alpha_2/\beta_2$. Hence, by Theorem 2 (b), the PPF is strictly concave, which was shown under a more general assumption in Tawada (1980).

Clarida and Findlay (1992) treated the Ricardo–Viner model with a public intermediate good. Recently, Tawada et al. (2021) extended their analysis and showed the possibility that the shape of the PPF becomes concave–convex–concave. In our present model, a generalized version of the Clarida and Findley economy is treated by placing the assumption that $0 < \beta_i < 1$ and $\alpha_i > 0$ for $i = 1$ and 2. To focus on this case, we continue our analysis with the inflection points of the PPF. Then, we present.

Lemma 2

Assume that $\alpha_1/\beta_1 \neq \alpha_2/\beta_2$. Then, there are at most two inflection points in the PPF. The necessary condition for the existence of two inflection points is that $\alpha_1 + \beta_1 \neq \alpha_2 + \beta_2$.

Proof. Putting (10) and (11) into (21) and arranging (21), we reach

$$\begin{aligned}\frac{d\lambda}{dx_1} = {} & \frac{\beta_2 A_2 R^{\alpha_2 - 1} L_2^{\beta_2 - 1}}{(\partial X_1/\partial L_1)\Delta L_1 L_2} \frac{1}{(\alpha_1/\beta_1) - (\alpha_2/\beta_2)} \\ & \times \Bigg[((\alpha_2 + \beta_2) - (\alpha_1 + \beta_1)) \left(1 + \frac{\alpha_2}{\beta_2}\right) \left(1 + \frac{\alpha_1}{\beta_1}\right) R^2 \\ & + \Bigg\{ ((\beta_1 - 1) - (\alpha_2 - \alpha_1)) \left(1 + \frac{\alpha_2}{\beta_2}\right) \frac{\alpha_1}{\beta_1} \\ & - ((\beta_2 - 1) + (\alpha_2 - \alpha_1)) \left(1 + \frac{\alpha_1}{\beta_1}\right) \frac{\alpha_2}{\beta_2} \Bigg\} LR + (\alpha_2 - \alpha_1) \frac{\alpha_1 \alpha_2}{\beta_1 \beta_2} L^2 \Bigg] \end{aligned} \tag{22}$$

(See Appendix for the derivation of (22).)

The number of inflection points in the PPF should be the number of roots of equation $d\lambda/dX_1 = 0$. Therefore, because of (22), the number of inflection points is two at most and it is necessary for the existence of two inflection points that $\alpha_1 + \beta_1 \neq \alpha_2 + \beta_2$ in (22). □

Now, we have the following theorem.

Theorem 3

(a) *If $(\alpha_1 - \alpha_2)\left(\frac{\alpha_1}{\beta_1} - \frac{\alpha_2}{\beta_2}\right) > 0$ and β_i is less than but sufficiently close to 1 for $i = 1$ and 2, the PPF is strictly concave–strictly convex–strictly concave as X_1 increases from zero to its maximum. Thus, there are two inflection points in the PPF.*

(b) *If* $\beta_1 < (>)1$ *and* $\beta_2 > (<)1$, *the PPF is first strictly concave (strictly convex) and then strictly convex (strictly concave) as* X_1 *increases from zero to its maximum. Thus, there is one inflection point in the PPF.*

Proof. The assertion of (a) can be shown from Theorem 2 (c) and Lemmas 1 and 2 (a). The assertion of (b) can be derived from Theorem 2 (c) and Lemma 2 (a). □

As for Theorem 3 (α), notice that the condition $(\alpha_1 - \alpha_2)\left(\frac{\alpha_1}{\beta_1} - \frac{\alpha_2}{\beta_2}\right) > 0$ implies that $\alpha_1 + \beta_1 > (<)\alpha_2 + \beta_2$ as $\alpha_1 > (<)\alpha_2$. Hence, the condition satisfies the necessary condition in Lemma 2. A special case where $\beta_1 = \beta_2$ of Theorem 3 (a) was shown in Tawada et al. (2021), which developed the analysis of Clarida and Findlay (1992).

5 Concluding Remarks

We investigated the shape of the PPF of a one-primary factor or the three primary factors, two of which are sector specific and two final goods economy with a pure public intermediate good, and derived the conditions for the PPF to have a convex portion under the Cobb–Douglas type of production functions. The economy considered in our present analysis contains the Ricardo and Ricardo–Viner models.

To conclude, we present two remarks.

Remark 1 There have been several studies inspecting the shape of PPF of the Heckscher–Ohlin type of economy where two primary factors and a pure public intermediate good exist (e.g., see, Tawada and Abe (1984), Okamoto (1985), Altenburg (1987)). In spite of these studies, there still remains ambiguity on the shape of the PPF in connection to the type of production functions. For a more precise analysis to obtain clear results, it may be convenient to focus on a special type of production function such as the Cobb–Douglas type.

In view of our present analysis, we can easily derive the result in the Heckscher–Ohlin type of public input economy where, if production functions are separable between the public intermediate good and primary factors and the factor intensity of primary inputs is the same between private industries at each point of the PPF, the PPF would become convex to the origin. This is because the PPF under any fixed supply of the public intermediate good is a straight line and the envelope of these straight lines has to be convex to the origin. We need to investigate the shape of PPF near each axis, the number of the inflection points on the PPF, and so on. These are future works.

Remark 2 We did not deal with trade analysis in this chapter. Thus, a brief discussion of trade may be in order finally. We suppose the economy treated in this chapter to be a small country and the government supplies the public intermediate good in order to maximize the country's welfare after trade. If the PPF is concave, the law of comparative advantage on the pattern of trade prevails in the sense that the good whose domestic relative price is lower than its international relative price is exported. And trade is necessarily gainful.

If there is a convex portion in the PPF, we cannot exclude the possibility that the good whose domestic relative price is higher than its international relative price is exported. As for the gains from trade, the consumption possibility frontier becomes a convex hull of the PPF, implying it to be concave and cover the PPF. Thus, the trade gains are always assured if there is a trading equilibrium. The problem is that once we assume that the government determines the level of public good supply so as to maximize the country's welfare, there appears the possibility of nonexistence of a trading equilibrium in a two-country economy. This actually occurs in Manning and McMillan's economy where the PPF is convex. In that case, after trade two countries specialize different goods with each other. Then, if there is a sufficiently large difference in the country scale between these countries, the world supply and demand may not be met by the specialization of each country.

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Appendix

The derivation of (22).

The bracket of the RHS in (21) is

$$(\beta_1-1)\left(1+\tfrac{\alpha_2}{\beta_2}\right)\tfrac{R}{L_1}+(\beta_2-1)\left(1+\tfrac{\alpha_1}{\beta_1}\right)\tfrac{R}{L_2}+(\alpha_2-\alpha_1)\left(\tfrac{\alpha_2}{\beta_2}-\tfrac{\alpha_1}{\beta_1}\right)$$
$$=\tfrac{1}{L_1L_2}\left[(\beta_1-1)\left(1+\tfrac{\alpha_2}{\beta_2}\right)RL_2+(\beta_2-1)\left(1+\tfrac{\alpha_1}{\beta_1}\right)RL_1+(\alpha_2-\alpha_1)\left(\tfrac{\alpha_2}{\beta_2}-\tfrac{\alpha_1}{\beta_1}\right)L_1L_2\right]$$

Further, the bracket of the RHS of the above equation is

$$(\beta_1-1)\left(1+\tfrac{\alpha_2}{\beta_2}\right)R\tfrac{1}{\frac{\alpha_1}{\beta_1}-\frac{\alpha_2}{\beta_2}}\left[\tfrac{\alpha_1}{\beta_1}L-\left(1+\tfrac{\alpha_1}{\beta_1}\right)R\right]$$
$$+(\beta_2-1)\left(1+\tfrac{\alpha_1}{\beta_1}\right)R\tfrac{1}{\frac{\alpha_1}{\beta_1}-\frac{\alpha_2}{\beta_2}}\left[\left(1+\tfrac{\alpha_2}{\beta_2}\right)R-\tfrac{\alpha_2}{\beta_2}L\right]$$
$$+(\alpha_2-\alpha_1)\left(\tfrac{\alpha_2}{\beta_2}-\tfrac{\alpha_1}{\beta_1}\right)\tfrac{1}{\left(\frac{\alpha_1}{\beta_1}-\frac{\alpha_2}{\beta_2}\right)^2}\left[\left(1+\tfrac{\alpha_2}{\beta_2}\right)R-\tfrac{\alpha_2}{\beta_2}L\right]\left[\tfrac{\alpha_1}{\beta_1}L-\left(1+\tfrac{\alpha_1}{\beta_1}\right)R\right]$$

$$=\tfrac{1}{\frac{\alpha_1}{\beta_1}-\frac{\alpha_2}{\beta_2}}\Bigg[(\beta_1-1)\left(1+\tfrac{\alpha_2}{\beta_2}\right)\left(\tfrac{\alpha_1}{\beta_1}L-\left(1+\tfrac{\alpha_1}{\beta_1}\right)R\right)R$$
$$+(\beta_2-1)\left(1+\tfrac{\alpha_1}{\beta_1}\right)\left(\left(1+\tfrac{\alpha_2}{\beta_2}\right)R-\tfrac{\alpha_2}{\beta_2}L\right)R$$
$$-(\alpha_2-\alpha_1)\left[\left(1+\tfrac{\alpha_2}{\beta_2}\right)R-\tfrac{\alpha_2}{\beta_2}L\right]\left[\tfrac{\alpha_1}{\beta_1}L-\left(1+\tfrac{\alpha_1}{\beta_1}\right)R\right]\Bigg]$$

The largest bracket of the RHS of the above equation is

$$\left[(\beta_2-1)\left(1+\tfrac{\alpha_1}{\beta_1}\right)\left(1+\tfrac{\alpha_2}{\beta_2}\right)-(\beta_1-1)\left(1+\tfrac{\alpha_2}{\beta_2}\right)\left(1+\tfrac{\alpha_1}{\beta_1}\right)+(\alpha_2-\alpha_1)\left(1+\tfrac{\alpha_2}{\beta_2}\right)\left(1+\tfrac{\alpha_1}{\beta_1}\right)\right]R^2$$
$$+\Bigg[(\beta_1-1)\left(1+\tfrac{\alpha_2}{\beta_2}\right)\tfrac{\alpha_1}{\beta_1}-(\beta_2-1)\left(1+\tfrac{\alpha_1}{\beta_1}\right)\tfrac{\alpha_2}{\beta_2}-(\alpha_2-\alpha_1)\left(1+\tfrac{\alpha_2}{\beta_2}\right)\tfrac{\alpha_1}{\beta_1}$$
$$-(\alpha_2-\alpha_1)\left(1+\tfrac{\alpha_1}{\beta_1}\right)\tfrac{\alpha_2}{\beta_2}\Bigg]LR+(\alpha_2-\alpha_1)\tfrac{\alpha_2\alpha_1}{\beta_2\beta_1}L^2$$

$$=((\beta_2-1)-(\beta_1-1)+(\alpha_2-\alpha_1))\left(1+\tfrac{\alpha_1}{\beta_1}\right)\left(1+\tfrac{\alpha_2}{\beta_2}\right)R^2$$
$$+\Bigg[((\beta_1-1)-(\alpha_2-\alpha_1))\left(1+\tfrac{\alpha_2}{\beta_2}\right)\tfrac{\alpha_1}{\beta_1}$$
$$-((\beta_2-1)+(\alpha_2-\alpha_1))\left(1+\tfrac{\alpha_1}{\beta_1}\right)\tfrac{\alpha_2}{\beta_2}\Bigg]LR+(\alpha_2-\alpha_1)\tfrac{\alpha_1\alpha_2}{\beta_1\beta_2}L^2$$

$$=[(\alpha_2+\beta_2)-(\alpha_1+\beta_1)]\left(1+\tfrac{\alpha_2}{\beta_2}\right)\left(1+\tfrac{\alpha_1}{\beta_1}\right)R^2$$
$$+\Bigg[[(\beta_1-1)-(\alpha_2-\alpha_1)]\left(1+\tfrac{\alpha_2}{\beta_2}\right)\tfrac{\alpha_1}{\beta_1}$$
$$-[(\beta_2-1)+(\alpha_2-\alpha_1)]\left(1+\tfrac{\alpha_1}{\beta_1}\right)\tfrac{\alpha_2}{\beta_2}\Bigg]LR+(\alpha_2-\alpha_1)\tfrac{\alpha_1\alpha_2}{\beta_1\beta_2}L^2$$

Thus, we have (22).

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A Note on the Internationalization Strategies of SMEs

Thanh Tam Nguyen-Huu and Med Kechidi

Abstract In this chapter, we provide an analysis of the internationalization strategies of SMEs. We investigate how the third market size can prevent their internationalization process. Interestingly, when the third market size reaches some thresholds, SMEs do a tariff-jumping as a second best. In particular, when the third market size is large enough, internationalization becomes impossible.

Keywords SMEs · Internationalization strategies · Export · Tariff-jumping · EPFDI

JEL Codes: F15, F23

1 Introduction

For a long time, Foreign Direct Investment (FDI) has been a well-known strategy used by Multinational Enterprises (MNEs) when integrating a global market. Depending on their strategic behaviors, an MNE can develop either a vertical or horizontal FDI. A vertical strategy is preferred when the firm seeks to minimize its production costs while the horizontal strategy's purpose is to serve a host country market.

It is noteworthy that the two mentioned strategies are no longer relevant to adapt to the rise of regional integration agreements (RIAs) during the last three decades. As a consequence, MNEs develop a new international strategy called export platform FDI (EPFDI). By practicing such a behavior, MNEs set up a

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production plant in a host country while exporting the output to third markets, particularly a global market. Such investment is mainly motivated when the export cost from the host country to the worldwide market is low as, for example, the host country has different trade agreements with other countries or is a WTO member. The third countries' market size (called hereafter third market size) is also an essential factor of EPFDI.

While studies on this topic almost examine the strategic behavior of large MNEs,[1] there is still limited research on small and medium-sized enterprises (SMEs)' internationalization against the rise of RIA.[2] The purpose of this chapter is to provide a theoretical framework investigating different internationalization strategies of an SME. We will show that the third market size, one of the main factors determining EPFDI, can become an obstacle preventing an SME from internationalizing.

The chapter is structured as follows. Section 2 introduces the model and the market equilibrium in the general case. Section 3 focuses on the situation of an SME. Section 4 concludes.

2 Internationalization Strategies: A Simple Model

In this section, we emphasize the strategic behaviors of an MNE against increasing RIA. We investigate the determining factors of each strategy. Our theoretical framework is in line with that developed in the literature of MNE strategies (Karolina et al., 2007; Minda & Nguyen-Huu, 2012; Motta & Norman, 1996; among others). These authors argue that regional economic integration can incite MNE to adopt an EPFDI.

2.1 The Model

We consider a model consisting of three countries: a host country A, an origin country O, and a third country T. Countries O and T are more developed than A while countries A and T can sign a bilateral trade agreement and in particular form a free trade area.

[1] See, for example, Motta and Norman (1996), Karolina et al. (2007), Minda and Nguyen-Huu (2012) for theoretical frameworks, or Barry (2004), Ito (2013) for empirical evidence.

[2] Litterature on SMEs' international activities almost considers either export or horizontal/verical FDI as the main internationationalization strategies (Lu and Beamish (2001), Kuo and Li (2003), Justin et al. (2017); among others). Other studies only use the term "SME internationalization strategies" without specifying explicitly the associated form (Chelliah et al., 2010; Soulaimane, 2011; Sui, 2014; among others) . Few research examines EPFDI as a possible strategy of SME to adopt the rise of RIA.

Table 1 Access costs to the third market

	Strategy	Production costs	Export costs	Fixed setup costs
Firm l	Export	$c_l + w_l$	τ_l	0
Firm m	Export	$c_m + w_m$	τ_m	0
	Tariff-jumping	w_m	0	F_t
	EPFDI	$c_l + w_l + g$	τ_l	F_a

There is a firm from country O, denoted by m. Its problem is determining whether or not to serve the third market. While deciding to supply the third market, this firm competes with L exporter firms from country A (denoted by firm l).[3]

By serving the third market, firm m has three possible strategies: export, tariff-jumping (having a plant in country T), or EPFDI (having a subsidiary in country A then exporting the associated production to country T). The export strategy includes extra-regional export costs τ_m while the tariff-jumping requires a fixed setup cost, F_t. EPFDI involves a fixed setup cost in country A, F_a, a technology transfer cost, g, and a so-called intra-regional exchange cost between A and T, τ_l. Moreover, being less developed than the third country, we can assume that the fixed setup cost in country A is higher than that of country T: $F_a > F_t$.

Assume that each unit of the good produced requires one unit of labor and one unit of capital. However, the cost of these factors varies by country. Compared to O and T, capital is more expensive, and labor is cheaper in A.

Let c_l be the capital price in country A and c_l that in countries O and T. Also, w_m is the labor cost in O and T, and w_l, the labor cost in A. These assumptions imply that O and T have the same variable production cost.

Let us define $\Delta c = c_l - c_m$ and $\Delta w = w_m - w_l$. Hence, Δc can be considered the comparative advantage of countries O and T over country A and then Δw, the country A comparative advantage over the other two countries.

To sum up, Table 1 shows the access costs to the third market for firms m and l.

The inverse demand function in the third market is given by

$$p_t = S_t - bQ_t$$

where p_t, S_t, Q_t are the price, the market size, and the quantity of final good demanded, respectively. Parameter b is an indicator of demand elasticity. A high value of b implies an elastic demand and vice versa.

There are L firms l and firm m in the third market. The demand function becomes

$$p_t = S_t - b\left(\sum q_l^R + q_m^R\right) \tag{1}$$

[3] To simplify the model's representation, let us assume that there is no firm from country T (firm t). In other words, we can consider that firms t, if there are any, have some stable market shares. Firms from foreign countries (either from A or O) can only compete in the remaining market shares.

where q_l^R, q_m^R are, respectively, the quantities of final good produced by firms l and m when the latter adopts a strategy R (export Exp, tariff-jumping TJ, or IDEEP Ep). Therefore, their profit function can be written as

$$\begin{aligned} \pi_l^R &= \left[S_t - b\left(\sum q_l^R + q_m^R\right)\right] q_l^R - \mathrm{CV}_l^R \\ \pi_m^R &= \left[S_t - b\left(\sum q_l^R + q_m^R\right)\right] q_m^R - \mathrm{CV}_m^R - F^R \end{aligned} \tag{2}$$

where π_l^R, π_m^R represents the profit of firms l and m, respectively, when the latter adopts a strategy R; CV_l^R, CV_m^Rs are the variable costs of access to the market of firms l and m, respectively, when the latter applies a strategy R; and F^R represents the fixed setup cost when firm m adopts a strategy R.

Notice that either tariff-jumping or EPFDI are no longer profitable if the following condition does not hold: $\mathrm{CV}_l^{\mathrm{Exp}} < \mathrm{CV}_l^{\mathrm{TJ}} < \mathrm{CV}_l^{\mathrm{Ep}}$.

2.2 Market Equilibrium

The firm problem is as follows:

$$\begin{aligned} \max_{q_l^R} \pi_l^R &= \left[S_t - b\left(\sum q_l^R + q_m^R\right)\right] q_l^R - \mathrm{CV}_l^R \\ \max_{q_m^R \le q^*} \pi_m^R &= \left[S_t - b\left(\sum q_l^R + q_m^R\right)\right] q_m^R - \mathrm{CV}_m^R - F^R \end{aligned} \tag{3}$$

Indeed, each firm maximizes its profit by taking the strategy applied by its competitors into account. The equilibrium on the third market, when firm m adopts a strategy R, is given by

$$q_l^{R*} = \frac{S_t - 2\mathrm{CV}_l^R + \mathrm{CV}_m^R}{3Lb}$$

$$q_m^{R*} = \frac{S_t - 2\mathrm{CV}_m^R + \mathrm{CV}_l^R}{3b}$$

from where we have

$$\begin{aligned} \pi_l^{R*} &= \left(q_l^{R*}\right)^2 = \left(\frac{S_t - 2\mathrm{CV}_l^R + \mathrm{CV}_m^R}{3Lb}\right)^2 \\ \pi_m^{R*} &= \left(q_m^{R*}\right)^2 - F^R = \left(\frac{S_t - 2\mathrm{CV}_m^R + \mathrm{CV}_l^R}{3b}\right)^2 - F^R \end{aligned} \tag{4}$$

Note that firm m output associated with an EPFDI or tariff-jumping strategy can be, respectively, written as

$$q_m^{\mathrm{Ep}*} = q_m^{\mathrm{JP}*} + \frac{\mathrm{CV}_m^{\mathrm{TJ}} - \mathrm{CV}_m^{\mathrm{Ep}}}{3b}$$

$$q_m^{\mathrm{JP}*} = q_m^{\mathrm{Exp}*} + \frac{\mathrm{CV}_m^{\mathrm{Exp}} - \mathrm{CV}_m^{\mathrm{TJ}}}{3b}$$

Since $\mathrm{CV}_m^{\mathrm{Exp}} > \mathrm{CV}_m^{\mathrm{TJ}} > \mathrm{CV}_m^{\mathrm{Ep}}$, we have $q_m^{\mathrm{Ep}*} > q_m^{\mathrm{JP}*} > q_m^{\mathrm{Exp}*}$. As a result, EPFDI generates the highest production output, followed by tariff-jumping and then export.

Let $S^{\mathrm{Ep}=\mathrm{TJ}}$, $S^{\mathrm{Ep}=\mathrm{Exp}}$, and $S^{\mathrm{Exp}=\mathrm{TJ}}$ denote the market size such that $\pi_m^{\mathrm{Ep}} = \pi_m^{\mathrm{TJ}}$, $\pi_m^{\mathrm{Ep}} = \pi_m^{\mathrm{TJ}}$, and $\pi_m^{\mathrm{Ep}} = \pi_m^{\mathrm{TJ}}$, respectively. Hence, when $S_t = S^{\mathrm{Ep}=\mathrm{TJ}}$, firm m is indifferent between IDEP and tariff-jumping. When $S_t = S^{\mathrm{Ep}=\mathrm{Exp}}$, she is indifferent between IDEP and export. This firm is neutral between tariff-jumping and exporting once $S_t = S^{\mathrm{Exp}=\mathrm{TJ}}$. Therefore, since $S_t > \overline{S} := \max\left(S^{\mathrm{Ep}=\mathrm{TJ}}, S^{\mathrm{Ep}=\mathrm{Exp}}\right)$, firm m prefers IDEP to the other two strategies. If $S^{\mathrm{Exp}=\mathrm{TJ}} < S_t < S^{\mathrm{Ep}=\mathrm{TJ}}$, then tariff-jumping is the best strategy. If $S_t < S^{\mathrm{Exp}=\mathrm{TJ}}$, then exporting is the most profitable. We get Proposition 1.

Proposition 1
If the third market size is large enough, EPFDI is more profitable than tariff-jumping and exporting. At the middle level of the third market size, tariff-jumping is the best strategy. For markets with a small size, exporting is the most profitable.

It is noteworthy that the analysis in this section is more applicable to large MNEs. However, it is crucial to investigate what happens when m is an SME constrained by their production capacity.

3 Internationalization Strategies of SMEs

In this section, we examine how the SME internationalization strategies can be affected by its capacity. A firm is an SME if either its workforce or its turnover does not exceed a certain threshold. In this research, we use the labor force as a criterion defining SME. Consequently, when firm m is an SME, its workforce cannot exceed a threshold E^*.

Let E_m^R be the required workforce to adopt a strategy R. This strategy can be adopted by an SME m only if $E_m^R \leq E^*$. Since each unit of good produced requires a unit of labor, it follows that a strategy R applied by firm m is subjected to the constraint: $q_m^R \leq q^*$, where q^* is the output produced with a workforce E^*.

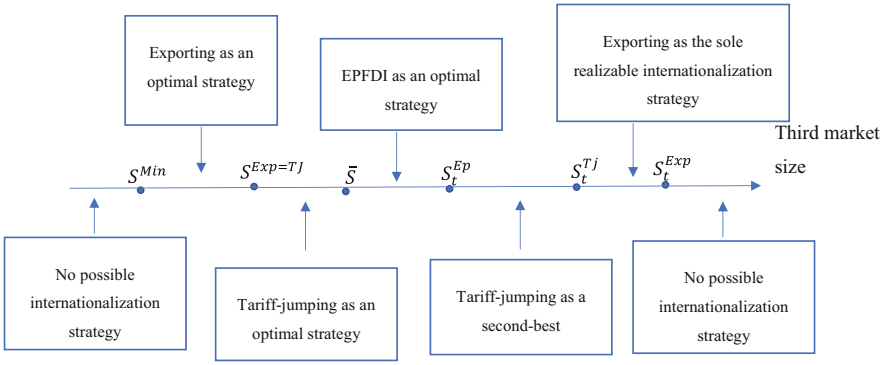

Fig. 1 Third market size and SME strategies

Notice that the output level of strategy R produced by the firm m, q_m^R, increases with the third market size ($\frac{\partial q_m^R}{\partial S_t} > 0$). As a result, when this size is large enough, q_m^{R*} becomes higher than q^*, $q_m^{R*} > q^*$. Thus, the strategy R cannot, in this case, be practicable by an SME. Figure 1 represents the different internationalization strategies practicable by an SME depending on the third market size.

Indeed, the SME internationalization strategies are determined by several critical thresholds of the third market size. Consider first the two extreme values: a minimum threshold S^{Min} and a maximum threshold S_t^{Exp}. S^{Min} is a level such that $q_m^{\text{Exp}}\left(S^{\text{Min}}\right) = 0$. Thus, when the third market size is too small, no internationalization strategy is profitable for firm m. Besides, S_t^{Exp} is a value such that $q_m^{\text{Exp}}\left(S_t^{\text{Exp}}\right) = q^*$. As a consequence, as soon as the third market size exceeds this critical threshold, $S_t > S_t^{\text{Exp}}$, we have $q_m^{\text{Exp}*} > q^*$. While $q_m^{\text{Ep}*} > q_m^{\text{JP}*} > q_m^{\text{Exp}*}$, it follows that no internationalization strategy is feasible for the SME m because the requested production level exceeds its capacity.

Second, $S^{\text{Exp}=\text{TJ}}$ and $\overline{S}$ are thresholds defined in Sect. 1. Between S^{Min} and $S^{\text{Exp}=\text{TJ}}$, exporting is the best strategy for firm m, while between $S^{\text{Exp}=\text{TJ}}$ and $S^{\text{Ep}=\text{TJ}}$, tariff-jumping is the optimal strategy.

Third, let us define two thresholds S_t^{Ep} and S_t^{TJ} so that $q_m^{\text{Ep}}\left(S_t^{\text{Ep}}\right) = q^*$and $q_m^{\text{TJ}}\left(S_t^{\text{TJ}}\right) = q^*$. So, it is trivial that $q_m^{\text{Ep}*} > q_m^{\text{Ep}}\left(S_t^{\text{Ep}}\right)$ and $q_m^{\text{TJ}*} > q_m^{\text{TJ}}\left(S_t^{\text{TJ}}\right)$.

Depending on these different thresholds, several scenarios are possible.

Scenario 1: $S_t \leq S_t^{\text{Ep}}$

In this case, we have $q_m^{\text{Ep}*} \leq q^*$. Hence, the third market size does not matter in the SME m internationalization strategies. If that size is between $\overline{S}$ and S_t^{Ep}, then EPFDI is the best internationalization strategy of firm m. When this size falls between $S_t^{\text{Exp}=\text{TJ}}$and $\overline{S}$, tariff-jumping replaces EPFDI as the best strategy, while between S_t^{Min} and $S_t^{\text{Exp}=\text{TJ}}$, exporting is the optimal strategy.

It is noteworthy that once the third market size exceeds S_t^{Ep}, it can hamper firm m internationalization strategies.

Scenario 2: $S_t^{\mathrm{Ep}} < S_t \leq S_t^{\mathrm{TJ}}$

We are in a context where $q_m^{\mathrm{Ep}*} > q^* \geq q_m^{\mathrm{TJ}*}$: firm m cannot achieve an optimal profit (from an EPFDI strategy) because the required production level exceeds its capacity. Nevertheless, a second-best solution is still possible:

- If $\pi_m^{\mathrm{Ep}}(q^*) > \pi_m^{\mathrm{TJ}*}$, firm m still adopts the IDEP strategy even if the optimal profit ($\pi_m^{\mathrm{Ep}*}$) is not achievable because this strategy always allows the SME to obtain a higher profit than a tariff-jumping or export does.
- If $\pi_m^{\mathrm{Ep}}(q^*) \leq \pi_m^{\mathrm{TJ}*}$, firm m develops a tariff-jumping.

In both cases, the strategy applied by the SME is the second best because due to its limited production capacity it cannot obtain a theoretically optimal profit. However, this second-best profit is still higher than that of exports. Notice that without such a constraint the optimal profit level is $\pi_m^{\mathrm{Ep}*}$. This result implies discrimination between an SME and a large firm when internationalizing. A large firm, with its high production capacity, can practice an EPFDI and achieve its optimal profit level regardless of the third market size. By contrast, when the third market exceeds a certain threshold, an SME can only adopt a second-best strategy: either an EPFDI with a suboptimal output level or a tariff-jumping. In both cases, the associated profit is lower than the theoretically optimal level.

Scenario 3: $S_t^{\mathrm{TJ}} < S_t \leq S_t^{\mathrm{Exp}}$

This scenario is even worse than the previous one because, on the one hand, $q_m^{\mathrm{TJ}*} > q^*$, and on the other hand, $\pi_m^{\mathrm{Ep}*} > \pi_m^{\mathrm{TJ}*} > \pi_m^{\mathrm{Exp}*}$. It is the case where EPFDI is an optimal strategy, followed by tariff-jumping. However, neither is practicable because the required output exceeds the capacity of an SME. Thus, internationalization can take place in two cases:

- When $\pi_m^{\mathrm{TJ}}(q^*) \leq \pi_m^{\mathrm{Exp}*}$, firm m applies an export as the only feasible internationalization strategy.
- To a lesser measure, when $\pi_m^{\mathrm{TJ}}(q^*) > \pi_m^{\mathrm{Exp}*}$, firm m can still adopt a tariff-jumping although the theoretically optimal output level ($q_m^{\mathrm{TJ}*}$) is not attainable because this strategy always allows to obtain a profit higher than that of an export strategy.

In both cases, the third market size matters much in the internationalization process of an SME because neither an optimal strategy nor a second best is adaptable because of its production constraint.

In conclusion, while the third market size is a favorable factor for the large MNEs in developing their international strategies, this factor can prevent SMEs from internationalizing. This result would allow us to document that large companies are

internationalizing, whether through EPFDI, tariff-jumping, or export to serve large foreign markets. On the other hand, SMEs are internationalizing to supply small- or medium-sized markets.

4 Conclusion

The last three decades have experienced a rise in RIA conducting to the appearance of a new investment called EPFDI. While there is developed literature on big MNE strategic behaviors against this rise, research on SMEs international activities remains limited. In this research, we have investigated SME internalization strategies in the RIA era.

The theoretical framework argues that the third market size, one of the main factors inciting a large MNE to develop its overseas activities, can become a barrier for an SME from internationalizing. An EPFDI can only be practicable with strict conditions: the third market size is neither too small nor too large. In most cases, an SME, by supplying a third market, uses either a tariff-jumping as a second best or exporting as the sole possible strategy abroad.

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The Pollution Haven Hypothesis in a Dual Economy

Shigemi Yabuuchi

Abstract The pollution haven hypothesis (PHH) states that economies with weak (strong) environmental standards have comparative advantages in the production of polluting (nonpolluting) products. Most studies on the PHH implicitly assume that developed countries have strong environmental standards. However, concerns about the environment are rising in developing countries as well. Many developing economies are characterized by wage differentials between the urban and rural sectors, and the attendant urban unemployment. Thus, this study examines whether the PHH is valid in a developing economy while focusing on the characteristic features of the labor market.

Keywords Pollution Haven Hypothesis · Environmental standard · Welfare · Wage differentials · Urban unemployment

1 Introduction

Factor endowments, production technologies, climate and geography, and several other factors determine comparative advantages. In contrast, the pollution haven hypothesis (PHH) states that economies with weak (strong) environmental standards have comparative advantages in the production of polluting (nonpolluting) products. If the other factors that influence the comparative advantage of an economy remain constant, then the price of polluting products will be higher in a country with strong environmental regulations because the emission abatement activity will require factor inputs, thereby raising the cost of production. Thus, this leads to the PHH.

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Trade theorists such as Pethig (1976), McGuire (1982), Copeland and Taylor (1994, 2004), Antweiler et al. (2001), Umanskaya and Barbier (2008), Lahiri (2012), and Yabuuchi (2019) examine the theoretical aspects of the PHH extensively. Most of these studies implicitly assume that the economies with strong environmental standards are those of developed countries that have neither labor market distortions nor unemployment. However, concerns about the environment are rising in developing countries as well. Many developing economies are characterized by wage differentials between the urban and rural sectors, and the attendant urban unemployment. Therefore, the current study investigates whether the PHH is valid in a developing economy while focusing on the characteristic features of the labor market.

Lahiri (2012) examined the PHH using the Heckscher–Ohlin–Samuelson (HOS) model comprising two (polluting and nonpolluting) industries and one emission abatement industry. She proposed separating the two effects for determining the effect of strong environmental standards on production and trade patterns. The emission abatement activity absorbs factors of production from the final sectors. This results in changes to the output in the final sectors, in accordance with the Rybczynski effect. On the other hand, a change in the emission abatement activity affects factor prices in accordance with the Stolper–Samuelson effect, which, in turn, influences production and trade. The former is called the effective endowment effect (EEE) while the latter is termed the factor price effect (FPE). Lahiri (2012) observed that the EEE increases or decreases polluting industries depending on the factor intensities, whereas the FPE changes them in a direction consistent with the PHH. Assuming that the validity of the PHH depends on these two effects, she derived some conditions under which the EEE is consistent with the PHH. Therefore, the purposes of the current study are (1) to examine whether Lahiri's (2012) findings pertaining to the PHH are valid in a developing economy with wage differentials and unemployment, and (2) investigate the impact of the environmental policy on unemployment and welfare.

The remainder of this chapter is structured as follows. We present the model and assumptions in Sect. 2 and examine the relationship between wage differentials and factor intensities in Sect. 3. Further, Sect. 4 provides some comparative static results pertaining to the effects of the environmental policy on the output of polluting and nonpolluting industries, and a discussion of the robustness of the PHH. We discuss the effects of the environmental policy on unemployment and welfare in Sects. 5 and 6, respectively. Finally, we offer our concluding remarks in Sect. 7.

2 The Model and Assumptions

Following Lahiri (2012), we assume a small open economy comprising two (polluting and nonpolluting) industries and one emission abatement industry. The nonpolluting (clean) sector X and the emission abatement sector A use the two factors of labor (L) and capital (K) while the polluting (dirty) sector Y both uses

labor, capital, and the emission abatement activity to produce each unit of product. Furthermore, the production functions increase in relation to each factor and satisfy linear homogenous and strictly quasi-concave properties. We denote the economy's environmental standard by e, representing a unit of the abatement activity. That is, e units of the abatement activity are required to produce one unit of the dirty product.

We assume that the economy is a developing country with a dual structure; that is, it has rural and urban areas. The nonpolluting sector X is located in a rural area while the polluting sector Y and abatement sector A are located in urban areas. Furthermore, we assume that the polluting sector Y produces manufacturing products, and that the nonpolluting sector X produces agricultural products. Following Harris and Todaro (1970), we set the urban wage rate ($\overline{w}$) relatively higher than the rural wage rate (w) because the polluting and abatement industries have well-organized trade unions and/or are governed by certain regulations mandating a minimum wage rate.[1] Therefore, rural workers prefer to relocate to urban areas in pursuit of a higher income, even at the risk of unemployment. L_U denotes unemployed labor, and L_Y and L_A denote employed labor in the polluting and abatement sectors, respectively. The probability of finding a job in the urban manufacturing sector is $((L_Y + L_A)/(L_Y + L_A + L_U))$. Rural workers move to urban areas until the expected wage rate in the urban areas $(\overline{w}\,(L_Y + L_A)\,/\,(L_Y + L_A + L_U))$ becomes equal to the actual rural wage rate (w). Thus, we can depict the labor allocation mechanism between urban and rural areas as follows:

$$\overline{w}\,(L_Y + L_A)\,/\,(L_Y + L_A + L_U) = w, \tag{1}$$

which we can express as

$$\overline{w} = (1 + \mu)\,w, \tag{2}$$

where $\mu = L_U/(L_Y + L_A)$. We assume that the abatement sector is located in an urban area. This implies that the abatement activity requires relatively advanced technologies, and that the workers receive a higher urban wage rate. The location itself is not significant. Alternatively, we can assume that the abatement activity uses traditional technologies such as soil improvement and tree planting, and that the workers receive the rural wage rate.[2]

[1] For the Harris–Todaro model and its extension to various aspects of economic problems, see, for example, Bhagwati and Srinivasan (1974), Corden and Findlay (1975), Batra and Naqvi (1987), Beladi and Naqvi (1988), Hazari and Sgro (1991), Gupta (1993), Yabuuchi (1993), Chao and Yu (1996), Chaudhuri (2005), Marjit and Kar (2005), and Beladi et al. (2008).

[2] For an extension of the Harris–Todaro model to environmental issues, see, for example, Tawada and Sun (2010), Daitoh and Omote (2011), and Yabuuchi (2013).

Thus, we can express the full employment conditions in capital and labor markets as

$$K = a_{YK}Y + a_{XK}X + a_{AK}A, \tag{3}$$

$$L = a_{YL}Y + a_{XL}X + a_{AL}A + L_U, \tag{4}$$

where K and L represent the endowments of capital and labor, respectively; Y, X, and A denote the output of the polluting, nonpolluting, and abatement sectors, respectively; and a_{ji} is the input coefficient of factor i required to produce one unit of product j ($i = L, K$; $j = X, Y, A$). Note that $e = A/Y$ by definition. Thus, we integrate the full employment conditions as follows:

$$K = b_{YK}Y + a_{XK}X, \tag{5}$$

$$L = b_{YL}Y + a_{XL}X, \tag{6}$$

where $b_{YK} = a_{YK} + ea_{AK}$ and $\tilde{b}_{YL} = (1+\mu)(a_{YL} + ea_{AL}) = (1+\mu)b_{YL}$ represent the *gross* (direct and indirect through the abatement activity) capital and labor input coefficients in sector Y, respectively, and a_{ij} is the *net* input coefficient. Both the *gross* and *net* input coefficients in sector X are identical by assumption.

Under perfect competition, the zero-profit conditions in the sectors are

$$1 = a_{XK}r + a_{XL}w, \tag{7}$$

$$p_A = a_{AK}r + a_{AL}\overline{w}, \tag{8}$$

$$p = a_{YK}r + a_{YL}\overline{w} + ep_A, \tag{9}$$

where p_A and p represent the price of products A and Y relative to product X, and r represent the rental. We assume that producing one unit of the dirty product requires e units of the abatement activity. Thus, the zero-profit condition in sector Y is

$$p = a_{YK}r + a_{YL}\overline{w} + e(a_{AK}r + a_{AL}\overline{w}) = b_{YK}r + \tilde{b}_{YL}\overline{w}. \tag{10}$$

3 Wage Differentials and Factor Intensities

Factor intensities play an important role in determining the effect of strong environmental standards on production and trade patterns. This section examines the relationship between wage differentials and factor intensities in the present context. Following the convention applied in the Harris–Todaro study, we assume that the polluting (manufacturing) sector is more capital-intensive than the nonpolluting

(agricultural) sector in the value sense; that is,$(ra_{XK}/wa_{XL}) < (ra_{YK}/\overline{w}a_{YL})$. This is known as the Khan–Neary condition (Khan, 1980; Neary, 1981). The condition implies that

$$|\tilde{a}| = (1+\mu)\, a_{YL}a_{XK} - a_{YK}a_{XL} < 0. \tag{11}$$

Further, we can write this expression as $(1+\mu)k_X < k_Y$, where $k_j = a_{jK}/a_{jL}$ $(j = X, Y)$. Note that the polluting sector is more capital-intensive than the nonpolluting sector in the physical sense (i.e., $k_X < k_Y$) if the polluting sector is more capital-intensive in the value sense (i.e., $(1+\mu)k_X < k_Y$) since

$$(a_{YL}a_{XK} - a_{YK}a_{XL}) < \{(1+\mu)\, a_{YL}a_{XK} - a_{YK}a_{XL}\} < 0.$$

Now, we assume that the abatement sector is more capital-intensive than the nonpolluting sector in the value sense (i.e., $(1+\mu)k_X < k_A$). This is consistent with our assumption that the abatement sector uses advanced technology and is located in an urban area. Note that this assumption implies that

$$\{(1+\mu)\, a_{AL}a_{XK} - a_{AK}a_{XL}\} < 0. \tag{12}$$

Regarding the wage differentials and unemployment, we summarize the relation between the gross and net factor intensities as follows:

$$\begin{aligned} \left|\tilde{b}\right| &= \tilde{b}_{YL}a_{XK} - b_{YK}a_{XL} \\ &= (1+\mu)\,(a_{YL} + ea_{AL})\, a_{XK} - (a_{YK} + ea_{AK})\, a_{XL} \\ &= \{(1+\mu)\,(a_{YL}a_{XK} - a_{YK}a_{XL})\} + e\,\{(1+\mu)\, a_{AL}a_{XK} - a_{AK}a_{XL}\}. \end{aligned} \tag{13}$$

It follows from (11) and (12) that $\left|\tilde{b}\right| = \tilde{b}_{YL}a_{XK} - b_{YK}a_{XL} < 0$. Thus, we summarize the assumption pertaining to factor intensities as follows.

Assumption 1
We assume that the polluting sector Y is more capital-intensive than the nonpolluting sector X in the value sense, and the abatement sector A is more capital-intensive than the nonpolluting sector X in the value sense.

Note that the integrated polluting sector Y (through the abatement activity) is more capital-intensive than the nonpolluting sector X (i.e., $\left|\tilde{b}\right| < 0$) under Assumption 1.

4 Wage Differentials and the Pollution Haven Hypothesis

This section investigates the changes in the output of the product and the possibility of the PHH. By differentiating (7), we obtain

$$\theta_{XK}\hat{r} + \theta_{XL}\hat{w} = 0, \tag{14}$$

where $\theta_{XK} = ra_{XK}$, $\theta_{XL} = wa_{XL}$, $\varepsilon = ep_A/p$, and $\hat{z} = dz/z$ for any variable z. Furthermore, differentiating (8) and (9) results in

$$\hat{p}_A = \theta_{AK}\hat{r} + \theta_{AL}\hat{\overline{w}} = \theta_{AK}\hat{r}, \tag{15}$$

$$\hat{p} = \theta_{YK}\hat{r} + \theta_{YL}\hat{\overline{w}} + \varepsilon\hat{p}_A + \varepsilon\hat{e} = \theta_{YK}\hat{r} + \varepsilon\hat{p}_A + \varepsilon\hat{e}, \tag{16}$$

where $\theta_{AK} = ra_{AK}/p_A$, $\theta_{AL} = \overline{w}a_{AL}/p_A$, $\theta_{YK} = ra_{YK}/p$, and $\theta_{YL} = \overline{w}a_{YL}/p$. By substituting (15) into (16) and considering $\hat{\overline{w}} = 0$, we obtain

$$\hat{p} = (\theta_{YK} + \varepsilon\theta_{AK})\,\hat{r} + \varepsilon\hat{e} = \overline{\theta}_{YK}\hat{r} + \varepsilon\hat{e}, \tag{17}$$

where $\overline{\theta}_{YK} = rb_{YK}/p$.

Further, under the constant price of the polluting product, we observe from (14) and (17) that

$$\hat{r} = -\left(\varepsilon/\overline{\theta}_{YK}\right)\hat{e}, \quad \hat{w} = \left(\varepsilon\theta_{XK}/\theta_{XL}\overline{\theta}_{YK}\right)\hat{e}. \tag{18}$$

By definition, the gross input coefficients in the polluting sector are $b_{YK} = a_{YK} + ea_{AK}$ and $b_{YL} = a_{YL} + ea_{AL}$. Note that

$$\hat{b}_{Yi} = \hat{\alpha}_{Yi} + s_{Ai}\hat{e}, \tag{19}$$

where $\hat{\alpha}_{Yi} = s_{Yi}\hat{a}_{Yi} + s_{Ai}\hat{a}_{Ai}$, $s_{Yi} = a_{Yi}/b_{Yi}$ $(i = L, K)$, and $s_{Ai} = ea_{Ai}/b_{Yi}$ $(i = L, K)$. $\hat{\alpha}_{Yi}$ denotes the partial change in $\hat{b}_{Yi}$ only due to factor price changes, excluding the exogenous change caused by $\hat{e}$. Therefore, it is evident from the cost minimization conditions that

$$\tilde{\theta}_{YL}\hat{\alpha}_{YL} + \overline{\theta}_{YK}\hat{\alpha}_{YK} = 0, \tag{20}$$

$$\theta_{XL}\hat{a}_{XL} + \theta_{XK}\hat{a}_{XK} = 0, \tag{21}$$

where $\tilde{\theta}_{YL} = \overline{w}b_{YL}/p = w\tilde{b}_{YL}/p$.

We define the elasticities of substitution between labor and capital in sectors Y and X as

$$\sigma_Y = \left(\hat{\alpha}_{YK} - \hat{\alpha}_{YL}\right) / \left(\hat{\overline{w}} - \hat{r}\right) = \left(\hat{\alpha}_{YK} - \hat{\alpha}_{YL}\right) / \left(-\hat{r}\right), \tag{22}$$

$$\sigma_X = \left(\hat{a}_{XK} - \hat{a}_{XL}\right) / \left(\hat{w} - \hat{r}\right). \tag{23}$$

It follows from (20)–(23) that

$$\hat{\alpha}_{YK} = -\tilde{\theta}_{YL}\sigma_Y\hat{r}, \quad \hat{\alpha}_{YL} = \overline{\theta}_{YK}\sigma_Y\hat{r}, \tag{24}$$

$$\hat{a}_{XK} = \theta_{XL}\sigma_X\left(\hat{w} - \hat{r}\right), \text{ and } \hat{a}_{XL} = -\theta_{XK}\sigma_X\left(\hat{w} - \hat{r}\right). \tag{25}$$

On the other hand, by differentiating (5) and (6), we can express the changes in the output due to the change in e as follows:

$$\lambda_{YK}\hat{Y} + \lambda_{XK}\hat{X} = \hat{K} - \left(\lambda_{YK}\hat{b}_{YK} + \lambda_{XK}\hat{a}_{XK}\right), \tag{26}$$

$$\tilde{\lambda}_{YL}\hat{Y} + \lambda_{XL}\hat{X} = \hat{L} - \left(\tilde{\lambda}_{YL}\hat{\tilde{b}}_{YL} + \lambda_{XL}\hat{a}_{XL}\right), \tag{27}$$

where $\lambda_{YK} = b_{YK}Y/K$, $\tilde{\lambda}_{YL} = \tilde{b}_{YL}Y/L = (1+\mu)\,b_{YL}Y/L = (1+\mu)\,\lambda_{YL}$, $\lambda_{XK} = a_{YK}X/K$, and $\lambda_{XL} = a_{XL}X/L$. Thus, under the constant endowments of capital and labor ($\hat{K} = \hat{L} = 0$), substituting (18) into (22) and (23), and considering (24) and (25), we can rewrite Eqs. (26) and (27) as

$$\lambda_{YK}\hat{Y} + \lambda_{XK}\hat{X} = -\left(T + \lambda_{YK}s_{AK}\right)\hat{e}, \tag{28}$$

$$\tilde{\lambda}_{YL}\hat{Y} + \lambda_{XL}\hat{X} = \left(S - \tilde{\lambda}_{YL}s_{AL}\right)\hat{e}, \tag{29}$$

respectively, where

$$T = \left(\lambda_{YK}\tilde{\theta}_{YL}\sigma_Y + \lambda_{XK}\sigma_X\right)\varepsilon/\overline{\theta}_{YK} \text{ and}$$

$$S = \left\{\tilde{\lambda}_{YL}\left(\theta_{XL}\overline{\theta}_{YK}\sigma_Y + \theta_{XK}\right) + \lambda_{XL}\theta_{XK}\sigma_X\right\}\varepsilon/\theta_{XL}\overline{\theta}_{YK}.$$

Solving (28) and (29) for $\hat{Y}$ and for $\hat{X}$ yields

$$\hat{Y} = \left\{\left(\lambda_{XL}\lambda_{YK}s_{AK} - \lambda_{XK}\tilde{\lambda}_{YL}s_{AL}\right) + \left(\lambda_{XL}T + \lambda_{XK}S\right)\right\}\hat{e}/\left|\tilde{\lambda}\right|, \tag{30}$$

$$\hat{X} = \left\{\left(s_{AL} - s_{AK}\right)\tilde{\lambda}_{YL}\lambda_{YK} - \left(\tilde{\lambda}_{YL}T + \lambda_{YK}S\right)\right\}\hat{e}/\left|\tilde{\lambda}\right|, \tag{31}$$

where $\left|\tilde{\lambda}\right| = \tilde{\lambda}_{YL}\lambda_{XK} - \lambda_{YK}\lambda_{XL}$. Note that $\left|\tilde{\lambda}\right| < 0$ by assumption. We capture the EEE using the first terms in (30) and (31) and the FPE using the second terms. The second terms in Eqs. (30) and (31) are $\{(\lambda_{XL}T + \lambda_{XK}S)\}\hat{e}/\left|\tilde{\lambda}\right| < 0$ and $-\left\{\left(\tilde{\lambda}_{YL}T + \lambda_{YK}S\right)\right\}\hat{e}/\left|\tilde{\lambda}\right| > 0$, respectively. Thus, the FPE decreased the output of the polluting sector Y and increased that of the nonpolluting sector X. This is consistent with the implication of the PHH. In contrast, the EEE observed in the first terms is not determinate, and it could increase the output of the polluting sector Y. The reallocation of factors from the final product sectors to the abatement sector caused the EEE. Thus, in the absence of other sources of comparative advantage, the increased environmental standards decreased the output and the PHH was valid if the EEE was negative. We can write the first term of (30) as

$$\left(\lambda_{XL}\lambda_{YK}s_{AK} - \lambda_{XK}\tilde{\lambda}_{YL}s_{AL}\right)\hat{e}/\left|\tilde{\lambda}\right| = \left(\lambda_{XL}\lambda_{YL}s_{AL}L/K\right)\{k_A - (1+\mu)\,k_X\}\,\hat{e}/\left|\tilde{\lambda}\right|. \tag{32}$$

It is evident from (32) that the EEE of sector Y is negative, rendering the PHH valid under Assumption 1. We summarize the results in Proposition 1.

Proposition 1 In a dual economy with a rural–urban wage differential, an increase (decrease) in environmental standards leads to a decrease (increase) in the output of the polluting industry under Assumption 1.

Thus, the results are consistent with the PHH in the absence of other sources of comparative advantage. The production of the abatement sector increases due to the strong regulation of pollution. This caused the reallocation of capital and labor from the final product sectors to the abatement sector, leading to a change in the output of the sectors, in accordance with the Rybczynski effect.

The output of the nonpolluting sector X decreased and the output of the polluting sector Y increased in relation to the expansion of the abatement if $k_A < k_X$ since more labor was absorbed from the final product sectors than capital. Moreover, the output of sector X decreased and that of sector Y remained constant if $k_A = k_X$. With regard to $k_X < k_A < k_Y$, the output of both the sectors decreased. Furthermore, the output of sector Y decreased and that of sector X remained constant if $k_A = k_Y$. Finally, if $k_Y < k_A$, then the output of sector Y decreased, whereas the output of sector X increased. Table 1 summarizes the changes in the output, where $+$ $(-)$ shows that the strict environmental policy increased (decreased) the output due to

Table 1 The effective endowment effect (EEE)

(k_A)	$<$	k_X	$<$	k_Y	$<$
X	$-$	0	$-$	$-$	$+$
Y	$+$	$-$	$-$	0	$-$

the EEE while 0 shows that the environmental policy did not change the output. Thus, the result of the change in the output of sector X leads to Proposition 2.

Proposition 2 In a dual economy with a rural–urban wage differential, an increase (decrease) in the environmental standards leads to an increase (decrease) in the output of the nonpolluting industry under Assumption 1 if $k_Y \leq k_A$.

This supports the PHH under these conditions. However, where $k_A < k_Y$, the change in the output of sector X is indeterminate because the FPE increased the output, while the EEE decreased it.

5 Environmental Policy and Unemployment

In this section, we analyze the effect of the environmental policy on urban unemployment. Considering the definition of μ, it follows from (1) that

$$\hat{\mu} = -\hat{w}/\Pi, \tag{33}$$

where $\Pi = \mu/(1+\mu) = L_U/(L_U + L_Y + L_A)$, which represents the unemployment rate in the urban area. Thus, from (18) and (33), it follows that

$$\hat{\mu} = -\hat{w}/\Pi = -\left(\varepsilon\theta_{XK}/\theta_{XL}\overline{\theta}_{YK}\right)\hat{e}/\Pi. \tag{34}$$

Therefore, it is evident that $\hat{\mu}/\hat{e} < 0$, implying that an increase in the environmental standards leads to a decrease in the unemployed–employed ratio in the urban area (μ). Additionally, it follows that $\hat{\Pi}/\hat{e} < 0$ since $d\Pi/d\mu > 0$ by definition. We summarize the results in Proposition 3.

Proposition 3 In a dual economy with a rural–urban wage differential, an increase (decrease) in the environmental standards leads to a decrease (increase) in the unemployed–employed ratio (μ) and the unemployment rate in an urban area (Π).

Next, we examine the effect of the environmental policy on the number of unemployed workers. Assuming that $L_Y = a_{YL}Y$, $L_A = a_{AL}A$, and $\mu = L_U/(L_Y + L_A)$, it follows that

$$\begin{aligned} \hat{L}_U &= \hat{\mu} + (dL_Y + dL_A)/(L_Y + L_A) \\ &= \hat{\mu} + l_Y\left(\hat{a}_{YL} + \hat{Y}\right) + l_A\left(\hat{a}_{AL} + \hat{A}\right), \end{aligned} \tag{35}$$

where $l_Y = L_Y/(L_Y + L_A)$ and $l_A = L_A/(L_Y + L_A)$. Further, by differentiating $a_{YL} = a_{YL}(\overline{w}, r, p_A)$, $a_{AL} = a_{AL}(\overline{w}, r)$, and (14), it follows that

$$\hat{a}_{YL} = \left(S^Y_{LK} + \theta_{AK}S^Y_{LA}\right)\hat{r} \text{ and } \hat{a}_{AL} = S^A_{LK}\hat{r}, \tag{36}$$

where $S_{LK}^{Y} = (r/a_{YL})(\partial a_{YL}/\partial r)$, $S_{LA}^{Y} = (p_A/a_{YL})(\partial a_{YL}/\partial p_A)$, and $S_{LK}^{A} = (r/a_{AL})(\partial a_{AL}/\partial r)$. We can see that $\hat{a}_{YL}/\hat{e} < 0$ and $\hat{a}_{AL}/\hat{e} < 0$ since it follows from (18) that $\hat{r}/\hat{e} = -(\varepsilon/\theta_{YK}) < 0$.

Additionally, we express the change in the number of unemployed workers, following from (35), as

$$\hat{L}_U/\hat{e} = \hat{\mu}/\hat{e} + \left\{l_Y\left(\hat{a}_{YL}/\hat{e}\right) + l_A\left(\hat{a}_{AL}/\hat{e}\right)\right\} + \left\{l_Y\left(\hat{Y}/\hat{e}\right) + l_A\left(\hat{A}/\hat{e}\right)\right\}. \tag{37}$$

If $\hat{\mu}/\hat{e} < 0$, $\hat{a}_{YL}/\hat{e} < 0$, and $\hat{a}_{AL}/\hat{e} < 0$, then the change in the number of unemployed workers depends on the last term of (37). Considering the definition of A, we express the term as

$$l_Y\left(\hat{Y}/\hat{e}\right) + l_A\left(\hat{A}/\hat{e}\right) = l_Y\left(\hat{Y}/\hat{e}\right) + l_A\left\{1 + \left(\hat{Y}/\hat{e}\right)\right\}. \tag{38}$$

Therefore, it is evident from (38) that $\left\{l_Y\left(\hat{Y}/\hat{e}\right) + l_A\left(\hat{A}/\hat{e}\right)\right\} < 0$, and further, $\hat{L}_U/\hat{e} < 0$ if $-\left(\hat{Y}/\hat{e}\right) > l_A$.

On the other hand, we observe that $(L - L_X)\Pi = L_U$, based on the definition of μ. Thus, since $\hat{\Pi}/\hat{e} < 0$, the number of unemployed workers decreased if the employment in the nonpolluting sector (L_X) increased. Furthermore, by differentiating $L_X = a_{XL}X$, we have

$$\hat{L}_X = \hat{a}_{XL} + \hat{X}. \tag{39}$$

Next, substituting (18) into (25) yields

$$\hat{a}_{XL}/\hat{e} = -\left(\theta_{XK}\sigma_X\varepsilon/\theta_{XL}\overline{\theta}_{YK}\right) < 0. \tag{40}$$

Further, by substituting (31) and (40) into (38), we have

$$\hat{L}_X = \left[\tilde{\lambda}_{YL}\lambda_{YK}\left(s_{AL} - s_{AK}\right) - \tilde{\lambda}_{YL}\left\{\lambda_{YK}\left(\theta_{XL}\sigma_Y + \theta_{XK}\right)\lambda_{XK}\sigma_X\right\}/\theta_{XL}\overline{\theta}_{YK}\right]\hat{e}/\left|\tilde{\lambda}\right|. \tag{41}$$

The first term on the right of (41) corresponds to the EEE, whereas the second term reveals the sum of the changes in a_{XL} and the FPE. Since the latter effect is positive, we derive Proposition 4 based on the discussion on the change in the output of the nonpolluting sector.

Proposition 4 In a dual economy with a rural–urban wage differential, an increase (decrease) in the environmental standards leads to a decrease (increase) in the number of unemployed workers if either (1) $-\left(\hat{Y}/\hat{e}\right) > l_A$ or (2) $k_Y \leq k_A$ under Assumption 1.

We can interpret the results as follows. We observe from (35) that an increase in the environmental standards leads to a decrease in the number of urban unemployed workers if the change in the sum of the employed workers in the two urban sectors is negative; that is, $d\left(L_Y + L_A\right)/\hat{e} < 0$, or if the weighted sum of the rate of changes in the output of the two urban sectors is negative; that is, $\left\{l_Y\left(\hat{Y}/\hat{e}\right) + l_A\left(\hat{A}/\hat{e}\right)\right\} < 0$ since $\hat{\mu}/\hat{e} < 0$, $\hat{a}_{YL}/\hat{e} < 0$, and $\hat{a}_{AL}/\hat{e} < 0$. The workers released from the urban sectors, as well as those previously unemployed, move to the rural area and gain employment there. That is, employment decreases in the urban areas, but more people work in the nonpolluting sector in the rural area. One sufficient condition for the decrease in unemployment is that the rate of the decrease in the output of the polluting sector is larger than the share of labor employed in the abatement sector of the total number of employed workers in the urban sector; that is, $-\left(\hat{Y}/\hat{e}\right) > l_A = L_A/\left(L_Y + L_A\right)$.

Conversely, the production cost of the polluting sector increases due to an increase in the input of the abatement product. This leads to an increase in the domestic price of the polluting product and induces a decrease in the rental rate and an increase in the wage rate, in accordance with the Stolper–Samuelson effect. The FPE expands the production of the nonpolluting products and contracts that of the polluting products. Furthermore, the amount of labor required to produce one unit of each product, that is, the labor coefficient, decreases due to the change in factor prices. Although the change in $L_X = a_{XL}X$ is generally indeterminate, it is evident that the sum of the changes in a_{XL} and the FPE is positive from the second term of (41). Thus, the change in L_X depends on the EEE, which we observe in the first term on the right of (41); it is positive if $k_Y \leq k_A$ under Assumption 1, as per Proposition 3. Therefore, urban unemployment decreases due to an increase in employment in the nonpolluting sector.

6 Environmental Policy and Welfare

Finally, in this section, we study the consequences of the environmental policy for welfare in the present model. U represents an index of social utility. Thus, we represent the strictly quasi-concave social utility function as

$$U = U\left(D_X, D_Y\right), \tag{42}$$

where D_X and D_Y denote the consumption of nonpolluting and polluting products, respectively. We can express the change in welfare as

$$dU/U_X = dD_X + \left(U_Y/U_X\right)dD_Y = dD_X + pdD_Y, \tag{43}$$

following the utility maximization condition, where $U_j = \partial U/\partial D_j > 0$, $(j = X, Y)$.

Here, the economy's budget constraint requires that we determine the value of expenditure by the value of income. Thus, it follows that

$$D_X + pD_Y = X_X + pX_Y + p_A X_A = wL + rK. \tag{44}$$

By differentiating (44) under the constant price of polluting product (p) and the endowments of factors, we obtain

$$dD_X + pdD_Y = Ldw + Kdr. \tag{45}$$

It is evident from (7) that

$$-(dw/dr) = k_X. \tag{46}$$

Thus, from (43), (44), and (46), we have

$$dU/U_X\hat{e} = L(k - k_X)\left(dr/\hat{e}\right), \tag{47}$$

where $k = K/L$. Thus, we have Proposition 5.

Proposition 5 In a dual economy with a rural–urban wage differential, an increase in the environmental standards leads to an improvement (deterioration) in welfare if $k_X > (<)k$.

Because $dw = -k_X dr$ from (46), we observe that welfare (national income) increases by $Ldw (= -Lk_X dr)$ due to a change in the wage rate while it decreases by $Lkdr$ due to a change in the rental rate. It is observed that $\hat{w}/\hat{e} > 0$ and $\hat{r}/\hat{e} < 0$ from (18). Thus, the beneficial effect of the change in the wage rate is greater (lesser) than the harmful effect of the change in the rental rate, and welfare improves (deteriorates) due to a strong environmental policy if $k_X > (<)k$.

Note that

$$l_X k_X + l_Y k_Y + l_A k_A = k, \tag{48}$$

where $l_j = L_j/L > 0$ $(j = X, Y, A)$ and $l_X + l_Y + l_A \leq 1$. Clearly, $l_X + l_Y + l_A = 1$ if there is no unemployment; otherwise, $l_X + l_Y + l_A < 1$. Therefore, an increase in the environmental standard must decrease welfare in the economy without unemployment since $k_X < k$ by the nature of convex linear combination. Thus, the environmental policy improves welfare only if $l_X + l_Y + l_A < 1$, or equivalently, if there is unemployment.

We can see from (48) that

$$k_X - k = (1 - l_X)k_X - (\alpha l_Y + \beta l_A)k_X, \tag{49}$$

where $\alpha = k_Y/k_X$ and $\beta = k_A/k_X$. Thus, it follows from (49) that

$$k_X > (<)\, k \text{ if and only if } (\alpha\Pi_Y + \beta\Pi_A) < (>)\, 1, \tag{50}$$

where $\Pi_Y = L_Y/(L_Y + L_A + L_U)$ and $\Pi_A = L_A/(L_Y + L_A + L_U)$. Thus, an increase in the environmental standards improves welfare either if the difference in the capital intensities between sector X and the other two sectors is small (i.e., α and β are close to one) or if employment in the urban sectors is small relative to urban unemployment (i.e., Π_Y and Π_A are small).

7 Concluding Remarks

Several studies on the PHH implicitly assume that developed (developing) countries have strong (weak) environmental standards and comparative advantages in the production of nonpolluting (polluting) products. However, environmental concerns have been rising in developing countries as well. Developing economies are characterized by wage differentials between the urban and rural sectors, and urban unemployment. Therefore, we examine the validity of the PHH in a developing economy. Primarily, we find that the PHH is valid under conditions similar to those of developed countries and conclude that a strong (weak) environmental policy tends to improve (exacerbate) the problem of unemployment in developing countries. Thus, a strong environmental policy introduced to improve the environment may be an effective measure to reduce unemployment. Further, an increase in the environmental standard may improve welfare if there is urban unemployment.

Several aspects of the PHH are open for further investigation. In this study, we presume that the abatement sector is located in an urban area and uses advanced technologies. However, the sector could be located in a rural area and uses traditional technologies. Furthermore, we examined the two effects (i.e., the EEE and the FPE) separately. Thus, it would also be interesting to investigate the possibility of the PHH by focusing on the interrelationship between the two effects. These constitute an important agenda for future research.

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Protecting Brain Drain Versus Excluding Low-Quality Workers

Kenji Kondoh and Kiyoshi Matsubara

Abstract Applying a simple two-country model, we find that under mutual reaction by each country regarding the productive quality of migrants, the host country may be able to reduce the total number of illegal immigrants by changing the restriction policy toward illegal immigration. On the other hand, the host country has no effective policy method to improve the average quality of immigrants, but the relative population increase in the source country may realize this improvement.

Keywords Illegal immigration · Brain drain · Strategic policies toward migration · Per-capita national income · Average quality of foreign workers

1 Introduction

Brander and Spencer's (1985) pioneering study provided a new framework of trade theory and proved that an optimal level of subsidy by one government to a domestic monopolistic firm that is competing with a foreign rival firm in the market of a third country can enhance domestic national welfare. Several extension studies on strategic trade policies have been accumulated since then, and this subject has become one of the main streams of trade theorists' research topics since the 1990s.

However, commonly intended to maximize the economic welfare of the domestic economy, US President Donald Trump adopted a completely different trade policy. In 2018, he started a trade war against China. He unilaterally raised tariffs and set other trade barriers against China with the goal of forcing it to make changes to what the United States says are "unfair trade practices." He insisted that the targets

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that should be defeated are growing trade deficit, the theft of intellectual property, and the forced transfer of American technology to China. Countermeasures were immediately taken to cope with America's raising of duties, and these two countries have continued and escalated mutual hostilities since then. Academic studies have just started to analyze this current and ongoing topic. Crowley (2019) constructed a narrative of the US–China trade war as the outgrowth of long-brewing tensions in the multilateral trading system. She concluded that the prospects for the future of the multilateral trading system look grim, the list of potentially effective avenues for achieving substantive reform is short, and it will require concerted efforts and serious compromises. Amiti et al. (2019a) explored the negative impacts of the Trump administration's trade policy on the prices and welfare of US residents. Amiti et al. (2019b) also empirically determined that US tariffs continue to be almost entirely borne by US firms and consumers.

The trade war is just one aspect of the current inward-looking American international economic policy. Trump started to introduce restricting immigration policies just after his inauguration. In 2017, he banned people from several countries, including Iran and Iraq, from entering the United States. He also insisted on constructing a wall at the border between the United States and Mexico as he had publicly promised during the election campaign. This coincides with the EU's current immigration policy after the migration crisis in 2015. Both cases show that developed countries no longer intend to receive unskilled workers. On the other hand, both the United States and the EU welcome highly skilled workers, such as medical doctors and scientists.

Remembering that Trump continuously emphasized "America first," these series of strategies surely do not consider improving world welfare but are just examples of precedence of the domestic economy. These strategies caused several negative distortions and inhumane results. Furthermore, different from an international trade war in which China can introduce an effective reaction policy, in the case of international migration, there are almost no countermeasures for the source developing country, such as Mexico. All they can do is to appeal against such unfairness and try to place this topic on the agenda of related international organizations. At this point, trade war may be regarded as essentially bilateral while friction due to migration is more unilateral. The source country of migration must endure unfair one-sided treatment, which currently seems to be a common understanding.

However, is this really true? The source country supplies not only unskilled workers who are sometimes prohibited from legal entry by the host country but also highly skilled ones who are welcomed and contribute to the economic prosperity of the host country. For a developing country, the outflow of these educated workers, such as medical doctors, implies the outflow of the sunk cost of education at least partially financed by national tax revenue, and thus, this "brain drain" surely causes economic loss. Although these skilled workers prefer to stay in a civilized, clean, and rich country where their income should be much higher than that in their home country, why does the government of the source country hesitate to stop the brain drain as a counter method to the attacking host country? Of course, to prevent trainees from moving abroad, many developing countries impose mandatory service

periods such as those implemented in the Philippines. Following the Economist Intelligence Unit (2017), Thailand has a system whereby public medical school graduates are required to work in the country for at least 3 years, with an added incentive of US$250 per month for those who do not practice privately. Vietnam and Mongolia all have mandatory rural service as a prerequisite for a postgraduate medical degree while India is discussing a similar idea.[1] Treating these restriction periods to prohibit the brain drain flexibly may be a good trump card for a developed country.

The justification for restricting the brain drain has been discussed in the academic field. Focusing on the host country side, Oberman (2013) investigated how immigration restrictions could help restrict the brain drain of skilled workers from poor countries; his conclusion was negative. He concluded that for restrictions to be justified, a series of demanding conditions must be satisfied. On the other hand, Brock and Blake (2015) asserted the necessity of restrictions. The authors argued that all of these state policies were based on the assumption that individuals were under obligation to contribute to and promote the institutions of justice in their society. This obligation could be explained by the foundational role of social institutions in the realization of social justice. To protect institutions of social justice, they proposed that the rights of some to exit their countries of origin should be tied to duties of justice that need to be satisfied before benefiting from a right to exit. Particularly in the special case of access to health care, states may be justified in restricting liberty rights.

We construct a very simple economic model of the conflict of migration between two countries. The main purpose is to theoretically examine the effects of immigration policies under mutual strategic reactions, that is, the source country controls the brain drain while the host country controls the minimum skill level of legal immigration. It should be noted that in our model we reflect the current situation in which both countries want to retain high-skilled workers who can contribute to economic growth and improve per-capita national income while low-skilled workers are not welcomed. There are no related theoretical studies that focused on the current topic of "scrambling for" and "palming off" workers between the two countries.

We found that the host country's introduction of stricter restriction policies toward illegal immigration that reduces the probability of success of illegal entry also implies that the host country welcomes former illegal lower productivity holders as legal workers. We also found that under certain conditions the source country adopts a reaction policy that causes more restricted control of brain drain. In the above case, we can assert that the total number of illegal immigrants will surely decrease but the effect on the average quality of immigrants is not certain. Moreover,

[1] On the other hand, China adopted an "overseas human resources recall policy" and accomplished certain results. Following the announcement by the Ministry of Education of China, the total number of international students from 1978 to 2018 was 5,857,100. Among these, 3,651,400 have returned to China. This can be counted as another success story regarding recovery from the loss of brain drain.

under certain conditions, a relative increase in population in the developing source country may contribute to the improvement of the average quality of immigrants in the host country.

The remainder of this chapter is organized as follows. We present our model in Sect. 2. Section 3 is devoted to the analysis, and concluding remarks are presented in Sect. 4.

2 The Model

Assume that there are two countries in the world. Country A is a developed country like Italy or Japan, while Country B is a developing country like Albania or the Philippines. To focus on international labor mobility, we assume that both countries produce the same single good and that there is no international trade. The primary factors of production are labor and capital. We also assume that there is no difference in production technology.

Supplying labor activity, all residents in both countries contribute to production. We assume the diversification of their skill, which causes an efficiency gap between workers. We also consider that a constant number of individuals are sufficiently large so that we may treat them as a continuum of individuals. Let $i \in [0, 1]$ be the index of individuals and denote a worker's productivity. Index 1 (0) indicates that the highest (lowest) skill holder and their productivity is equal to 1 (0). Workers with different productivities are uniformly distributed. In autarky, we normalize the total real number of workers in Country B, L^B, as unity and total efficiency initial endowment of workers, L_E^B, can be expressed 1/2. In Country A, the total real number of workers, L^A, is α. Thus, the total efficiency stock of workers, L_E^A, is $\alpha/2$.

The production function of each country is an ordinary Cobb–Douglas type, which can be expressed as

$$X^A = \left(K^A\right)^{\frac{1}{2}} \left(L_E^A\right)^{\frac{1}{2}}, \tag{1}$$

$$X^B = \left(K^B\right)^{\frac{1}{2}} \left(L_E^B\right)^{\frac{1}{2}}, \tag{2}$$

where X^A and X^B are outputs and K^A and K^B are capital endowments in Countries A and B, respectively. In autarky, we assume

$$K^A/L_E^A > K^B/L_E^B. \tag{3}$$

This implies that Country A is capital abundant, and under the assumption of perfect competition, this condition could cause international migration from Country B to Country A due to the wage gap.

We consider the case in which each country intends to optimally choose the amount and quality of migrants to maximize its per-capita national income. In each country, we consider that there is no pure investor and all of the residents supply labor force. Thus, capital is owned by some of the rich residents with relatively high productivity and the total number of population in Country A (B) is $\alpha(1)$, which is equal to labor endowment.

Country B (the source country) chooses the lowest index i_1 that is prohibited from migrating. In the usual case, the developing labor-abundant country welcomes the outflow of labor. In our model, as each worker has different productivity, to maintain the so-called "brain" of the country, Country B prohibits the emigration of higher productivity holders. Thus, a worker whose index is $i \in [i_1, 1]$ stays in Country B and one whose index is $i \in [0, i_1]$ intends to migrate with permission from the source country. To simplify our analysis, we assume that the government of Country B can enforce higher productivity holders not to migrate at no cost. As all of the capital in Country B is owned by higher productivity holders, international migration will not cause any capital outflow.

Country A (the host country) chooses the lowest index i_0 that permits legal immigration. We assume $i_0 < i_1$ that individuals $i \in [i_0, i_1]$ can migrate from Country B to Country A legally, but individuals $i \in [0, i_0]$ can migrate only illegally. Country A also chooses enforcement policies to exclude illegal lower productivity workers by using public servants. Stronger restriction policies are adopted, and a larger number of public servants are necessary, which reduces the number of workers employed in the production sector. Let e $(0 < e < 1)$ denote the probability of success of entry for illegal immigrants from Country B. If there is no restriction policy with no public servant, $e = 1$ and efficiency stock of labor for production in Country A is $\alpha/2$. Here, we assume that to fulfill a perfect restriction policy, $e = 0$, it is necessary to employ all workers in Country A as public servants. Thus, in this case, the efficiency stock of labor for production is null. Considering the above situation, we reasonably define the efficiency stock of labor for production as a function of e, and, to simplify our analysis, it can be expressed as $\alpha e/2$.

The real number of foreign workers in Country A can be expressed as $i_1 - (1 - e)i_0$, and the efficiency stock of foreign workers can also be expressed as $\left[i_1^2 - (1 - e)\, i_0^2\right]/2$.

Exogenously given e, the number of public servants or the level of disclosure, Country B chooses the optimal level of i_1 regarding i_0 as exogenously given just for reaction toward the strategy of Country A. Country A chooses the optimal level of i_0 regarding i_1 as exogenously given just for reaction toward the strategy of Country B. Then, the Nash equilibrium $\left(i_0^*, i_1^*\right)$ can be obtained.

It is widely known that in the case of homogeneous individuals free migration is the most beneficial to maximize world GDP (the sum of GDP of both countries) in a simple two-country one-good two-factor McDougal model. However, in this case, we consider that each country focuses on whether a worker's migration will increase or decrease the average national income. Even though workers are paid depending on their productivity and some of them gain capital income, the government must redistribute residents' aggregate income more equally through tax

and social insurance policies. For this reason, the government prefers workers with higher productivity who can contribute to an increase in per-capita income.

Let $\tilde{L}^A$, $\tilde{L}^B$, $\tilde{L}_E^A$ and $\tilde{L}_E^B$ be the real number of workers (residents) in Countries A and B and the efficiency stock of labor after migration, respectively. Thus, we have

$$\tilde{L}^A = \alpha + i_1 - (1-e)\, i_0, \tag{4}$$

$$\tilde{L}^B = 1 - i_1 + (1-e)\, i_0, \tag{5}$$

$$\tilde{L}_E^A = \frac{1}{2}\left[\alpha e + i_1^2 - (1-e)\, i_0^2\right], \tag{6}$$

$$\tilde{L}_E^B = \frac{1}{2}\left[1 - i_1^2 + (1-e)\, i_0^2\right]. \tag{7}$$

3 Analysis

A Nash equilibrium solution can be obtained by maximizing the per-capita national income of Countries A and B with respect to i_0 and i_1, that is, $\partial(\tilde{X}^A/\tilde{L}^A)/\partial i_0 = 0$ and $\partial(\tilde{X}^B/\tilde{L}^B)/\partial i_1 = 0$, respectively, where $\tilde{X}^A = \left(K^A\right)^{\frac{1}{2}}\left(\tilde{L}_E^A\right)^{\frac{1}{2}}$ and $\tilde{X}^B = \left(K^B\right)^{\frac{1}{2}}\left(\tilde{L}_E^B\right)^{\frac{1}{2}}$. Thus, we have the following two first-order conditions:

$$\alpha e + i_1^2 - (\alpha + i_1)\, i_0 = 0, \tag{8}$$

$$i_1 - 1 + (1-e)\,(i_1 - i_0)\, i_0 = 0. \tag{9}$$

Total differentiation of (8) and (9) yields

$$\begin{bmatrix} -(\alpha + i_1) & 2i_1 - i_0 \\ (1-e)\,(i_1 - 2i_0) & (1-e)\, i_0 + 1 \end{bmatrix}\begin{bmatrix} di_0 \\ di_1 \end{bmatrix} = \begin{bmatrix} -\alpha \\ i_0\,(i_1 - i_0) \end{bmatrix} de + \begin{bmatrix} i_0 - e \\ 0 \end{bmatrix} d\alpha, \tag{10}$$

and determinant of the LHS matrix of (10) is $\Delta = -\alpha - i_1 - (1-e)[\alpha i_0 + 2(i_1 - i_0)^2] < 0$.

3.1 The Effects of Strict Restriction Policy Toward Illegal Immigration

From (10), we have

$$\Delta \frac{di_0}{de} = \begin{vmatrix} -\alpha & 2i_1 - i_0 \\ i_0 (i_1 - i_0) & (1-e) i_0 + 1 \end{vmatrix}$$
$$= -\alpha [(1-e) i_0 + 1] - i_0 (2i_1 - i_0) (i_1 - i_0) < 0, \tag{11}$$

$$\Delta \frac{di_1}{de} = \begin{vmatrix} -(\alpha + i_1) & -\alpha \\ (1-e)(-2i_0 + i_1) & i_0 (i_1 - i_0) \end{vmatrix}$$
$$= \alpha (1-e)(i_1 - 2i_0) - i_0 (i_1 - i_0)(\alpha + i_1). \tag{12}$$

The negative sign of (11) implies $di_0/de > 0$, that is, the introduction of a strict restriction policy toward illegal immigration always reduces the minimum productivity index of legal migration from Country B to Country A in equilibrium. The sign of (12) is not clear. In the case that restriction policy toward illegal immigration is almost free entry, that is, e is close to unity, and/or the size of Country A is sufficiently small compared with Country B, that is, α is close to null, we can assert that the sign of (12) is negative. In addition, in the case that $i_1 < 2i_0$ in equilibrium, (12) should be negative in sign. In the above cases, we can assert $di_1/de > 0$, that is, increasing restriction toward illegal immigration by Country A causes strict restriction of high productivity holders' brain drain as a reaction by source Country B.

We now have Proposition 1.

Proposition 1
Under mutual strategic migration reactions between the host and source countries, the host country's introduction of stricter restriction policies toward illegal immigration will cause reactions by the source country. Due to the increased employment of public servants, the host country can change the status of relatively lower-productivity workers from legal to illegal in equilibrium. On the other hand, under certain conditions, the outflow of higher productivity workers, that is, "brain drain," will be more restricted. As a result, the total number of illegal immigrants in the host country will surely decrease.

We find that there is a possibility that strict restriction policies can reduce the total number of illegal immigrants because of decreasing i_0 and e while a change in the average productivity of the host country in that case is not clear. In other words, restricting the illegal entry of lower productivity workers may not contribute to the improvement of the average quality of total workers in the host country.

3.2 The Effect of Increasing Population in the Source Country

As we consider the case of international migration from a developing country to a developed country, a population increase in the source country (or a population decrease in the host country) is a realistic scenario. Here, we can examine this by analyzing the effects caused by a decrease in α, the relative population magnitude of the host country to the source country. From (10), we have

$$\begin{aligned}\Delta \frac{di_0}{d\alpha} &= \begin{vmatrix} i_0 - e & 2i_1 - i_0 \\ 0 & (1-e)\, i_0 + 1 \end{vmatrix} = (i_0 - e)\left[(1-e)\, i_0 + 1\right] \\ &= i_0 e^2 - \left[i_0^2 + i_0 + 1\right] e + i_0 + i_0^2,\end{aligned} \tag{13}$$

$$\begin{aligned}\Delta \frac{di_1}{d\alpha} &= \begin{vmatrix} -(\alpha + i_1) & i_0 - e \\ (1-e)\,(-2i_0 + i_1) & 0 \end{vmatrix} = (i_1 - 2i_0)\,(1-e)\,(i_0 - e) \\ &= (i_1 - 2i_0)\left[-e^2 + (1 + i_0)\, e - i_0\right].\end{aligned} \tag{14}$$

The sign of (13) is not clear. If a restriction policy toward illegal immigration is almost free entrance, that is, e is close to unity, the sign of (13) is negative, that is, $di_0/d\alpha > 0$. On the other hand, if such a restriction policy is already sufficiently strict, that is, e is close to null, we can assert that the sign of (13) is positive, that is, $di_0/d\alpha < 0$. In a general case, if $e > i_0$ ($e < i_0$) in equilibrium, we can assert that the sign of (13) is negative (positive), that is, $di_0/d\alpha > (<)0$, respectively.

The sign of (14) is also unclear. If $i_1 < 2i_0$ ($i_1 > 2i_0$) and a restriction policy toward illegal immigration is already sufficiently strict to satisfy $e < i_0$ in equilibrium, the sign of (14) is negative (positive), that is, $di_1/d\alpha > (<)0$, respectively. On the other hand, in the case where $i_1 < 2i_0$ ($i_1 > 2i_0$) and a restriction policy toward illegal immigration is quite loose to satisfy $e > i_0$ in equilibrium, we can assert that the sign of (14) is positive (negative), that is, $di_1/d\alpha < (>)0$.

Summarizing the above results, under the condition of $i_1 > 2i_0$, which implies that each country's strategy toward the productive quality of migrants is relatively loose, if an initial restriction policy on illegal immigrants' entrance is sufficiently strict to satisfy $e < i_0$, increasing labor endowment of the source country, that is, a decrease in α, will enhance the average quality of workers in the host country due to the increasing i_1 and i_0. On the other hand, if an initial restriction policy is sufficiently loose to satisfy $e > i_0$, increasing labor endowment of the home country, that is, a decrease in α, will reduce the average quality of workers in the host country.

We now have Proposition 2.

Proposition 2
Under mutual strategic migration reactions between the host and source countries, if each country's strategy toward the productive quality of migrants is relatively loose and the restriction policy toward illegal immigration is strict to satisfy $i_1/2 > i_0 > e$, then increasing the population of the source country will enhance the average quality

of labor in the host country in equilibrium. On the other hand, if the initial restriction policy is sufficiently loose to satisfy $i_1 > 2i_0$ and $i_0 < e$, the result may be opposite.

It should be noted that in the above case with improving average quality of foreign workers the number of illegal immigrants may increase. This is because, even though i_0 increased, the increased total population of the source country will enhance the total number of illegal immigrants of each index holder.

4 Concluding Remarks

Applying the aforementioned simple two-country model, we find that under mutual reaction by each country about the productive quality of migrants, the host country may be able to reduce the total number of illegal immigrants by changing the restriction policy toward illegal immigration. On the other hand, to improve the average quality of immigrants, the host country has no effective policy method, but the relative population increase in the source country may realize this improvement.

The remaining subjects are as follows. First, we consider the restriction policy of the host country with exogenous employment of public servants. While it may be reasonable to consider another scenario in which the host country optimally chooses e to maximize per-capita income at the first stage and after that, given e, the Nash equilibrium of i_1 and i_0 will be determined by both countries. Second, the objective function of each country could be replaced by maximizing the average income of domestic people that excludes migrants. For the host country, this assumption may be realistic. Third, it may be better to consider international trade and examine the effects of trade policies that may change the decision-making of migrants.

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Allocation and Effectiveness of Foreign Aid: An Overview

Ngoc-Sang Pham and Thi Kim Cuong Pham

Abstract This study investigates the nexus between foreign aid and economic outcomes in recipient countries and examines the aid rules to promote its effectiveness. Analyses aim to provide an overview of the two important points in aid literature: aid effectiveness and aid allocation. First, we focus on internal and external factors that can explain why foreign aid is effective in some recipient countries but ineffective in others. Both theoretical and empirical analyses are explored. Second, our work discusses the principal elements influencing aid rules often qualified as suboptimal. Finally, we analyze the criteria and conditions for an optimal allocation of aid, taking into account recipient characteristics and donors' preferences.

Keywords Aid allocation · Aid effectiveness · Economic growth · Fiscal policy · Poverty reduction · Public spending

1 Introduction

Since the United Nations Summit in September 2000, at which the Millennium Development Goals (MDGs) were agreed upon, foreign aid, in particular, Official Development Assistance (ODA), has been continually increasing (Fig. 1). Development aid provided by the donors in the OECD Development Assistance Committee (DAC) reached a peak of 152.8 billion USD in 2019 and increased by 1.4% in real terms compared to 2018, with more aid to the poorest countries. Foreign aid

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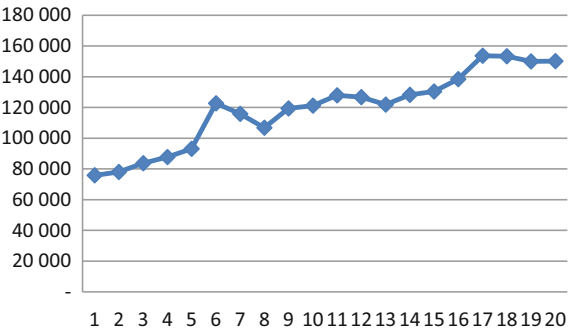

Fig. 1 ODA net (constant 2018 USD million) by DAC members between 2000 and 2019. (Source: OECD.org)

constitutes an important source of revenue for numerous recipient countries and can reach up to 10% of GDP in low-income countries.[1]

ODA flows are the main tool for economic cooperation between developed countries (donors) and developing countries (recipients). ODA finances infrastructure and action projects to fight hunger, promote poverty reduction, public health, education, etc., for the goals of economic development and welfare improvement in recipient countries. ODA accounts for more than two-thirds of external financing to least-developed countries as a lever to mobilize private investment and increase domestic tax revenues in recipient countries.

Developing countries, particularly the most vulnerable and low-income countries, need foreign aid because it may provide favorable conditions for a generation of economic growth and attainment of sustainable development. Several studies have offered substantial results on the nexus between foreign aid, its allocation, and economic outcomes of recipient countries. It would be important to summarize the main points regarding the effectiveness and allocation of aid to identify (1) the main factors influencing the aid effects in recipient countries and (2) the main characteristics taken into account in aid policy practiced by donor countries. It is also necessary to highlight how the interaction between recipient and donor policies can determine aid effectiveness.

The scope of our analysis is the following. In Sect. 2, we review theoretical growth models that explain the relationship between foreign aid and economic growth, as well as the effects of aid rules. Section 3 analyzes the effects of foreign aid on the recipient countries' economic outcomes and government behavior based on a number of recent empirical studies. In terms of economic outcomes, we underline economic growth, income distribution, and poverty reduction as the three important points helping recipient countries to achieve sustainable development goals. In addition, we emphasize the conditional effects of aid, particularly the fact that aid may have striking impacts on the recipient's fiscal policy and public expenditures, and explain how the interaction between the recipient's fiscal policy

[1] See http://www.oecd.org/dac/financing-sustainable-development/development-finance-data/ODA-2019-detailed-summary.pdf.

and economic and institutional characteristics determine the final effects of aid. In Sect. 4, we discuss different criteria and principal elements influencing the aid allocation often qualified as suboptimal from a Pareto point of view. We also present the normative approach to analyze the optimal allocation of aid. Section 5 provides final remarks and a discussion concerning the foreign aid in the global pandemic context due to the Covid-19.

2 Foreign Aid and Public Finance in Theoretical Growth Models

The evaluation of aid effects is necessary to determine an efficient allocation of aid to recipient countries. Many issues are under debate regarding the effectiveness of foreign aid in terms of economic growth. While empirical studies are abundant, there are relatively few theoretical analyses on this issue. The role of foreign aid in the growth process of developing countries has been modeled in a growth model by Chenery and Strout (1966), who argue that foreign aid affects growth through investment. Precisely, in a recipient country, its investment is the sum of domestic saving and foreign aid that equals a fraction of the recipient's GNP. If we refer to a Solow exogenous model, it is straightforward to find a positive effect of aid on recipient countries' economic growth.

Chartterjee et al. (2003) examine the effects of foreign transfers in a continuous-time growth model à la Rebelo (1991), where the accumulation of public capital comes from two sources: domestic government expenditure and foreign transfer. They assume that foreign transfer is proportional to the recipient's GDP, but not subject to conditions based on the donor's strategy and the recipient's need and performance, which are often mentioned in aid rules. The authors distinguish the effects of two types of transfer: a pure (untied) transfer and a transfer tied to investment in public capital so that the recipient government faces the flow budget constraint as $\tau Y + \overline{T} + \dot{D} + a = \overline{G} + \lambda a + r D$,where the left-hand side represents government revenues with income tax τY, lump-sum tax $\overline{T}$,debt accumulation $\dot{D}$, and foreign transfer a. The right-hand side corresponds to overall public expenditures: government expenditure on public capital $\overline{G}$, capital transfer from donors λa, and interest payments on debt rD. Their study examines the structural conditions of the recipient economy, which can influence aid effectiveness. Given this budget constraint, the case $\lambda = 1$ implies that foreign transfers are tied to public investment. In contrast, the case $\lambda = 0$ means that foreign transfer is not invested in public capital and represents a pure (untied) transfer.

Their analyses around the steady state showed that a pure transfer has no dynamic consequences for the recipient economy but is welfare improving while a transfer

tied to public investment generates dynamic adjustments and affects economic growth in the long run. In particular, the benefits of tied transfer can be maximized by the recipient determination regarding the appropriated expenditure and tax rates τ. Results underline the recipient government's role in response to a foreign transfer in the latter's effectiveness. The authors also indicate a striking difference in the impact of two types of transfer on the public debt D of the recipient economy: a pure transfer leads to higher lung-run indebtedness while a transfer tied to public investment leads to a reduction in the long-run debt.

Chartterjee and Tursnovky (2007), as an extension of Chartterjee et al. (2003), examine the link between aid, growth, and welfare by focusing on the role of the endogeneity of labor supply, public capital–production externalities, and fiscal deficit in the recipient country. These three aspects determine the contrasting effects of untied and tied foreign aid on the recipient country's macroeconomic performance. It is demonstrated that untied aid, which encourages leisure and consumption, may lower the equilibrium growth rate but improve welfare in the long run. In contrast, foreign aid, tied to public investment, raises labor productivity, encourages additional work effort, and increases long-run growth. Besides, numerical simulation analysis in this study shows that transitional adjustments to a foreign transfer are sensitive to the elasticity of labor supply and the elasticity of substitution between inputs in production, and the relative importance of the labor–leisure choice in utility.

Using a discrete-time overlapping generations (OLG) model, Dalgaard (2008) studies the effect of the following aid policy rule: the flow of aid a_t depends negatively on the recipient's income per capita y_{t-1} and the so-called donor's exogenous degree of inequality aversion λ, so that $a_t = \phi y_{t-1}^{\lambda}, \phi > 0, \lambda < 0$. In this OLG growth model, he shows that an exogenous increase in foreign aid, represented by a higher value of parameter ϕ, leads to a higher steady-state income and a higher social welfare in the recipient country. Besides, the degree of inequality aversion λ of the donor determines the characteristics of the transitional dynamics of income per capita. Figure 2 from Dalgaard (2008) shows a monotonic transition to the unique steady state (see 1A) or an oscillation transition (see 1B) when the degree of inequality aversion is weak or strong, respectively. The economy may stagnate (see 1C) even though it receives foreign aid, or it is characterized by a two-period cycle (see 1D) in other cases of inequality aversion.

Pham and Pham (2020) consider a discrete-time general equilibrium framework where public investment, partially financed by aid, may improve the recipient economy's TFP. They model aid per capita at period t as $a_t = \max\{\overline{a} - \phi k_t, 0\}$ where the couple $(\overline{a}, \phi)$ is interpreted as the aid rule imposed by the donor and represents aid conditionalities while the physical capital per capita k_t represents the recipient country's need. This modeling takes into account the donor's rules and the recipient's needs, which are represented by a low initial capital stock. According to the above formula, aid flows are limited by an upper threshold, and the recipient

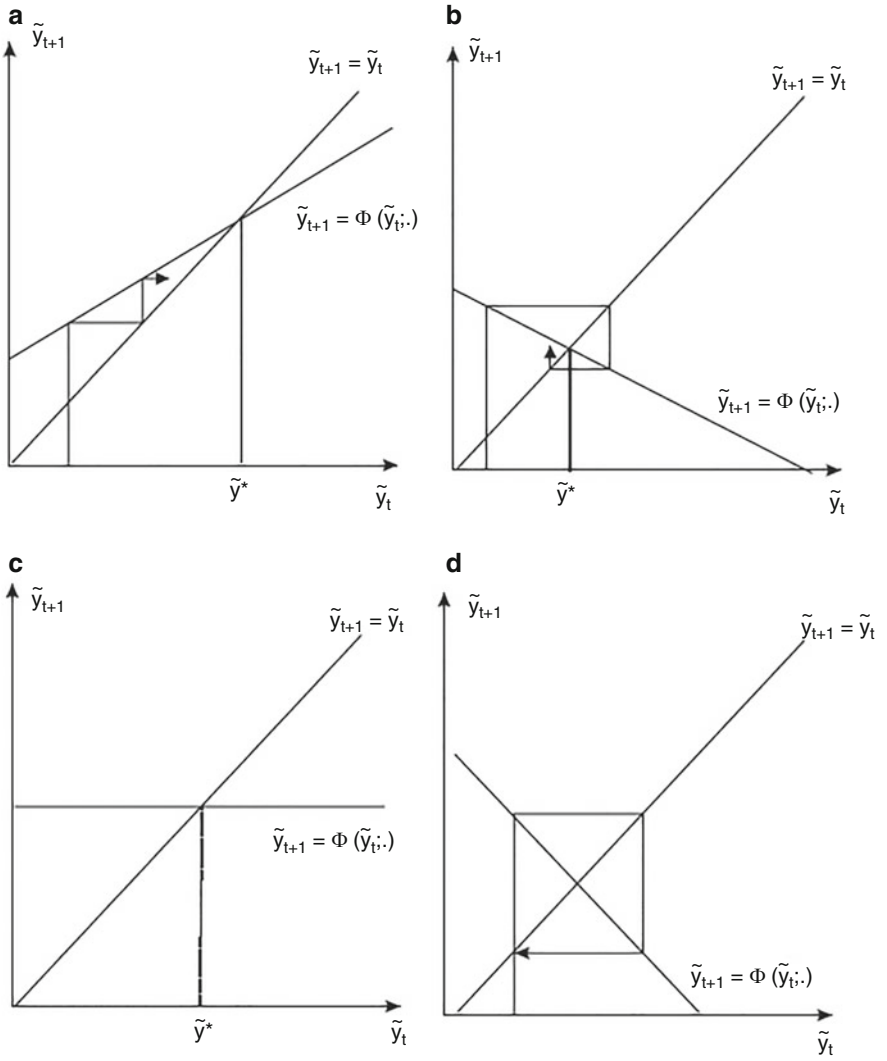

Fig. 2 Transitional dynamics and donor inequality aversion: degree of inequality aversion determines the characteristics of the transitional path. (Source: Dalgaard, 2008)

country would no longer receive aid once it was rich enough. This modeling is also compatible with aid allocation rules used in several bilateral and multilateral aid policies (World Bank's International Development Association, Asian Development Bank, European Development Fund, etc.).

By providing a full analysis of transitional dynamics, Pham and Pham (2020) explain how foreign aid can help a small recipient country to escape the poverty trap and potentially get economic growth in the long run. Unlike Dalgaard (2008), they underline the role played by the recipient fiscal policy and government effort in financing public investment and the efficiency in the use of aid. The global dynamics of equilibrium is quite complex: the capital path may diverge or converge to a steady state, or fluctuate around it. There may also be a two-period cycle. These different outcomes are analyzed in four distinguished levels of circumstances depending on the degree of corruption in the use of aid, the autonomous technology, the fixed cost and efficiency of public investment, as well as the donor's rules.

It should be noticed that the effectiveness of aid depends on how aid is used in recipient countries and on the absorptive capacity of these countries. Two questions arise: Does aid reduce recipient governments' effort in financing public expenditure? If so, what is the impact of the crowding-out effect on economic outputs in a small recipient country? Pham and Pham (2019) address these questions in a two-period model by endogenizing the use of foreign aid and fiscal policy in a recipient country. They assume that overall public expenditures, comprising public services and public investment, are financed by two sources: foreign aid and tax revenue. The recipient government makes its decisions regarding public services, public investment, and the manner to use foreign aid when caring about the population's welfare and its own interest. Their framework indicates a crowding-out effect on the tax effort, which is reinforced by public investment's low efficiency. However, due to a positive effect of aid on public investment, the final effect of aid on economic growth is positive. The aid effect depends on the recipient circumstances, reflected by the efficiency of public investment, as well as the donors' sensitivity with respect to this efficiency.

Focusing on a bilateral aid and its optimal design as well as its effectiveness in a neoclassical framework, Scholl (2009) underlines the conflict of interests between a donor and a recipient government. Using a neoclassical growth framework, he analyzes the link between aid, incentive conditionality, and economic growth following different types of recipient government (from weakly to highly benevolent). Aid conditionality is endogenous and defined by the following rule: the aid amount is chosen by maximizing the donor's utility subject to competitive equilibrium and the government budget constraint in the recipient country. Compared to an unconditional policy, the optimal conditional aid policy is more effective because it strongly stimulates the steady-state economic performance and improves welfare on both sides: recipient household's welfare and donor's welfare.[2]

[2] For contracting with foreign aid in a static model, see Azam and Laffont (2003). See Bourguignon and Plateau (2017) for an overview of the theoretical literature that deals with the problem of governance in donor–recipient relationships by using the contract theory.

3 Conditional Effectiveness of Aid: How Does Foreign Aid Affect Recipients' Government Behavior and Economic Outcomes?

3.1 Aid and Government Behavior in Recipient Countries

One of the most important issues regarding the aid effectiveness concerns the recipient government's decisions. A question concerning (desirable or undesirable) fungibility of aid[3] arises: Is aid used to finance public expenditures (to promote economic growth) and social expenditures (to improve social welfare) or is it misappropriated by corrupt governments? Understanding the relationship between aid, government behavior, and economic outcomes in recipient countries has important implications for aid policy and donor decisions. However, existing empirical studies do not provide a consensus in this regard, and the debate continues.

As a significant component of the public budget in developing countries, foreign aid has been used to finance public expenditures, both in the social sector (e.g., sanitation, education, health, etc.) and in the productive sector (e.g., infrastructure, public investment, etc.). There is evidence that foreign aid increases public expenditures in recipient countries (Remmer, 2004; Van de Walle & Mu, 2007; Feeny & McGillivray, 2010; Morissey, 2015, etc.). Using cross-country data over the period 1970–1999, Remmer (2004) underlines a positive link between foreign aid and government size. A positive effect of foreign aid on public investment is found by Ouattara (2006b). Precisely, based on a sample of recipient countries over the period 1980–2000, this study also shows that aid flows exert a positive effect on developmental expenditure (such as health and education), but a negative impact on nondevelopmental spending (wages, salaries, and subsidies).

Although there is a consensus on the positive link between foreign aid flows and the overall public expenditure, the nexus between aid and recipient fiscal policy is not conclusive. An important question is whether and how foreign aid matters for fiscal policy?[4] In general, studies examining fiscal policy focus on taxes, public expenditures, and borrowing in budget deficits. Ouattara (2006b), using panel data of aid recipient countries over the period 1980–2000, concludes an absence of a significant link between aid and fiscal policy. On the opposite, Remmer (2004) shows a negative relation between aid and tax effort. Feeny (2007) develops a fiscal response model to investigate the impact of foreign aid on recurrent expenditures (i.e., nondevelopmental expenditures such as wages, regular administrative costs of running government department and services), developmental expenditures, tax revenues, and borrowing behavior in the Melanesian countries (Fiji, Papua New Guinea, the Solomon Islands, Vanuatu) for the period 1989–2002. Their results

[3] This means that recipient countries divert aid flows to fund items that the donors did not wish to support.

[4] See Morissey (2015) for further details on this issue.

show that foreign aid has positively impacted general public expenditures, but Melanesian countries have lowered their tax revenues in response to aid inflows. In the same vein, Combes et al. (2016), using data from 59 developing countries during the period 1960–2010, underline a significant effect of foreign aid on recipient countries' fiscal policy. Besides, the fiscal effect of aid is stronger in countries with a low governance score and a low absorptive capacity.

When considering a single recipient country, several empirical analyses also show that foreign aid matters for the conduct of fiscal policy and affects domestic borrowing. For instance, considering Ghana's case, Osei et al. (2005) show that aid is associated with improved fiscal performance, increases its tax revenue, and is used to reduce borrowing. It follows that recurrent expenditure, usually financed by tax revenue, rises more than investment expenditure due to the aid increase. In this sense, aid is fungible even if it enables fiscal performance. Ouattara (2006a) also shows a negative effect of aid on domestic borrowing for the case of Senegal over the period 1970–2000. Concerning the case of Papua New Guinea studied in Feeny and McGillivray (2010), they observe that aid decreases tax revenue over 1969–2000. This negative fiscal policy response may be considered an argument for research on the dependence on foreign aid donors.

The crowding-out effect of aid on public expenditures was recently tested in a field experiment among in-office-elected politicians in Malawi. Seim et al. (2020) examine how foreign aid or information about foreign aid affects politicians' decisions regarding the provision of development goods within the education sector. These authors randomly assigned 460 elected local politicians to receive or not receive information about foreign aid projects at schools in their constituencies. After receiving or not receiving information, these local politicians make real decisions regarding the allocation of development goods to these same schools. Observational decisions show that when public policymakers receive information about an aid project in a given school, they are less likely to target that school with development spending. This result shows a crowding-out effect of aid in the education sector, more precisely a spatial crowding-out effect, as aid causes a spatial reallocation of spending within the education sector. However, this fungibility of aid has no negative impact on development outcomes because many politicians in this field experiment make their allocation decision in favor of schools that had not yet received support, rather in favor of schools with their political family members in attendance.

Regarding the non-negative fungibility, other studies such as Pettersson (2007), Wagstaff (2011), van de Walle and Mu (2007), and Rana and Koch (2020a, b) also show that aid fungibility has not necessarily a negative impact on the aid effectiveness targeted at growth, health, welfare, etc. In particular, Rana and Koch (2020b) establish an inverse U-shape between aid inflows and fungibility in the Pakistan case. According to this study, the fungibility of development aid can help progress toward the development goals when looking at it from the perspective of welfare and redistribution effect. Shifting resources from initial programmatic and geographic projects to others could mean that public expenditures partially funded by foreign aid may be used more efficiently, as showed by the field

experiment in Seim et al. (2020) mentioned above. Obviously, governance quality plays an important role in determining the degree of fungibility and the desirable or undesirable fungibility (Kaya & Kaya, 2020).

3.2 Aid and Economic Outcomes in Recipient Countries

The debate regarding the effectiveness of aid is driven by extensive empirical investigations using different data samples. The main conclusion shows that foreign aid is an external factor playing a conducive role in reaching economic development targets in recipient countries. Foreign aid may contribute to stimulating economic growth and reducing poverty in recipient countries. Still, its impact is contingent on different factors such as recipient countries' quality of governance, economic vulnerability, tax effort, etc. (Burnside & Dollar, 2000; Guillaumont & Chauvet, 2001; Maruta et al., 2020), as well as on the donor's conditionality and targets in aid allocation rules (Carter, 2014; Guillaumont & Wagner, 2014).

3.2.1 Foreign Aid and Economic Growth

There is a consensus on the fact that aid rarely has a direct effect on the growth rate. Its impacts on the recipients' economic growth, if significant, are often conditional on several factors in recipient countries such as institutional quality, political stability, macroeconomic environment, and absorptive capacity (Boone, 1996; Burnside & Dollar, 2000; Easterly, 2003; Moyo, 2009; Mosley, 2015; Temple & Van de Sijpe, 2017; Maruta et al., 2020; etc.).

Burnside and Dollar (2000) is one of the first studies that shed light on the aid's conditional effectiveness and provide part of the scientific background for the policy recommendations in the World Bank.[5] They investigate the nexus between foreign aid, good macroeconomic policy, and economic growth in the recipient countries. The authors use a panel of 56 countries over 1970–1993 and form a policy index to measure macroeconomic policies that consist of three variables: openness measure, inflation rate, and budget surplus. They show that aid effect on growth depends on the nature of macroeconomic policies: in countries with good fiscal, monetary, and trade policies, foreign aid has a higher impact on growth than in countries with bad policies. This finding is summarized in Table 1, which indicates that the derivative of growth rate with respect to aid is significant and positive at a good policy level (policy = 2.4 compared to the case of policy = 1.2).

The authors also underline that macroeconomic policy is more important for aid effectiveness in low-income countries as the cross-derivative of growth rate with

[5] The World Bank book *Assessing Aid* presenting the aid policy uses the same policy indicator recommended by Burnside and Dollar.

Table 1 The impact of aid and macroeconomic policy on growth rate (Burnside & Dollar, 2000)

		C. In regressions with simple interaction terms		
		At policy = 1.2	At policy = 2.4	Difference
All countries (5)	OLS	0.20(0.15)	0.43** (0.18)	0.23** (0.09)
	2SLS	−0.12(0.31)	0.11 (0.31)	0.22* (0.13)
Lower-income countries (8)	OLS	0.13(0.15)	0.47** (0.20)	0.33** (0.11)
	2SLS	0.05(0.22)	0.37 (0.27)	0.32** (0.15)

* Significantly greater than 0 at the 10-percent level
** Significantly greater than 0 at the 5-percent level

respect to aid and policy is higher in the low-income sample than in the whole sample. Table 1 (last column) shows that this cross-derivative of growth calculated for an OLS regression (2SLS) is equal to 0.33 (0.32) for the low-income sample and only 0.23 (0.22) for the whole sample.

Collier and Dollar (2001, 2002) propose another indicator of policy performance: the World Bank's Country and Institutional Assessment (CPIA). This indicator is the arithmetic mean of the 20 components assessed on a scale from 1 to 6 and grouped into four clusters (economic management, structural policies, policies for social inclusion and equity, public sector management and institutions). Each component has a 5% weight in the overall rating.[6] Using data covering 62 developing countries over the period 1974–1997, Collier and Dollar (2001, 2002) show that aid may promote economic growth and reduce poverty in recipient countries if the quality of their policies is sufficiently high. In other words, development aid and CPIA are complementary in the growth equation. Consequently, an effective aid allocation should increase aid to countries having high policy quality.

Using sectoral foreign aid rather than aggregate aid, Maruta et al. (2020) also underline a conditional effect of aid on economic growth. These authors, using data on bilateral aid flows into three sectors (education, health, and agriculture) received by 74 countries over 1980–2016, show that the marginal effect of each aid category is conditional on the level of institutional quality measured by the International Country Risk Guide (ICRG) Index. Obviously, aid effectiveness also depends on the recipient government's decisions. Mosley (2015) focuses on tax effort, which is an important indicator of institutional structure. He underlines that it is important for recipient countries to broaden their tax structure to improve aid effectiveness in economic growth. Tax effort is also considered as an important factor explaining the aid effectiveness in a theoretical analysis by Pham and Pham (2020).

Other factors such as economic vulnerability, political instability, and absorptive capacity determining the aid effects on economic growth are underlined by Guillaumont and Chauvet (2001) and Chauvet and Guillaumont (2004, 2009). These authors argue that while the economic vulnerability to external shocks is negatively

[6] Further details of the CPIA can be found in World Bank (2010) and Collier and Dollar (2001, 2002).

associated with growth the marginal effect of aid on growth is an increasing function of economic vulnerability. This index is one of several criteria retained by the United Nations Committee for Development Policy in identifying the least-developed countries. The principal components of the economic vulnerability index are population, share of agriculture, forestry and fisheries in GDP, exports concentration, remoteness from main world markets, adjusted for landlockness, instability of exports receipts, instability of agricultural production, and homelessness due to natural disasters.[7] These studies also indicate that the marginal effect of aid depends positively on policy quality: aid effectiveness is influenced by political instability.

Without rejecting the conditionality of aid effects, certain studies still show a certain fragility of results (Easterly, 2003; Easterly et al., 2004; Guillaumont & Wagner, 2014; etc.). Using the same empirical specification as that in Burnside and Dollar (2000), but expanding the sample of data set, Easterly et al. (2004) nuance the claim from that of these authors. The results on aid effectiveness seem to be fragile when varying the sample and the definition of different variables such as aid, growth, and good policy (Easterly, 2003). Hansen and Tarp (2001) show that the effectiveness of aid is contingent on investment and human capital in recipient countries, and aid has no effect on growth when controlling these variables. Their findings shed light on the link between aid, investment, and human capital, and show that aid increases economic growth through its impact on capital accumulation.

It should be noticed that the effect of aid on growth is not only heterogeneous and country-specific characteristics but also nonlinear and depending on its level. There may exist a threshold from which the marginal effect of aid becomes very small and converges to zero. In other words, aid may positively impact economic growth, but with diminishing returns (Hansen & Tarp, 2001; Wagner, 2014). This point reflects the role of absorptive capacity in recipient countries: a high level of foreign aid may exert no impact because aid is not effectively used. In Chauvet and Guillaumont (2004), the education level (as a measure of human capital) and electricity (as a measure of physical infrastructure) form an indicator of absorptive capacity, which improves the aid effectiveness. Islam (2005) shows an aid Laffer curve in recipient countries with political stability. Moreover, there may also exist a critical threshold above which aid is effective, illustrating the need for "big bush" in certain very vulnerable countries to observe a significant effect of aid on growth.

The existence of these two thresholds is identified in Wagner (2014) using a database including 89 recipient countries. As shown in Fig. 3, the relationship between economic growth and aid per capita is nonlinear, and there exist two thresholds between them aid has a positive effect on growth. Besides, Wagner (2014) also mentions that the level of these thresholds depends on the economic vulnerability of recipient countries.

The nonlinear nexus between aid and economic growth and the heterogeneous impact of aid for different groups of countries were analyzed by Harb and Hall (2019) using data comprising 25 developing countries during the period 1984–2008.

[7] See Cariolle (2011) for more details.

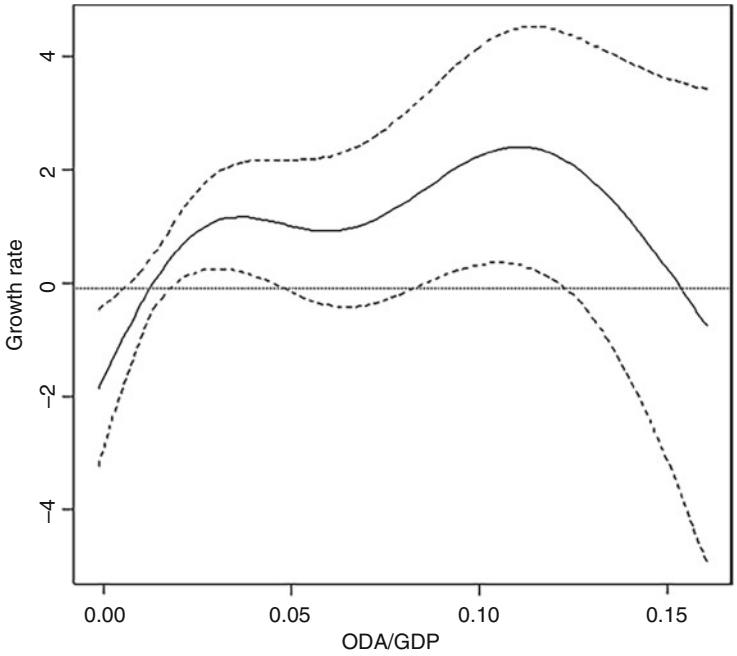

Fig. 3 Growth rate and aid per capita. (Source: Wagner, 2014)

They distinguish three groups of countries (low and least developed, lower-middle-income, and upper-middle-income) and identify each group's threshold level of aid. The aid effect above and below this threshold is estimated, corresponding to π_1 and π_2, in Table 2. The last column of this table represents the value of this threshold: 1.221% of GDP for the upper-middle-income group, 4.333% of GDP for the lower-middle-income countries, and 11.385% of GDP for the low- and least-developed countries. Information given in columns π_1 and π_2 indicates that for the upper-middle-income countries the foreign aid is only effective below the threshold of 1221% of GDP, that is, above this threshold, aid does not affect growth (π_1 insignificant). Regarding the low- and least-developed countries, and lower-middle-income countries, the findings in Harb and Hall support the big-push concept as aid becomes effective only when it exceeds the threshold level (π_1 positive and significant). Below this threshold level, aid exerts no impact on economic growth for both groups (π_2 insignificant).

3.2.2 Foreign Aid, Inequality, and Income Distribution

Focusing on other aspects than economic growth, Chong et al. (2009) investigate whether foreign aid reduces income inequality in recipient countries. Their finding shows that foreign aid can impact income inequality, but only in countries having

Table 2 Estimated threshold level of aid for different groups of countries, 1984–2008 (Harb & Hall, 2019)

Variable	π_2		π_1	Transition variables C
(a) Upper middle income countries				
Aid	0.4913(0.0947)*		0.4134 (0.8333)	
Inflation		−0.1151(0.0049)***		
Investment		0.4169(0.0003)***		1.221345
Government expenditure		−0.4037(0.0003)***		
M2		−0.0355(0.2472)		
(b) Lower middle income countries				
Aid	−0.105155(0.2525)		0.83563 (0.0382)**	
Inflation		−0.03001(0.3103)		
Investment		0.1216(0.0479)**		4.3337***(0.000)
Government expenditure		−0.02789(0.5403)		
M2				
(c) Low and least developed countries				
Aid	0.09507(0.5668)		1.14157 (0.000)***	11.38522***(0.000)
Inflation		−0.0049(0.6825)		
Investment		0.3697(0.0074)***		
Government expenditure		−0.48357(0.0404)**		
M2		0.02548(0.5021)		

Notes: Dependent variable is real GDP per capita growth. Values in parentheses represent *p*-values. *, **, *** display the significance levels at 10%, 5%, and 1%, respectively. π_1 and π_2 represent the impact of aid above and below the estimated threshold level. Column C shows the threshold level

good institutions measured by a low level of corruption. However, this finding does not appear to be robust when testing other institutional variables. Likewise, Arndt et al. (2015), using data for the period 1970–2007, indicate that aid does not have a significant effect on income inequality, even though it can stimulate economic growth and improve social welfare indicators such as school enrolment, life expectancy, and infant mortality.

Bourguignon et al. (2009) consider aid allocation from high-income donors to developing countries as a pure redistribution of global income. They examine how international policies on foreign aid affect the international income distribution over the period 1995–2002. Different indicators, such as Gini coefficient, Theil entropy, Atkinson measure, and the mean logarithmic deviation, are used to measure the international income distribution. It is shown that international aid transfers have only a small impact on these inequality measures during the considered period. However, this result is based on a strong assumption that all individuals within a recipient country benefit equally from this transfer in the same way. Such an analysis also ignores the impact of aid policies on the within-recipient country distribution of income.

Paradoxically, aid may increase income inequality in recipient countries (Bjørnskov, 2010; Herzer & Nunnenkamp, 2012). On the one hand, this result may be explained by the fact that two key criteria in aid allocation (need and merit) for aid effectiveness are violated. It is also explained by undesirable aid fungibility (i.e., the recipients' governments have incentives to use aid in other sectors than those initially targeted by donors). On the other hand, the negative effect of aid on income distribution may result from the downward of recipients' competitiveness through real exchange rate appreciation. In such a situation, the poor people may be seriously affected (Bjørnskov, 2010). Herzer and Nunnenkamp (2012), using data for 21 recipient countries over the period 1970–1995, find that aid has an inequality increasing effect on income distribution. Moreover, this effect is robust to different estimation methods, different inequality data sets, and different inequality measures such as the Gini coefficient and the Estimated Household Income Inequality Index.

3.2.3 Aid and Poverty Reduction

One of the targets of the Millennium Development Goals and the Sustainable Development Goals is poverty reduction. It is crucial to understand whether foreign aid is effective in poverty reduction and by which channels it may lead to poverty reduction. In the seminal papers of Collier and Dollar (2001, 2002), the authors underline that by its effects on economic growth aid may be conducive to poverty reduction in recipient countries, depending on the elasticity of poverty reduction with respect to the growth rate. In other words, for a marginal effect of aid on growth, the number of poor getting out of poverty depends on this growth elasticity. A strong assumption in these studies remains in the constancy of this elasticity and its uniformity among recipient countries. All recipient countries are supposed to have a growth elasticity of poverty reduction equal to -2. This assumption is

not supported by the analysis in Bourguignon (2003), which is instead for the heterogeneity of growth elasticity of poverty reduction among recipient countries. In particular, Bourguignon (2003) underlines an inverted nexus between growth elasticity of poverty reduction and the initial level of poverty itself.

Economic growth is not the only channel through which aid reduces poverty in recipient countries. Kaya et al. (2013) focus on aid allocated to the agricultural sector because most of the poor live in rural areas, and their main sources of income are from agriculture and related activities. Aid targeting specific sectors such as the agricultural sector may be more effective in reducing poverty than aid targeting GDP growth per capita. Indeed, using a panel of 46 recipient countries over the period 1980–2003 and the poverty headcount ratio at 1 dollar/day as a poverty indicator, their analysis shows that a 1% increase in aid is associated with a 0.21% decrease in the headcount poverty ratio of the recipient countries. The authors underline that foreign aid may also influence the composition of public expenditures in favor of pro-poor expenditure. Sector-specific aid may affect the poverty level either directly through enhancing services and projects or indirectly through economic growth reflected in lagged values of aid used as an explicative variable. In particular, Kaya et al. (2013) show that the growth elasticity of poverty (in absolute value) is equal to 1.7 or 3.5 based on different specifications.

Several empirical investigations linking aid to monetary poverty reduction indicate that aid could be pro-poor (Mosley et al., 2004; Mosley & Suleiman, 2007; De Matteis, 2013; Alvi & Senbeta, 2012; Mahembe et al., 2019). Mosley et al. (2004) and Mosley and Suleiman (2007) shed light on the fact that aid effect in reducing poverty is contingent on corruption level, income distribution, and the categories of pro-poor expenditures in recipient countries. In particular, using a sample of 79 recipient countries over the period 1981–2004, Alvi and Senbeta (2012) underline that bilateral aid, often supposed more motivated by donors' interests, does not necessarily reduce poverty while multilateral aid can promote poverty reduction. De Matteis (2013) shows that when aid allocation targets a poverty-focused perspective its effectiveness in poverty reduction is amplified.

Guillaumont and Wagner (2014) and Mahembe and Odhiambo (2017) underline that foreign aid could be pro-poor without impacting monetary poverty. The reason is that aid used to fund infrastructure and public social expenditure that benefit the poor people promotes universal access to primary education and health care.[8] These authors also indicate that if aid has a stabilizing impact, that is, aid can stabilize economic growth, it can make growth more pro-poor. According to Guillaumont and Wagner (2014), aid allocation should be balanced between growth target and public social expenditures (aid to health, aid to education, etc.) because aid can contribute to reducing poverty (through its impact on the size of public social expenditures) and improve the productivity in social factors.

[8] For instance, d'Aiglepierre and Wagner (2013) showed that aid to primary education exerts a significant effect on school enrolment and repetition rates in primary school. Likewise, Arndt et al. (2015) showed that aid can improve school enrolment and reduce infant mortality.

4 Aid Allocation

This section discusses the criteria and conditions used by different institutions and donor countries when allocating aid. We also analyze alternative allocations of aid qualified as optimal in aid literature, focusing on poverty reduction, economic growth, population welfare, as well as donors' preferences.

4.1 Aid Allocation: Motivation and Criteria

Foreign aid constitutes an important source of revenue in developing countries. Since 2000 when the United Nations Millennium Declaration was signed and the Millennium Development Goals were agreed, foreign aid, particularly Official Development Assistance (ODA), has been continually increasing (Fig. 1). For example, it rose by 69% in real terms between 2000 and 2010 and has doubled between 2000 and 2020.

One of the most relevant questions is how aid is allocated to recipient countries or which factors are used in allocating aid. Several donors employ the *performance-based allocation* systems in allocating aid. These allocation systems give priority to the countries in need (in terms of population size and income), and also those with the ability to use aid effectively: poor countries and/or with a high need should receive a high amount of aid. For instance, the World Bank's International Development Association (IDA) uses the following specific form $\text{Aid}_i = y_i^{\beta} P_i^{\gamma} N_i$, where Aid_i is the aid allocated to country *i,* N_i is country *i*'s population size, and P_i represents the performance rating of country *i,* based on an assessment of the quality of its policies and institutions. P_i is determined by the World Bank's Country Performance and Institutional Assessment (CPIA). The income per capita y_i represents the recipient's need. This aid allocation based on performance adheres to the effectiveness principle, the IDA rule sets $\beta = -0.125$ and $\gamma = 5$. Compared to the IDA, other international institutions such as the Asian Development Bank, the European Development Fund, and the UK's Department for International Development use different variants of this rule. For instance, the Asian Development Bank formula assigns a higher weight to recipient countries' poverty but lower to the recipient's population size. In a study for the 2008 Development Cooperation Forum at the UN Economic and Social Council, Andersson (2008) evoked several other measures of recipients' need and performance influencing the form of aid allocation. Recipients' need is measured by low GDP per capita, low IDH, high child mortality, post-conflict country, etc., while its performance is measured by the growth of GDP per capita or government effectiveness index, etc.

Several empirical analyses on aid allocation rules emphasize the two main characteristics in recipient countries: their need for assistance, measured by their income per capita, and their absorption constraint representing their ability to use aid effectively, measured by the World Bank's Country Performance Rating (Easterly,

2007; Easterly & Pfutze, 2008; Knack et al., 2011; etc.). Dreher et al. (2015) focus on the recipient's need in terms of gender gaps in education, health, or women's rights and shed light on the fact that donors increase aid to countries with larger gender gaps and low female achievement in health and education. Their analysis also shows the evidence of an aid allocation based on merit as donors tend to reward countries that achieve reductions in gender gaps or reduce female deprivations in health and education.

In'airat (2014) examines whether good governance is a criterion for selectivity in aid allocation using a panel of 122 recipient countries over 2001–2010. For good governance, the author uses the Worldwide Governance Indicators developed by Kaufmann et al. (2013) and composed of six dimensions: voice and accountability, government effectiveness, lack of regulatory burden, rule of law, independency of the judiciary system, and control for corruption. Their analysis shows evidence of donors' preference for good governance. This result is in the vein of an aid allocation based on the performance criterion. In particular, when using individually six governance indicators, this study shows that only control of corruption and voice and accountability (including civil liberties and political stability) significantly affect donors' decision for aid allocation. A more recent analysis of Weiler et al. (2018) on bilateral aid for climate change adaptation (adaptation aid) over the period 2010–2015 also reflects the results on foreign aid literature. This study tests whether good governance or recipient merit matters for allocation of adaptation aid and shows that donors' decision seems to confirm a principle of performance-based allocation. Countries with good governance (measured by the Worldwide Governance Indicators) are more likely to receive more adaptation aid because they are perceived as better able to use and absorb received aid amounts.

Other analyses underline the link between aid allocation and donors' interests, particularly in bilateral aid (Alesina & Dollar, 2000; & Tichit, 2004; Berthelemy, 2006; Nunnenkamp & Öhler, 2011; Weiler et al., 2018; Couharde et al., 2019; etc.). Political variables (strategic allies, political and civil rights, political interests) or macroeconomic conditions in recipient countries such as trade openness and commercial allies are potential criteria influencing donors' decisions. For instance, Alesina and Dollar (2000) find that most donor countries, apart from France, Italy, Belgium, and Austria, favor recipient countries having better political and civil rights. Donors also use bilateral aid as a foreign policy tool to promote their own economic and political goals. By analyzing bilateral aid allocation for climate change adaptation, Weiler et al. (2018) show that donors take into account their economic interest (measured in terms of the total export of all commodities from the donor to the recipient country). In Nunnenkamp and Öhler (2011), donor strategic interests are reflected by the recipient's relative importance as a donor's export market, and by the degree of recipient UN voting coincidence with the donor.

Couharde et al. (2019) investigate the donors' strategic interests focusing on the role of oil on bilateral aid policy. Analyzing the aid allocation of the G7 donors (Canada, Germany, France, Italy, Japan, the United Kingdom, and the United States) over the period 1980–2010 to 82 recipients, their study shows that aid amount allocated by these donors significantly increases with their oil dependence. The

Table 3 Oil and aid allocation of the G7 donors, 1980–2010 (Couharde et al., 2019)

	(1)	(2)	(3)
Variables	Aid share	Aid share	Aid total
Oil reserves	0.0459*** (0.0106)	0.0498*** (0.0106)	0.0232* (0.0130)
Lagged Dep	4.048*** (0.386)	3.093*** (0.369)	0.000413.68e-05
Multilateral aid		0.101*** (0.0264)	0.148*** (0.0483)
Trade		0.138*** (0.0431)	0.499*** (0.0679)

Notes: Dependent variables: aid share of a recipient in the total aid commitments allocated by the G7 donors, aid total received by a recipient. Values in parentheses represent *p*-values. *, **, and *** display the significance levels at 10%, 5%, and 1% respectively

authors consider the ratio of net oil import–oil consumption of donors to represent the donors' energy security motives. Their analysis shows that strategic interests in terms of oil security impact the G7 donors' aid allocation since a higher oil interest of donors (i.e., higher oil import) results in a higher aid to oil-rich recipient countries. Energy security motives encourage the G7 donors to provide more aid. The oil–aid nexus is highlighted in this study, which shows that the oil endowment held by recipient countries significantly impacts aid commitments by the G7 donors. In other words, oil-rich developing countries are more inclined to receive aid from the G7 donors that are oil importers. Table 3 shows that the coefficient associated with the variable oil reserves is positive and significant. A 1% increase in oil endowment results in a 0.0498% increase in the share of a recipient in the total aid of the G7 donors (column 2). This coefficient given in column 3 indicates that a 1% increase in oil endowment of a recipient leads to a 0.0232% increase in aid received from the G7 donors.

Donors' preferences in aid distribution may be represented by the influence of colonial ties and language homogeneity between aid organizations and recipients (Berthelemy & Tichit, 2004; Maiden & Brockway, 2018). Several African countries have received aid from their former colonizing country. Maiden and Brockway (2018) consider the case of agricultural aid distributed to 56 villages in northern Mali in 2015 and found that several international aid organizations like the FAO and the Red Cross do not seem to target their aid in need as the most vulnerable villages to exogenous shocks seem not to receive the highest aid flows. There is rather a strong nexus between aid and language preference as their findings show that French-speaking villages with French-speakers leaders can receive more aid than others (five other languages). The authors interpret this criterion influencing aid decision as a proof to assumptions that French-speaker leaders are rewarded for being better educated and more closely aligned with the central government in the use of aid.

4.2 Optimal Aid Allocation: How Should Aid Be Allocated?

It is undeniable that performance (i.e., good governance, good macroeconomic policy in recipient countries, etc.) is the most frequent argument to explain aid distribution. International institutions such as the World Bank, the Asian Development Bank, and the European Development Fund, continue to promote this criterion in their aid allocation despite its limitations.

From a normative point of view, many issues are under debate regarding the optimal choice for aid allocation (Collier & Dollar, 2001, 2002; Wood, 2008, Llavador & Roemer, 2001; Cogneau & Naudet, 2007; Carter, 2014; etc.). For instance, Collier and Dollar (2001, 2002) adopt a utilitarian vision by maximizing a social welfare function, which is the reduction of poverty in all recipient countries. More precisely, Collier and Dollar (2001, 2002) estimate the aid allocation that maximizes the reduction of the number of poor in recipient countries. The following optimization problem in Collier and Dollar (2002) summarizes this idea:

$$\underset{\{A^i\}}{\text{Max}} \left\{ \text{Poverty reduction} \equiv \sum_i G^i \alpha^i h^i N^i \right\} \quad \text{subject to} \quad \sum_i A^i y^i N^i = \overline{A}, \quad A^i \geq 0,$$

where $U^i = G^i \alpha^i h^i N^i$ is country i's utility function that depends on its growth rate of per capita income G^i, its elasticity of poverty reduction with respect to income α^i assumed to be equal to -2, its poverty index h^i, and its population N^i. This expression of U^i represents the number of poor in reduction depending on aid as growth rate G^i in recipient country i is a function of aid A^i. The constraint indicates that the sum of aid allocated to all countries (where y^i is per capita income in recipient country i) should be equal to the total available amount of aid $\overline{A}$. The main idea of the optimization problem is the following. The reduction of poverty depends on several factors such as economic growth, initial poverty, and growth elasticity of poverty reduction. Economic growth is in turn influenced by aid and policy quality. Consequently, the optimal aid allocation reducing the poverty is determined by the initial poverty of the recipient country and their policy quality.

The first-order condition for this maximization problem implies that $G^i_A \alpha^i h^i N^i = \lambda y^i N^i$, for any i, where λ corresponds to the shadow value of aid and G^i_A is the marginal effect of aid on growth rate depending on aid amount A^i, and, in particular, on the recipient policy performance measured by CPIA. Table 4 presents the estimated values of G^i_A using data on 59 recipient countries over the period 1974–1997.

Based on these first-order conditions and the estimate of G^i_A, Collier and Dollar (2002) propose an optimal aid allocation that is different from the observed one. Compared to the observed allocation of aid, the Collier and Dollar's allocation gives more aid to the poorest countries implementing the highest policy quality (high CPIA). In other words, an optimal aid policy should give more aid to countries that use it more efficiently for the goal of poverty reduction. However, Dalgaard et al.

Table 4 Aid impact on growth and policy performance (Collier & Dollar, 2002)

	Derivative of the growth rate with respect to 1% of GDP in aid, evaluated at:				
			CPIA		
			2.16	3.04	3.91
Aid/GDP	0	I	0.13	0.40	0.67
		II	1.39	0.55	0.70
		III	−0.01	0.36	0.72
		IV	0.29	0.47	0.65
	2.15	I	0.04	0.32	0.59
		II	0.23	0.39	0.55
		III	−0.10	0.27	0.64
		IV	0.20	0.39	0.56
	4.70	I	−0.06	0.21	0.48
		II	0.05	0.21	0.37
		III	−0.20	0.17	0.53
		IV	0.10	0.28	0.46

Notes: G_A^i is evaluated at three different levels of aid (0%, 2.15%, and 4.4% of GDP) and three different values of CPIA (2.16, 3.04, and 3.91) for four different specifications

(2004) suggest reconsidering the Collier and Dollar's rule and shed light on a deep nexus between aid effect and structural characteristics in terms of institutions or climatic circumstances. According to these authors, strong fundamental characteristics may compensate for a bad policy performance. In the same vein as Collier and Dollar (2001, 2002), Wood (2008) includes an intertemporal aspect in his analysis and considers not only initial poverty but also future poverty in aid donors' objective function.

This utilitarian approach of Collier and Dollar is criticized for its lack of consideration for fairness. In this sense, Llavador and Roemer (2001) and Cogneau and Naudet (2007) adopt the Rawlsian principle in calculating the optimal allocation of aid in order to satisfy the objective of equal opportunities. To equalize the growth opportunities of recipient countries, the donors should provide an allocation that compensates countries for bad initial circumstances so that the final differences in outcomes between countries will be only imputed to differences in their efforts, not their initial circumstances. In Llavador and Roemer (2001), the effort variable is defined by economic management, which is the weighted average of three macroeconomic markers: budget surplus relative to GDP, inflation, and trade openness. The initial circumstances or initial disadvantages of country *i* are defined as the component of the growth rate, which is not explained by effort or aid.

Cogneau and Naudet (2007) underline that the optimal aid allocation of Llavador and Roemer (2001) is paradoxically in favor of countries with high macroeconomic performances such as South Korea, Indonesia, and Thailand (low inflation, small budget deficit, and major open trade) to the detriment of countries with bad circumstances such as Nicaragua and Zambia. That devises a way of allocating aid that also includes equal opportunity by using another method. These authors

separate the effort and circumstances of recipient countries as in Llavador and Roemer (2001) but use the same framework as Collier and Dollar. However, their aid allocation shares out poverty risks more fairly among the world's population, and their results show that donors should give more aid to the poorest countries than the observed aid allocation.

Note that there is a trade-off between need and effectiveness in the performance-based principle mentioned above. The poorest countries with the greatest need often have the lowest performance or lowest absorption capacity, that is, they are judged to use aid less effectively (McGillivray & Pham, 2017). It seems that such an aid allocation makes a dichotomy between fairness (favoring need criterion) and efficiency (favoring performance criterion). In addition, performance is narrowly defined and is only one attribute, among others, influencing aid effectiveness (McGillivray, 2003; Amprou et al., 2007). This performance approach may be considered as inequitable, ignoring structural handicaps in poor countries and then providing less aid to countries that need it most. Guillaumont et al. (2017), McGillivray and Pham (2017), and Guillaumont et al. (2018) focus on a fairness argument when underlying the lack of human capital and recipient's economic vulnerability rather than policy rating in allocating aid. To go beyond the limitations of the performance approach, Guillaumont et al. (2017) propose an augmented performance-based aid allocation that takes into account an index of structural vulnerability and an index of low human capital in the measurement of performance rather than the country policy rating as mentioned in the above IDA formula. Their analysis proposes that the performance approach used in several multilateral development banks could be improved by taking into account these structural handicaps of recipient countries: more aid should be provided to countries with a high economic vulnerability. Their argument fits in a philosophy of fairness that proposes that aid should compensate the recipient country for its vulnerable initial situation so that all countries can obtain the same initial opportunities.

Carter (2014) proposes an optimal aid allocation that maximizes the welfare of recipient countries rather than economic growth and assumes that recipient countries are neoclassical economies undergoing transition dynamics. This study is based on a neoclassical growth model that permits a welfare-based allocation of aid. In this setting, the objective of maximizing welfare in recipient countries may lead to an optimal allocation giving more aid to countries that are least able to stimulate economic growth. The donor optimization problem consists of allocating a total amount of aid $\overline{A}$ to m recipient countries by choosing parameters β and γ in allocation rule to maximize the sum of recipient lifetime utilities:

$$\underset{\beta,\gamma}{\text{Max}} \sum_i \int_0^{\infty} L_{it}.U\left(c_{it}\right) e^{-\rho t} dt \text{ subject to the allocation rule } aid_{it} = \frac{y_{it}^{\beta} P_i^{\gamma} N_{it}}{\sum_j^m y_{jt}^{\beta} P_j^{\gamma} N_{jt}} \overline{A} \tag{1}$$

and subject to the optimizing behavior by households (Euler equation), capital accumulation, initial capital in each recipient, and its absorptive capacity constraint.

Table 5 Optimal coefficients in the allocation rule under aid impact function and total aid amount (Carter, 2014)

Varying D.		
	V_A	
$D/\sum Y_i(\%)$	β	γ
2	−1.45	0.65
3	−0.58	0.625
5	0.2	0.625
10	0.975	0.625

Notes: V_A is the impact function of aid determining the relationship between gross received aid and effective aid. Total aid takes four levels: 2%, 3%, 5%, and 10% of total GDP in m recipients

The measure of absorptive capacity P_i that enters in the allocation rule is defined as the percentage of aid absorbed at some reference level of aid and assumed to be constant over time. Recipient i receives a share $\alpha_{it} = \frac{y_{it}^{\beta} P_i^{\gamma} N_{it}}{\sum_j^m y_{jt}^{\beta} P_j^{\gamma} N_{jt}}$ of the fixed total amount of aid $\overline{A}$,and α_{it} varies over time.

Table 5 shows the optimal values of β and γ for four levels of total aid and the impact function of aid V_A that determines the relationship between gross received aid and effective aid. According to their numerical simulations based on the above optimization problem, it is shown that when aid generosity is high, the optimal value β becomes positive. It means that the optimal allocation may not favor the poor countries as in the presence of absorptive constraint: giving too much aid to poor recipients is wasteful and inefficient. The optimal sensitivity to absorptive capacity, γ, seems not affected by the total amount of aid.

In a companion paper, Carter et al. (2015) assume that a donor in the North anticipates that consumption and investment decisions are made by optimizing households in the South (recipients) and takes into account limits in the extent to which recipients can effectively absorb aid. The donor then maximizes a weighted average of welfares in the global North and the global South by choosing an optimal path for international transfers. Here, the North and South's welfare function is the intertemporal utility of representative households, which depends on their consumption paths. By running simulations with specific preferences, Carter et al. (2015) find that optimal transfers depend on several factors: (1) the weight a donor sets on recipient welfare, (2) the form of utility functions, (3) the recipient's capacity to absorb foreign aid, (4) the relative level of the balanced growth path of the recipient, and (5) the recipient's initial distance from that balanced growth path.

5 Discussion and Conclusion

We have provided an overview of the allocation and effectiveness of foreign aid. From theoretical and empirical perspectives, we have looked at internal and external factors that explain why foreign aid is effective in some recipient countries but

ineffective in others. We have also discussed the criteria and conditions for optimal aid allocation, taking into account recipient characteristics and donors' preferences. In brief, the effects and optimal aid allocation depend on both sides: donors and recipient countries. They rely not only on the forms of aid but also on the recipient countries' circumstances.

We conclude by mentioning the issue of foreign aid in the context of the Covid-19. The current global pandemic has led to an economic crisis in most countries in the world. It is the worst economic crisis since the Great Depression. The most vulnerable and less developed countries suffer from the economic and health crises more than the developed countries. Achieving the post-2015 Sustainable Development Goals becomes more and more difficult in a worldwide crisis environment, whereas most of the donors do not meet the amount of ODA equal to 0.7% of GNI targeted by the United Nations (except for Luxembourg, Norway, Sweden, Denmark, and the United Kingdom as shown in Fig. 4).

For most of the poorest countries, the Covid-19 crisis is revealing and exacerbating their existing vulnerable situations, and they need more than ever foreign aid. Therefore, this current crisis has important implications for foreign aid budgets and donors' priority. Questions arise to the aid policy carried out by donor countries: What do we expect from donors during and after the current world crises? Do such crises lead donor countries to reduce foreign aid?

The joint statement by the OECD Development Assistance Committee (DAC) in Avril 2020[9] recognized that the Covid-19 pandemic "does not respect national boundaries" and "demands a strong, coordinated, inclusive and coherent global response. International and multilateral cooperation is more important now than ever." There are reasons to expect that statements made by the OECD DAC members will be honored and foreign aid would not be cut in the next years. Moreover, as assessed in OECD (2020),[10] ODA flows in its 60-year story have been the most stable external resource for developing countries and resilient to economic crises. When considering economic and health crises as global public bad, it is important to stabilize or increase foreign aid budgets allocated to developing countries since it is in all countries' interest to control and eliminate global crises. Donor governments may also have support from citizens in their countries during the crisis period if presenting foreign aid as a strategic policy for the global public good, not as a charity program (Kobayashi et al., 2021).

[9] OECD (2020), "COVID-19 Global Pandemic: Joint Statement by the Development Assistance Committee (DAC) of the Organisation for Economic Co-operation and Development (OECD)", OECD, Paris, https://www.oecd.org/dac/development-assistance-committee/DAC-Joint-Statement-COVID-19.pdf.

[10] OECD (2020), "Six decades of ODA: insights and outlook in the COVID-19 crisis", OECD Development Co-operation Profiles 2020, OECD Publishing, Paris. https://doi.org/10.1787/2dcf1367-en.

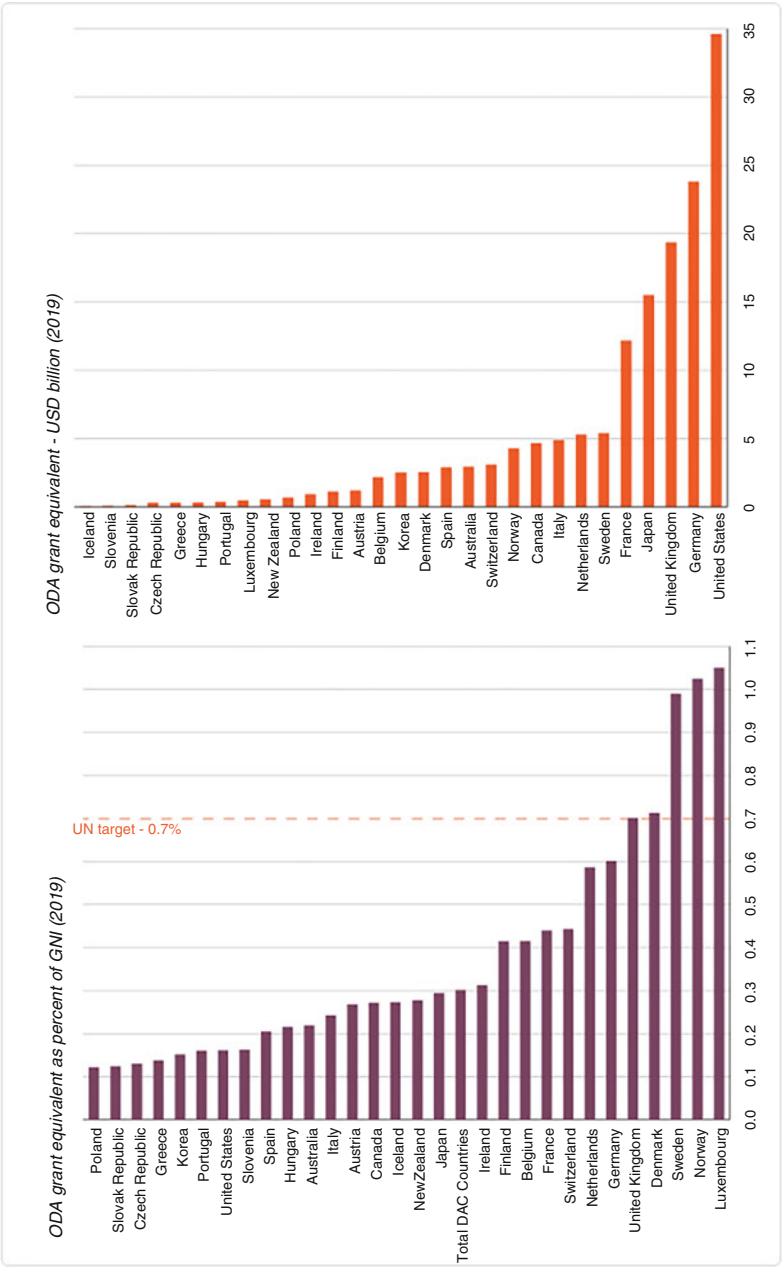

Fig. 4 ODA from members of the OECD's Development Assistance Committee in 2019. (Source: OECD.org)

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Smarter Teachers, Smarter Students? Some New Evidence from Sub-Saharan Africa

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Abstract We study the effect of teacher subject knowledge on student achievement in mathematics and reading by using a data set from six sub-Saharan African countries. By using an estimation based on within-teacher within-student strategy, we can avoid a potential endogeneity bias. In most estimations and most countries, we do not find a significant teacher knowledge effect. The main reasons are teacher absenteeism and the need to focus on core knowledge. For instance, a high level of teacher absenteeism and low teacher performance in a subset of items that are also administered to students can attenuate the teacher subject knowledge effect on student learning. When the conditions of low absenteeism and high teacher performance are met, teacher subject knowledge can have a significant and positive effect on student achievement.

Keywords Teacher knowledge · Africa · Learning · SACMEQ · Cognitive skills

JEL Classification: I2, O12

1 Introduction

The role of teachers in promoting student learning is beyond doubt. Among different aspects of teacher quality, teacher skills, as measured by their scores in subjects and by pedagogical knowledge tests or observations of teaching practices, are among the observable factors which are significantly correlated with learning achievement

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(Wayne & Youngs, 2003; Hanushek & Rivkin, 2010). This topic is investigated by abundant literature on developed countries, with a particular focus on the US context (e.g. see Coenen et al. (2018) for a survey).

Several studies on developing countries exist, but most of them suffer from biases due to omitted student and teacher characteristics.[1] One exception is the study by Metzler and Woessmann (2012), which used a unique data set from Peru and tested both students and their teachers. Based on the methodology provided in Dee (2005a), they found that 1 standard deviation (SD) in subject-specific teacher scores increased student achievement by about 0.09 SD in mathematics. Relatively few papers have focused on sub-Saharan Africa using the data from the Southern and Eastern Africa Consortium for the Monitoring of Education Quality (SACMEQ).[2] However, most of them suffer from two drawbacks. The first pertains to the aforementioned omitted variables bias. The second relates to the homogeneity assumption, which posits that the teacher knowledge effect is identical across countries.

Using the 2007 wave of SACMEQ data, our chapter investigates the effect of teacher subject knowledge on student achievement to make two novel contributions with respect to the gap identified above. Firstly, we account for country heterogeneity by allowing the teacher subject knowledge effect to differ across countries given the major differences in education systems and the distribution of teacher knowledge. A recent paper by Bietenbeck et al. (2017) used SACMEQ data but assumed that the teacher subject knowledge effect was similar across countries. We show that this is not the case and highlight the need to analyse countries separately. Secondly, we focus on specific factors which may temper the effect of teacher knowledge on student performance. Previous papers did not include any focus on pedagogical processes. We find that teacher quality matters. However, in specific conditions, the knowledge of teachers may not be sufficiently mediated towards students. We suppose that two main specific factors need to be controlled for in order to obtain the consistent effect of teacher knowledge. For instance, teachers may not have the basic skills taught to their students. To control for this, a subset of common items were administered to both students and teachers. The focus on these items can allow us to better assess the ability of teachers to transfer their knowledge. When the analysis is restricted to students who are taught by teachers with a high score in these items, the effect on student achievement is

[1] For example, Harbison and Hanushek (1992) on Brazil; Tan et al. (1997) on the Philippines; Bedi and Marshall (2002) on Honduras; Santibanez (2006) on Mexico; Behrman et al. (2008) on Pakistan; Marshall (2009) on Guatemala; and Metzler and Woessmann (2012) on Peru. For a recent review of literature on the education production function in the developing countries, see Behrman (2010), Glewwe et al. (2011), and Murnane and Ganimian (2014).

[2] SACMEQ is a survey on reading and mathematics achievement levels, which was administered to grade 6 students in 15 countries/regions in three waves: 1995, 2000, and 2007. The survey also included a teacher knowledge test on these two subjects. Countries included in SACMEQ are Botswana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zanzibar, Uganda, Zambia, and Zimbabwe.

strongly positive in five out of six countries included in the final sample for reading. Another factor is teacher absenteeism, which may be very high in some countries. When we distinguish between schools with low and high absenteeism, a positive and significant relationship reappears in three countries for reading while we find contradictory results for the sample of teachers with high absenteeism. These two specific factors may explain why previous papers find only weak effects of teacher knowledge in low-income countries.

The results of this analysis provide responses to key questions for policymakers, especially in low-income countries, pertaining to teacher recruitment criteria, teacher allocation decisions, and the content of teacher education. Insofar as teacher subject knowledge is a significant predictor of learning outcomes, then it needs to be taken into account in all these policy decisions. We also find that the effect of teacher subject knowledge on student learning outcomes differs greatly between countries. Policymakers must therefore remain mindful of country heterogeneity when designing education measures.

The remainder of the chapter is structured as follows. Section 2 provides a summary of the literature on the issue, drawing on sub-Saharan African data. Section 3 presents the estimation strategy. Section 4 describes the data. Section 5 presents the main results and provides evidence on heterogeneous effects. Section 6 reports the results from robustness checks, and Sect. 7 concludes.

2 Related Literature on Sub-Saharan Africa

The literature on the impact of teacher knowledge on student performance is relatively recent for sub-Saharan Africa, owing to the recent publication of the SACMEQ data. Most existing studies assume a certain homogeneity in the effect of teacher knowledge across countries and are subject to an estimation bias due to the omission of some teacher-specific characteristics.

In particular, Bonnet (2008) combined both teachers' knowledge and their behaviour using SACMEQ II data.[3] However, the author explored the relationship by controlling only for two variables, which may lead to biased estimates. Wechtler et al. (2007) presented results on the cost-effectiveness of inputs in primary education by using data from PASEC[4] and SACMEQ. These authors combined several factors at three different levels (student, school, and country) and provide results for all the SACMEQ countries. Although they included specific constants for each country, the estimation model assumed that the effects of each variable are the same across countries and they did not include the teacher score variable in their estimation while controlling for teacher academic qualification. Hungi and Thuku

[3] While SACMEQ II was conducted in 2000, the third wave was completed in 2007.

[4] PASEC is a pupil assessment conducted by the CONFEMEN. It is mainly conducted for francophone countries.

(2010a) used a hierarchical regression model on the 2000 data to assess the impact of a large number of factors on student achievement, including teacher subject knowledge. They found that the teacher's reading score has an effect on student reading achievement in only 2 of the 12 countries analysed. However, they did not correct their specification for selection bias or measurement error (Hungi & Thuku, 2010b). Shepherd (2013) examined teacher subject knowledge in South Africa using the 2007 wave and found that teacher knowledge improves student achievement in the wealthiest quintile of schools. Hein and Allen (2013) used a student-fixed-effects estimation technique and found that most observable characteristics are weak predictors. Teacher subject competency test scores are only significant in the Seychelles. Bold et al. (2017) estimated the teacher subject knowledge effect in sub-Saharan Africa using the World Bank-funded Service Delivery Indicators surveys. These surveys were administered to grade 4 students in seven countries. The authors found a significant effect for mathematics but not for reading. Bietenbeck et al. (2017) used the same data as in this paper. They also tested different specifications in order to take into account the potential endogenous issues. However, no specific estimation was performed for each country, on the assumption that the teacher knowledge effect would be identical across sub-Saharan African countries. The main innovation in our chapter is therefore the potential heterogeneity regarding the teacher subject knowledge effect on pupils across sub-Saharan African countries. Our results tend to show that considering Africa as a homogenous region may conduct to biased results.

3 Methodology

For the analysis of the link between teacher knowledge and student achievement, we consider an education production function with an explicit focus on teacher skills. As in Metzler and Woessmann (2012), we specify the following correlated random-effects model:

$$y_{i1} = \beta_1 T_{t1} + \gamma U_{t1} + \alpha Z_i + \delta X_{i1} + \mu_i + \tau_{t1} + \varepsilon_{i1} \tag{1a}$$

$$y_{i2} = \beta_2 T_{t2} + \gamma U_{t2} + \alpha Z_i + \delta X_{i2} + \mu_i + \tau_{t2} + \varepsilon_{i2} \tag{1b}$$

where y_{ij} are test scores of student i in subjects j ($j = 1$ for mathematics, 2 for reading). Teachers t are characterized by subject-specific knowledge T_{tj} and non-subject-specific characteristics U_{tj} such as pedagogical skills and general motivation. The latter can differ across the two equations when students are taught by different teachers in each subject. Additional factors are non-subject-specific (Z_i) and subject-specific (X_{ij}) characteristics of students and schools.

Three issues are important for modelling the relationship. First, there is a potential endogeneity bias when unobserved teacher characteristics may be cor-

related with teacher subject knowledge. Second, the available measure of teacher skills can potentially be stripped down further to a subject-specific and a core skills component. Third, even after this refinement, an error in the measurement of subject-specific teacher knowledge can also lead to a bias in the estimate of its effect. The coefficient vectors β_1, β_2, and γ characterize the impact of all subject-specific and non-subject-specific teacher characteristics that represent overall teacher quality as estimated by value-added studies (Hanushek & Rivkin, 2010). However, an endogeneity bias is likely to hamper identification of the effect of teacher quality in Eqs. (1a) and (1b). Indeed, the error term consists of a student-specific component μ_i, a teacher-specific component τ_t, and a subject-specific component ε_{ij}. The unobserved student effect μ_i is correlated with the observed inputs such as $\mu_i = \eta_1 T_{t1} + \eta_2 T_{t2} + \theta_1 U_{t1} + \theta_2 U_{t2} + \chi Z_i + \Phi X_{i1} + \Phi X_{i2} + \omega_{i2}$ where ω_i is the white noise (Chamberlain, 1982). After grouping terms, the model becomes (see also Metzler & Woessmann, 2012)

$$y_{i1} = (\beta_1 + \eta_1)\, T_{t1} + \eta_2 T_{t2} + (\gamma + \theta_1)\, U_{t1} + \theta_2 U_{t2} + (\alpha + \chi)\, Z_i + (\delta + \Phi)\, X_{i1} + \Phi X_{i2} + \tau_{t1} + \varepsilon'_{i1} \tag{2a}$$

$$y_{i2} = \eta_1 \mathrm{T_{t1}} + (\beta_2 + \eta_2)\, T_{t2} + \theta_1 U_{t1} + (\gamma + \theta_2)\, U_{t2} + (\alpha + \chi)\, Z_i + \Phi X_{i1} + (\delta + \Phi)\, X_{i2} + \tau_{t2} + \varepsilon'_{i2} \tag{2b}$$

where $\varepsilon'_{ij} = \varepsilon_{ij} + \omega_{\mathrm{i}}$ is the new error term. Estimations can be performed by seemingly unrelated regressions (SURs), adjusted for clustering at school level. The effect of teacher subject knowledge on student achievement in mathematics (β_1) is given by the difference between the coefficient associated with the teacher's mathematics test score in Eq. (2a) and that in Eq. (2b). The effect of teacher subject knowledge in reading (β_2) is computed similarly.

In this model, teacher scores in each subject enter the reduced-form equation of both subjects. The β parameters represent the effect of teacher subject knowledge while the η coefficients capture the extent to which standard models would be biased due to the omission of unobserved teacher factors.

Available fixed-effects estimators implicitly require that teacher effects are the same across subjects. Instead of imposing this kind of restriction a priori, it is possible to test for the overidentification restrictions $\beta_1 = \beta_2 = \beta$ and $\eta_1 = \eta_2 = \eta$ (omission bias). If these restrictions cannot be rejected, it is possible to specify correlated random-effects models that constrain coefficients β, or both β and η, to be the same across subjects in Eqs. (2a) and (2b).

If in a correlated random-effects model both of these restrictions are valid, the estimation becomes similar to a conventional fixed-effects models, and hence it eliminates bias from unobserved non-subject-specific student characteristics (Dee, 2005b, 2007; Clotfelter et al., 2010; Metzler & Woessmann, 2012). It should be noted that, for the identification strategy of β and γ in Eqs. (2a) and (2b), we have to assume that either there is no specific assignment of students to teachers or there

is no correlation between the assignment and students' subject-specific propensity for achievement. Such assignments are generally considered to be unlikely in the case of the countries analysed in this chapter.

In order to avoid the bias that can arise when there is a specific assignment of teachers to students on the basis of student subject-specific propensity for achievement, we restrict the analysis to the sample of students who are taught by the same teacher in the two subjects (called 'same teacher' sample). In such a setting, $U_{t1} = U_{t2} = U_t$ and $\tau_{t1} = \tau_{t2} = \tau_t$.

4 Data

The SACMEQ survey is suitable for this identification strategy as it evaluates both student and teacher skills in two subjects, reading and mathematics. The SACMEQ 2007 wave was collected using a stratified two-stage cluster sample design. At the first stage, schools were selected within provinces with probability proportional to the number of students in the defined target population. At the second stage, a sample of 25 grade 6 students was randomly selected in each school. In addition, the mathematics and reading grade 6 teachers of the three largest classes in each school were tested.

The student and teacher tests used different sets of items but featured some common items (20 and 13 items for reading and mathematics, respectively) in order to anchor the results. Student and teacher tests in both subjects were scaled using Rasch modelling. All student test scores were placed on a common scale with mean 500 and standard deviation 100 across students.[5]

Three groups of students were excluded from the full sample: those who could not be linked to a teacher (4772 students), those who had at least one teacher with missing test scores (4055 students), and those with missing test scores (83 students). As mentioned above, the identification strategy requires the same teacher to teach both subjects. The proportion of students who are taught both subjects by the same teacher in grade 6 varies greatly between SACMEQ countries (Table A.1). For this reason, the analysis only focuses on six countries with a sufficient number of observations: Botswana, Malawi, South Africa, Swaziland, Zambia, and Zimbabwe. The percentage of students with the same teacher in the two subjects ranges from 17% in Swaziland to 92% in Zimbabwe. The total sample of students taught by the same teacher includes 11,999 students (46% of the full sample).

Descriptive statistics are provided in Tables A.1 and A.2. Among countries included in the study, the highest performing country is Swaziland in both reading and mathematics, followed by Botswana. The lowest performing country in our

[5] Teacher scores are not scaled with a specific mean. However, we found that the overall mean score in reading is equal to approximately 750 with a standard deviation of 70, whereas for math, we find higher values (mean 790 and standard deviation 105).

sample is Malawi, with about 100 score points below Swaziland. Although students' and teachers' scores are not directly comparable, a sample of similar items was included in both tests. As expected, teachers perform better than students. The highest performing teachers are in Zimbabwe, with approximately 800 score points in reading and 850 in math. In all countries, approximately half the students are girls, and a very low proportion of students speak English at home (Table A.2). A socio-economic status index was used to compare inequalities between and among countries (Dolata, 2005). The poorest country in our sample appears to be Malawi, with an SES index below 5. Conversely, the SES index for South Africa is almost 10, indicating a better socio-economic level of students. This difference is also highlighted by a higher proportion of students with university-level educated parents in South Africa compared to other countries like Zambia. While the proportion of students whose mother has university-level education is 24% in South Africa, less than 5% of students in Malawi are in the same position. Some countries are more urban than others. This is especially the case of South Africa, where nearly 72% of students live in urban areas compared to 40% in Malawi. Teacher characteristics are very different between countries. While most teachers are female in Swaziland (70%), in Malawi, practically three-quarters of teachers are male. The group of teachers with university education and teacher training constitutes the majority of teachers in South Africa and Swaziland, whereas a very low proportion of such teachers are present in Malawi and Zambia.

All results provided above support the idea that we should not group all countries into a single group for the estimation of the teacher knowledge effect on student performance. We provide the results of both the full sample and individual country samples in order to see to what extent the results differ between countries.

Since our estimation strategy is more focused on students who are taught by the same teacher, we must accept the hypothesis that the subsample constituted by the group is representative of the whole population.[6] As can be seen in Table A.1, teacher performances between the full sample and the same teacher sample do not significantly differ. Similarly, student performances across countries are quite similar between the two samples. Another important point is the degree of reliability of teacher scores. While the reliability ratio is expected to be equal to 0.80 in order to obtain a good estimation of teacher subject knowledge, we found that Cronbach's alpha (i.e. a proxy for the reliability ratio) is lower than 0.5 in most countries (Cronbach, 1951). In countries like Swaziland, the teacher scores are only explained at 33%, which is a very low level. This low level of Cronbach's alpha raises the question of the reliability of teacher scores. However, given the context of education in sub-Saharan Africa, such a low level of data reliability is common and very few data sets provide higher reliability levels.

[6] Excluding students who are taught by different teachers may create a selection bias. To control this, we added estimations of teacher knowledge effect where we focused on samples of students who are not taught by the same teacher (see Table 1 columns 9 and 10). Selection bias is shown to be absent since results are not significant for most countries, especially those where the proportion of students taught by similar teachers is low.

5 Results

5.1 Baseline Results

The estimation results are presented in Tables 1, 2, and 3. Table 1 presents the ordinary least-squares regression results with several controls to test for the stability of coefficients and potential omitted variables bias. Table 2 presents the results of the correlated random-effects model. Table 3 reports the most interesting results, where we address the issues of teacher knowledge transferability and teacher absenteeism. To facilitate the reading of results, only the coefficients concerning the teacher knowledge variable are presented. Moreover, both student and teacher test scores are standardized with a mean of 0 and a standard deviation of 1 across countries. Throughout our analysis, standard errors are clustered at the school level to account for possible correlations in the error structure within schools.

Table 1 begins by reporting the result of regressing student learning achievement on teacher knowledge without any control variables (columns 1 and 2). The teacher knowledge effect is found to be positive and significant in both mathematics and reading for only two countries (Botswana and South Africa), but to a major extent. For instance, an increase of 1 standard deviation of teacher knowledge induces an increase of about 0.40 standard deviation in South Africa in both subjects. When all countries are pooled, the effect is positive and significant in both subjects (equal to 0.16 standard deviation). Results are quite similar, regardless of the skill tested.

The next set of regressions, which adds controls for student, teacher, and school variables, reduces the size of the correlations (columns 3 and 4). There is a significant and positive teacher subject knowledge effect in both skills only in South Africa, while the effect becomes significant only for reading in Swaziland. Compared to the baseline results, the size of the teacher subject knowledge effect is either reduced and/or no longer significant. For instance, in South Africa, the teacher subject knowledge effect for mathematics is equal to 0.10 standard deviation in mathematics and 0.07 standard deviation in reading when all controls are introduced. When all countries are pooled, the size of the effect drops by two-thirds to approximately 0.05 standard deviation, but remains positive and significant. Controlling for omitted variable bias is hence important to reduce the potential bias regarding the amplitude of the effect of teacher knowledge on student achievement. Moreover, our results tend to confirm the heterogeneity of results within African countries.

In the meantime, omitted teacher characteristics such as pedagogical skills and motivation (included in the teacher-specific error component τ_t) could cause biases in estimates of the observed teacher attributes. To avoid such biases, the analysis is restricted to samples of students who were taught by the same teacher in the two subjects (columns 5–8). When we both use the same-teacher sample and include controls, the effect of teacher subject knowledge is 0.04 standard deviation for both skills. At the individual country level, while teacher subject knowledge is only significant in one country for mathematics (South Africa), we now find a significant

Table 1 Baseline results: cross-sectional regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Full sample				Same teacher sample				Different teacher sample	
	OLS		SUR		OLS		SUR		OLS	
	Mathematics	Reading	Mathematics	Reading	Mathematics	Reading	Mathematics	Reading	Mathematics	Reading
SACMEQ	0.165	0.168	0.064	0.053	0.082	0.011	0.042	0.045	0.240	0.220
	(0.020)***	(0.021)***	(0.010)***	(0.010)***	(0.024)***	(0.029)***	(0.013)***	(0.013)***	(0.029)***	(0.032)***
Botswana	0.113	0.131	0.030	0.021	0.132	0.102	0.027	0.017	0.014	0.270
	(0.045)**	(0.053)**	(0.016)*	(0.015)	(0.050)***	(0.055)*	(0.019)	(0.016)	(0.104)	(0.136)*
Malawi	0.044	0.056	0.055	0.079	0.111	0.148	0.113	0.202	−0.020	−0.111
	(0.051)	(0.073)	(0.042)	(0.054)	(0.075)	(0.121)	(0.075)	(0.088)**	(0.063)	(0.067)
South Africa	0.411	0.405	0.099	0.068	0.459	0.553	0.119	0.108	0.397	0.379
	(0.035)***	(0.039)***	(0.018)***	(0.017)***	(0.078)***	(0.077)***	(0.052)**	(0.040)***	(0.038)***	(0.042)***
Swaziland	0.052	0.040	0.022	0.045	−0.140	0.177	−0.083	0.058	0.091	0.008
	(0.033)	(0.048)	(0.020)	(0.026)*	(0.059)**	(0.074)**	(0.060)	(0.062)	(0.036)**	(0.055)
Zambia	0.028	0.038	0.008	0.038*	0.028	0.047	0.015	0.040	0.007	−0.080
	(0.040)	(0.043)	(0.023)	(0.023)	(0.042)	(0.044)	(0.022)	(0.023)*	(0.074)	(0.148)
Zimbabwe	−0.014	−0.039	0.024	−0.008	−0.013	−0.026	0.026	−0.011	−0.031	−0.452
	(0.043)	(0.049)	(0.019)	(0.018)	(0.042)	(0.049)	(0.019)	(0.019)	(0.352)	(0.263)

Note: Dependent variable: student test score in mathematics and reading, respectively. Clustered standard errors in the SUR models are estimated by maximum likelihood. Robust standard errors (adjusted for clustering at classroom level) in parentheses: significance at ***1, **5, and *10%

Table 2 Effect of teacher test scores: correlated random-effects models (same-teacher sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Unrestricted model		Restricted model		Fixed-effect model	Unrestricted model		Restricted model	
	Mathematics	Reading	Mathematics	Reading	Mathematics + reading	$\chi^2\ (\eta_1 = \eta_2)$	$\chi^2\ (\beta_1 = \beta_2)$	$\chi^2\ (\beta_1 = \beta_2)$	Observations
SACMEQ	0.014	0.020	0.013	0.021	0.017	0.38	0.16	0.40	11,585
	(0.249)	(0.106)*	(0.296)	(0.087)*	(0.098)*	(0.54)	(0.69)	(0.53)	
Botswana	0.000	−0.010	0.001	−0.010	−0.005	0.03	0.25	0.37	3142
	(0.990)	(0.618)	(0.968)	(0.589)	(0.760)	(0.87)	(0.62)	(0.54)	
Malawi	0.064	0.137	0.065	0.135	0.103	0.01	2.55	1.49	1394
	(0.369)	(0.024)**	(0.376)	(0.031)**	(0.096)*	(0.93)	(0.12)	(0.22)	
South Africa	0.064	0.074	0.064	0.072	0.070	0.02	0.05	0.04	892
	(0.272)	(0.117)	(0.269)	(0.111)	(0.125)	(0.88)	(0.82)	(0.84)	
Swaziland	0.002	0.036	n.a.	n.a.	n.a.	8.14	0.24	8.74	709
	(0.974)	(0.572)	n.a.	n.a.	n.a.	(0.00)***	(0.63)	(0.00)***	
Zambia	0.018	0.034	0.015	0.036	0.027	0.15	0.37	0.52	2656
	(0.496)	(0.117)	(0.560)	(0.103)*	(0.172)	(0.70)	(0.54)	(0.47)	
Zimbabwe	0.004	−0.029	0.005	−0.031	n.a.	0.09	2.55	3.05	2792
	(0.786)	(0.113)	(0.737)	(0.011)	n.a.	(0.77)	(0.11)	(0.08)*	

Note: Dependent variable: student test score in mathematics and reading, respectively. Regressions in the two subjects estimated by seemingly unrelated regressions (SUR). Sample: students who are taught by the same teacher. Coefficients are 'implied beta'. Implied beta represents the effects of the teacher test score, given by the difference between the estimate on the teacher test score in each subject and the equation of the student test score in the other subject (see Eqs. (2a) and (2b)). Regressions include controls for student gender, student first language, urban area, private school, complete school, teacher gender, and teacher university degree. Clustered standard errors in the SUR models are estimated by maximum likelihood. Robust standard errors (adjusted for clustering at classroom level) in parentheses: significance at ***1, **5, and *10%.

Table 3 Effect of teacher test scores in subsamples relative to teacher absenteeism

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	High teacher absenteeism (according to teachers)				Best-performing teachers in 'core items'			
	Yes		No		Yes		No	
	Implied β	Probability	Implied β	Probability	Implied β	Probability	Implied β	Probability
Mathematics								
SACMEQ	−0.007	(0.662)	0.022	(0.034)**	0.032	(0.101)*	0.015	(0.196)
Botswana	−0.038	(0.137)	0.021	(0.249)	0.007	(0.839)	−0.005	(0.791)
Malawi	0.079	(0.280)	0.061	(0.175)	0.067	(0.348)	0.013	(0.812)
South Africa	−0.140	(0.050)**	0.172	(0.000)***	0.160	(0.016)**	0.058	(0.289)
Swaziland	−0.414	(0.002)***	0.051	(0.260)	0.061	(0.762)	0.061	(0.219)
Zambia	0.075	(0.039)**	0.004	(0.886)	−0.036	(0.425)	0.019	(0.500)
Zimbabwe	−0.012	(0.669)	0.016	(0.350)	0.082	(0.051)**	−0.011	(0.489)
Reading								
SACMEQ	−0.008	(0.634)	0.029	(0.006)***	0.036	(0.059)*	0.011	(0.300)
Botswana	−0.084	(0.008)***	0.014	(0.415)	0.092	(0.019)**	−0.021	(0.193)
Malawi	0.177	(0.018)**	0.156	(0.001)***	0.268	(0.000)***	0.081	(0.081)*
South Africa	0.018	(0.790)	0.139	(0.003)***	0.191	(0.005)***	0.044	(0.290)
Swaziland	−0.195	(0.047)**	0.069	(0.216)	0.160	(0.241)	−0.051	(0.366)
Zambia	0.024	(0.546)	0.037	(0.148)	0.100	(0.044)**	0.034	(0.155)
Zimbabwe	−0.027	(0.300)	−0.036	(0.043)**	−0.033	(0.378)	−0.028	(0.090)*

Note: Dependent variable: student test score in mathematics and reading, respectively. Regressions in the two subjects estimated by seemingly unrelated regressions (SUR). Sample: students who are taught by the same teacher. Coefficients are 'implied beta'. Implied beta represents the effects of the teacher test score, given by the difference between the estimate on the teacher test score in each subject and the equation of the student test score in the other subject (see Eqs. (2a) and (2b)). Regressions include controls for student gender, student first language, urban area, private school, complete school, teacher gender, and teacher university degree. Clustered standard errors in the SUR models are estimated by maximum likelihood. Robust standard errors (adjusted for clustering at classroom level) in parentheses: significance at ***1, **5, and *10%.

effect in three out of six countries in reading. Taken as a whole, the SACMEQ sample shows that there is still a significant effect of teacher knowledge on student performance. The amplitude of the effect is quite close to that found in the literature, that is, 0.04 SD.

Table 2 presents the results of the correlated random-effects models of Eqs. (2a) and (2b). The effect of teacher subject knowledge on student achievement in mathematics (implied β_1) is given by the difference between the regression coefficient on the teachers' mathematics test score in the mathematics equation minus the regression coefficient on the teachers' mathematics test score in the reading subject (see Eqs. (2a) and (2b)), and vice versa for reading (implied β_2). Regressions include controls for student gender, student speaking English at home, urban area, private school, teacher gender, and teacher university degree, factors which have been found to be the most powerful predictors in a simple OLS regression.

With both the same teacher sample and the correlated random-effects model used (columns 1 and 2), the teacher subject knowledge effect is no longer significant when all countries are pooled for mathematics while we find a (positive) and significant effect for reading, but with a very low amplitude (i.e. 0.02 standard deviation). At the individual country level, results are insignificant for all countries in mathematics and only significant for Malawi in reading with a high positive effect (i.e. 0.13 standard deviation). Restrictions on ηs and βs are then conducted in columns 3–5, but results are almost similar to the unrestricted estimations.

The above results might suggest that teacher knowledge does not matter in sub-Saharan African countries. We believe, however, that these results are biased because we do not control for specific teacher characteristics, which may reduce the overall teacher knowledge effect on student achievement. Even if we restrict our sample to the same-teacher sample, unobserved teacher characteristics may still not be sufficiently captured in our estimations and thus may distort the size and the significance of our estimated coefficients. For instance, in almost all studies, it is assumed that teachers with a high level of subject knowledge are able to transfer it to students while those with a low level of subject knowledge cannot do so. However, the ability to transfer knowledge is often neglected because it is difficult to measure. Two approaches can be examined. First, it is possible to focus on teacher absenteeism. Bold et al. (2017) analysed data from five countries in sub-Saharan Africa (Kenya, Uganda, Nigeria, Mozambique, and Togo) based on an unannounced visit to schools and classroom observations. Only 72% of teachers were found in the classroom they were supposed to be in. Moreover, they found that the actual teaching time was only 3.25 h per day on average, despite a scheduled duration of 5.2 h.

The first part of Table 3 reports results for the subsamples of schools with high and low absenteeism (according to the teacher measure). Even if a given teacher may have strong teaching skills in teaching mathematics and reading, a potential high level of absenteeism can distort the direct effect of teacher knowledge on student performance. Therefore, the effect of teacher knowledge can be only observed in schools where the level of teacher absenteeism is low. We tested for this

heterogeneity by distinguishing between schools with high and low absenteeism. Teachers were asked how many days they were absent during the current school year and for what reasons. As there are several reasons for absenteeism, we gathered all these possibilities to obtain the total number of days where teachers were absent.[7] Then, we divided the sample into two parts by using the third quintile of the number of days of absenteeism inside each country. The group of teachers with high absenteeism is defined as the teachers whose absences exceeded a particular threshold (found in Table A.2). Teacher absenteeism is approximately equal to 10 days in most countries. However, big differences still exist. In particular, South Africa appears to be the country with the highest teacher absenteeism (19 days), Zambia being the lowest (ca. 6 days). By way of comparison, Chaudhury et al. (2006) presented results which cover several continents including Africa, where the average teacher absence rate is equal to 19% over the sample of countries studied. Bruns and Luque (2014), based on data from a large sample of classrooms in Latin American and Caribbean countries, found that teachers only spend between 52 and 85% of class time on academic activities. In India, Kremer et al. (2013) found similar results and even fewer teachers who are actually engaged in teaching activities. All these findings support the idea that teacher absenteeism may be an important factor explaining why we fail to find a significant effect for teacher knowledge.

Results from Table 3 also show that when teacher absenteeism is high, there is a negative and significant teacher subject knowledge effect in Botswana (reading), South Africa (mathematics), and Swaziland (both skills). Conversely, in schools where teacher absenteeism is low or non-existent, a positive and significant teacher subject knowledge effect is observed in mathematics (South Africa) and reading (Malawi and South Africa). The case of South Africa is very interesting since the sign of the effect is opposite in mathematics when we divide the sample between low and high absenteeism teacher groups: this may explain why when we estimate the teacher knowledge effect over the whole same-teacher sample the overall effect is biased downwards and thus provides counterintuitive results. Nevertheless, it should be noted that the correction made for teacher absenteeism is not perfect in our estimation since it is based on direct information provided by the teachers themselves.

[7] This question (number 21 of the teacher questionnaire) is formulated as follows: 'How many days were you absent during this school year due to the following reasons? (Please write the numbers in the box for *each* country. Please write "O" for a particular category if you were not absent for this reason.)'. Possible reasons: 21.01. 'My own illness'. 21.02. 'My own injury'. 21.03. 'Family member's illness'. 21.04. 'Family member's injury'. 21.05. 'Funerals (family, colleagues, friends)'. 21.06. 'Medical appointment(s)'. 21.07. 'Bad weather / road not accessible'. 21.08. 'Official business (e.g.: meeting, examination, course)'. 21.09. 'Maternity leave'. 21.10. 'Security reasons (riots, civil disturbance, etc.)'. 21.11. 'Teachers' strikes'. 21.12. 'Other reasons'.

As a second approach, we used the fact that the teacher subject knowledge test included a subset of questions that were also administered to students. While our chapter innovates in that it distinguishes between skills for the evaluation of teacher knowledge effects, we also investigate an additional dimension of cognitive skills. Indeed, in each skill test, some items are exactly similar to student tests. These items are the easiest in the entire test and can be considered as the representation of 'core skills' that every teacher needs to teach. We make the following assumption: regardless of their overall performance, a given teacher can have a significantly higher effect on student performance if he/she performs better in these core skills. In that sense, we think that a teacher with a high general performance can have a low performance in 'core items'. This may be the case for teachers who have strong advanced skills but are unable to perform some calculus or to remember basic grammar rules. Our results tend to support this hypothesis since we find different results between both groups. Taylor and Taylor et al. (2013) singled out three patterns of teacher knowledge. First, there are items in the teacher test in which both teachers and their students achieve good scores. Teachers may well be transferring knowledge in these knowledge areas. Additionally, knowledge impedance and complex impedance rely on cases where teachers think that it is difficult to transmit knowledge. All these factors may be important in understanding why smarter teachers do not always increase student test scores. However, due to the difficulty of measuring all three dimensions, we only focus on knowledge transmission difficulties, which we call 'knowledge transferability'. It is clear that the direct relationship between performing well in common skills and pedagogical skills can be subject to caution without a clear demonstration of this relationship. However, we assume that a teacher who can easily answer on 'core skills' items will be able to explain the basic skills in mathematics and reading. Thus, while several factors can account for high pedagogical skills, our explanation only relates to one of them (i.e. a subset of the teacher knowledge questions which are identical to the student knowledge questions). It remains thus possible to compare the proportion of common items answered correctly by both teachers and students as a measure of teacher subject knowledge that is more relevant to student needs.

Part II of Table 3 reports results for the 20% of teachers who scored either lowest or highest in these common items and compares them with the other teachers. As with previous results, teacher subject knowledge is found to be more significant and positive for reading than for mathematics. For the full sample of students, we find a significant and positive teacher knowledge effect for both skills. The amplitude of the effect is dramatically reduced from 0.17 SD in a standard OLS estimation to 0.03 in our preferred estimation. This suggests that the teacher knowledge effect can only be found when including appropriate controls, using a precise estimation technique, and focusing on specific skills which are more suited to skills transferability from teachers to students.

If we now focus on individual countries, results clearly show that focusing on the subsample of teachers performing best on 'core skills' shows the true effect of teacher knowledge on student achievement. While the teacher reading knowledge effect is significant in the top-performing teachers in four out of six countries under study, it is significant in only one country for the sample of low-performing teachers. For mathematics, the effect is significant in two countries for the top-performing teacher group while there is no country where it has an effect for the lowest performing teacher group. For instance, in South Africa, the effect of teacher subject knowledge in both subjects is significantly positive only among the top-performing group of teachers while it is insignificant for the low-performing teacher group. In countries like Zambia or Zimbabwe, teacher subject knowledge has a greater effect in the top-performing teacher sample.

6 Robustness Check

We ran a robustness check in order to establish to what extent our previous results are stable. A potential reason for the absence of a positive and significant teacher subject knowledge effect is the existence of heterogeneous effects across the population. Table A.4 reports the results for three such subsamples (by student gender, teacher gender, and school socio-economic index) to test for heterogeneity. Looking first at results from the pooled sample, in the case of mathematics, the teacher subject knowledge effect is significant and positive only in the subpopulation of students taught by female teachers and is low (at 0.02 standard deviation). For reading, the effect is positive and significant and of a comparable order of magnitude for the subpopulations of male students, students taught by male teachers, and students in schools with a low average socio-economic index.

Looking at the results by country, there is no clear pattern of teacher subject knowledge effects across specific subsamples. Interestingly, the effect of teacher knowledge is significant in the female student group in two countries (Malawi and South Africa) while there is no clear difference in other countries, with the exception of Zambia, where the effect is significant only for the male group in reading. In the case of teacher gender, there is a strong and positive effect of being taught by a female teacher in South Africa and Zambia. However, the effect is somewhat misleading, suggesting that teacher gender does not have a specific effect on student knowledge. Finally, with respect to the socio-economic level of schools, the teacher subject knowledge effect is positive and significant for mathematics in the wealthiest schools in South Africa but not significant in the poorest schools, a finding that echoes those of Shepherd (2013). Similar results can be found for Malawi and Zimbabwe. In summary, no clear pattern emerges from the estimations, suggesting the absence of a general heterogeneity across the population in our estimations.

Another check, as highlighted in Sect. 2, relates to the bias resulting from student sorting that can arise when there is more than one class per grade in a school and the best students are assigned to the class with the best teacher. Although this is highly unlikely to be the case in low-developing countries, we performed some additional robustness checks. One way to control for such a bias is to restrict the sample to schools that only have one classroom per grade, which we can call the 'same-teacher one-classroom' (STOC) sample, in reference to Metzler and Woessmann (2012). This restriction eliminates all biases from sorting between classes within the grade of a school. Moreover, since most one-classroom schools are located in rural regions, the restricted sample additionally eliminates all possible issues resulting from non-random selection of schools by parents. This sample restriction also rules out a bias from prior differences in student achievement as students cannot be allocated to appropriate teachers on grounds of within-student performance differences between the subjects.

One drawback of using the 'same-teacher one-classroom' sample is that results cannot be generalized. Indeed, the sample size drops dramatically for some countries, such as South Africa, where it covers only 7% of the total student population. Moreover, such estimations can be done for only four of the six countries. Results are presented in Table A.5. There are no strong differences between the results of the 'same teacher' sample (Table 2) and the 'same-teacher one-classroom' sample (Table A.5), although the magnitude of the effect is reduced. Results for reading are more robust and significant for Malawi and Swaziland (restricted model). While the teacher subject knowledge effect was equal to 0.02 standard deviation for the SACMEQ group in the 'same teacher' sample, it reaches 0.04 standard deviation in the 'same-teacher one-classroom' sample, indicating a small upward bias due to measurement error.

7 Concluding Remarks

This chapter has examined the effect of teacher subject knowledge on student learning outcomes in six Southern and Eastern African countries which took part in a regional student learning achievement survey in 2007. Compared to previous research, the main innovation of our chapter is to separate estimations across countries, instead of pooling all available observations (as it has been done in Bietenbeck et al., 2017). The estimation focused on students who were taught by the same teacher in two subjects (reading and mathematics) in order to control for bias estimation. Initial estimates controlling for unobserved student characteristics, omitted school and teacher variables, found positive and significant effects for some countries.

We have proposed two main explanations for these findings. First, a high level of teacher absenteeism can weaken the link between teacher knowledge and student learning scores. This is especially the case for countries like South Africa, where teacher absenteeism affects about one-fifth of students. This might explain that, even if teachers have a high skill level, the high prevalence of absenteeism can distort the expected positive effect of teacher knowledge on student performance. Taken to the extreme, it may lead to a negative and significant effect when, all things being equal, the highest performing teachers are more frequently absent than other teachers in a given country. South Africa is probably the country where teacher absenteeism most reduces the expected positive effect of teacher knowledge on schooling quality.

Moreover, even if teachers score well in subject knowledge tests, they may lack pedagogical skills in order to transfer knowledge to students. Accordingly, we focused on items that were common in teacher and student questionnaires and divided the sample according to the level of teacher performance in these common items. We show that in the sample of high-performing teachers the teacher subject knowledge effect is strong and significant for most countries while the effect is not significant in the sample of low-performing teachers.

A significant effect of teacher knowledge is found in Botswana, Malawi, and South Africa while the effect is insignificant in Swaziland or Zimbabwe. This suggests either that the effect of teacher knowledge is difficult to estimate or that other factors may temper the effect of teacher knowledge. Some of them are not measured in our data (e.g. teacher-specific variables, like teacher motivation, and real student absenteeism).

Compared to previous research, there are sizeable effects in our study. For instance, Metzler and Woessmann (2012) found that the effect on reading scores was 0.085 SD in Peru. Our estimates are also higher than the existing results for school systems in high-income countries. According to Rockoff (2004), a 1 SD increase in teacher knowledge raises student reading and mathematics scores by approximately 0.10 SD in the United States.

Finally, our results indicate that teacher knowledge is a significant predictor of learning outcomes, suggesting that it should be accounted for in policy decisions, especially in developing countries, regarding teacher recruitment criteria, teacher allocation decisions, and the content of teacher education.

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Appendix Tables

Table A.1 Baseline information about samples, scores, and Cronbach's alphas

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
	Full sample							Same-teacher					Same-teacher, one-classroom				
		Teacher score		Student score		Cronbach's alpha for teachers			Teacher score		Student score			Teacher score		Student score	
	Students	Reading	Mathematics	Reading	Mathematics	Reading	Mathematics	Students	Reading	Mathematics	Reading	Mathematics	Students	Reading	Mathematics	Reading	Mathematics
SACMEQ	25,666	762	784	499	498	0.48	0.61	11,999	765	785	491	491	4477	750	779	457	465
Botswana	3868	770	780	537	522	0.43	0.55	3142	767	777	553	520	271	757	755	541	526
Malawi	2781	720	762	433	447	0.53	0.64	1394	717	764	427	444	1331	715	761	425	442
South Africa	9071	758	769	498	497	0.57	0.63	892	769	756	510	507	635	725	713	457	469
Swaziland	4030	767	813	550	542	0.33	0.63	709	761	798	542	536	709	749	816	535	532
Zambia	2895	758	742	435	435	0.38	0.61	2656	758	743	436	436	920	765	747	427	428
Zimbabwe	3021	794	852	506	517	0.48	0.58	2792	794	853	506	515	800	807	875	471	484

Note: The sample of SACMEQ countries only includes the countries listed above. The following countries are not included: Kenya, Lesotho, Mauritius, Mozambique, Namibia, Seychelles, Tanzania, Uganda, and Zanzibar

Table A.2 Descriptive statistics

	Botswana	Malawi	South Africa	Swaziland	Zambia	Zimbabwe
Student level						
Reading score	535	433	495	549	434	508
Mathematics score	521	447	495	541	435	520
% girl	50	49	51	50	49	56
Abs. SES level	9.00	4.99	9.61	8.39	6.08	7.24
% speak English	10	7	15	6	8	13
% mother univ. level	17	5	24	21	8	23
% father univ. level	20	12	28	24	17	28
% not repeated	69	40	72	44	66	69
% read. homework	56	20	56	76	31	54
% math. homework	56	20	56	76	31	54
School level						
% rural areas	48	76	50	70	65	71
School size	583	1251	703	544	932	749
School SES level	9.00	4.99	9.61	8.39	6.08	7.24
School resources index	2.07	2.34	1.93	2.10	2.33	2.13
Teacher level						
Mathematics						
Score	780	762	764	811	740	852
% Female	67	25	58	51	53	29
% university level	42	1	66	93	25	52
% training	64	11	91	76	8	92
Experience	13.42	12.23	15.31	10.51	6.14	11.47
Teacher absenteeism (days)	11.03	9.24	19.17	7.63	15.00	11.97
Threshold for high absenteeism	10	12	26	16	9	14
Resources	2.60	2.76	2.82	2.75	2.59	2.58
Reading						
Score	769	720	758	768	758	795
% female	66	26	68	70	53	29
% university level	41	1	61	93	25	52
% training	63	8	87	78	8	92
Experience	13.07	11.40	16.54	10.69	6.14	11.47
Teacher absenteeism (days)	10.76	9.78	18.86	8.17	15.00	11.97
Threshold for high absenteeism	11	13	25	16	9	14
Resources	2.90	2.72	2.96	3.05	2.59	2.58

Table A.3 Descriptive statistics on teacher absenteeism and teacher performance (same-teacher sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Source: teachers							Source: school directors						
	Low absenteeism			High absenteeism				Low absenteeism			High absenteeism			
	%	Score in reading	Score in maths	%	Score in reading	Score in maths	Δ btw high and low	%	Score in reading	Score in maths	%	Score in reading	Score in maths	Δ btw high and low
SACMEQ	31	753	779	29	755	769	−4	83	755	777	17	744	771	−9
Botswana	75	767	774	25	768	786	7	91	767	775	9	764	799	11
Malawi	72	715	768	28	722	753	−4	76	716	764	24	719	764	2
South Africa	59	796	785	41	726	718	−69	91	771	761	9	733	717	−41
Swaziland	76	753	808	24	783	767	−6	83	760	807	17	763	757	−24
Zambia	71	754	747	29	770	728	−2	86	761	746	14	748	729	−15
Zimbabwe	74	796	856	26	787	846	−10	32	797	856	68	778	839	−18

Table A.4 Robustness check: effect of teacher test scores in subsamples

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Student is female				Teacher is female				School with a high socio-economic index			
	Yes		No		Yes		No		Yes		No	
	Implied β	Probability	Implied β	Probability	Implied β	Probability	Implied β	Probability	Implied β	Probability	Implied β	Probability
Mathematics												
SACMEQ	0.017	(0.15)	0.011	(0.37)	0.035	(0.01)***	−0.003	(0.82)	0.014	(0.52)	0.013	(0.19)
Botswana	0.002	(0.90)	−0.001	(0.96)	0.010	(0.61)	0.002	(0.94)	0.031	(0.47)	−0.005	(0.76)
Malawi	0.084	(0.10)*	0.046	(0.41)	0.017	(0.52)	0.060	(0.12)	0.181	(0.08)*	0.047	(0.25)
South Africa	0.142	(0.02)**	0.021	(0.72)	0.164	(0.00)***	−0.103	(0.19)	0.214	(0.01)***	0.011	(0.84)
Swaziland	0.005	(0.93)	0.011	(0.84)	−0.004	(0.94)	0.057	(0.49)	−0.137	(0.14)	0.041	(0.33)
Zambia	0.003	(0.92)	0.036	(0.21)	0.056	(0.07)*	−0.017	(0.57)	−0.040	(0.48)	0.036	(0.12)
Zimbabwe	0.030	(0.11)	−0.030	(0.15)	−0.010	(0.67)	0.014	(0.44)	0.091	(0.02)**	0.004	(0.78)
Reading												
SACMEQ	0.011	(0.34)	0.028	(0.03)**	0.010	(0.43)	0.022	(0.06)*	−0.016	(0.43)	0.026	(0.01)***
Botswana	−0.002	(0.92)	−0.017	(0.43)	−0.036	(0.07)*	0.014	(0.51)	−0.009	(0.81)	−0.010	(0.53)
Malawi	0.116	(0.00)***	0.112	(0.01)**	0.091	(0.64)	0.118	(0.00)***	0.133	(0.12)	0.110	(0.00)***
South Africa	0.103	(0.05)**	0.027	(0.61)	0.120	(0.01)***	−0.070	(0.34)	0.126	(0.16)	0.041	(0.33)
Swaziland	0.003	(0.95)	0.082	(0.16)	0.034	(0.49)	0.073	(0.30)	−0.018	(0.04)**	0.111	(0.02)**
Zambia	0.027	(0.37)	0.050	(0.10)*	0.041	(0.19)	0.030	(0.30)	0.025	(0.59)	0.037	(0.11)
Zimbabwe	−0.042	(0.02)**	−0.009	(0.67)	−0.019	(0.45)	−0.032	(0.06)*	−0.031	(0.42)	−0.030	(0.05)**

Note: Dependent variable: student test score in mathematics and reading, respectively. For each subsample, regressions in the two subjects estimated by seemingly unrelated regressions (SUR). Sample: same-teacher sample, stratified in two subsamples based on whether combined teacher–student characteristic in the head column is true or not. Coefficients are 'implied beta'. Implied beta represents the effects of the teacher test score, given by the difference between the estimate on the teacher test score in the respective subject and the equation of the student test score in the other subject (see Eqs. (2a) and (2b)). Regressions include controls for student gender, student first language, urban area, private school, complete school, teacher gender, and teacher university degree. Clustered standard errors in the SUR models are estimated by maximum likelihood. Robust standard errors (adjusted for clustering at classroom level) in parentheses: significance at ***1, **5, and *10%

Table A.5 Robustness check: effect of teacher test scores, correlated random-effects models (same-teacher one-classroom sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Unrestricted model		Restricted model		Fixed-effect model	Unrestricted model		Restricted model	
	Mathematics	Reading	Mathematics	Reading	Math + reading	χ^2 ($\eta_1 = \eta_2$)	χ^2 ($\beta_1 = \beta_2$)	χ^2 ($\beta_1 = \beta_2$)	Observations
SACMEQ	0.037	0.047	0.0312	0.005	0.042	0.64	0.14	0.52	4278
	(0.145)	(0.091)*	(0.222)	(0.065)*	(0.063)*	(0.42)	(0.71)	(0.47)	
Malawi	0.061	0.119	0.064	0.134	0.100	0.14	1.71	1.28	1331
	(0.413)	(0.035)**	(0.403)	(0.055)**	(0.130)	(0.71)	(0.19)	(0.25)	
Swaziland	0.052	0.062	0.013	0.113	n.a.	4.00	0.06	3.86	471
	(0.327)	(0.310)	(0.771)	(0.085)*	n.a.	(0.05)**	(0.81)	(0.06)*	
Zambia	0.044	−0.005	0.043	−0.001	0.021	0.01	0.42	0.33	920
	(0.34)	(0.91)	(0.370)	(0.969)	(0.559)	(0.90)	(0.52)	(0.56)	
Zimbabwe	0.037	−0.045	0.041	−0.051	−0.004	0.18	1.58	2.37	800
	(0.386)	(0.447)	(0.368)	(0.317)	(0.926)	(0.68)	(0.21)	(0.12)	

Note: Dependent variable: student test score in math and reading, respectively. Regressions in the two subjects estimated by seemingly unrelated regressions (SUR). Sample: same-teacher or same-teacher-one classroom (STOC). Coefficients are 'implied beta'. Implied beta represents the effects of the teacher test score, given by the difference between the estimate on the teacher test score in the respective subject and the equation of the student test score in the other subject (see Eqs. (2a) and (2b)). Regressions include controls for student gender, student first language, urban area, private school, complete school, teacher gender, and teacher university degree. Clustered standard errors in the SUR models are estimated by maximum likelihood. Robust standard errors (adjusted for clustering at classroom level) in parentheses: significance at ***1, **5, and *10%

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Social Capital, Income, and Subjective Well-Being in Developing Countries: Evidence from Vietnam

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Abstract Using data from the Vietnam Access to Resources Households Survey in 2012 and 2014, our chapter analyzes the relationship between social capital and well-being from a multidimensional perspective. Our results indicate heterogeneous impacts of social capital dimensions on each measure of well-beings. There is a trade-off between the objective well-being and subjective well-being when people invest in social capital. It is necessary to study the relationship between social capital and individual well-being using a multidimensional approach.

Keywords Social capital · Well-being · Trust · Cooperation · Organizational membership · Blow-up and cluster estimator

1 Introduction

In this chapter, we adapt Putnam's definition of social capital, defined as the "connections among individuals' social networks and norms of reciprocity and trustworthiness that arise from them" to investigate the connection between social capital and individual well-being. In particular, we attempt to link various concepts of social capital to the multidimensional nature of well-beings, both subjective and objective measures of well-beings in Vietnam.

Social researchers generally consider social capital as irreplaceable social resources that could facilitate positive outcomes in a wide range of phenomena (see Helliwell, 2006; Kawachi et al., 2004). While a number of authors focus

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on measuring social capital and developed a theoretical model of social capital (Narayan & Pritchett, 1997; Fafchamps, 1998; Glaeser et al., 2002; Isham et al. (2002); Grootaert & van Bastelaer, 2002), others have been exploring the relationship between social capital and firm performance (Barr, 1998; Le-Van et al., 2018), subjective well-being (Hommerich & Tiefenbach, 2018), household income, and risk behavior. More recently, social capital has become a popular concept with policymakers in both developed and developing countries (OECD, 2017), and the OECD (2017) identifies social capital as one of the four main resources for sustaining human well-being over time.

For generations, economists have conveniently used GDP and disposable income per capita to measure the standard of living. Governments around the world also routinely design economic policies that aim at GDP growth as a measure of national prosperity. At the same time, economists have long recognized that quality of life is not only about the standard of living and paid increasing attention to measures of subjective well-being. A comprehensive assessment of individual well-being should include both monetary and nonmonetary measures (Boarini et al., 2012), and there is strong evidence that subjective well-being measures capture specific components of well-being that other nonsubjective measures miss (Boarini et al., 2013).

Given that one of the core characteristics of social capital is about possessing networks, we distinguish three dimensions of social capital classified by Putnam (2000) that are based on network attributes, including bonding, bridging, and linking social capital, and examine the interdependence between these measures and the individual well-beings of household heads in Vietnam.[1] Bonding social capital consists of links and ties between individuals that share similar characteristics or within the same social group (Helliwell & Putnam, 2004), encompassing closed networks of close friends and families. In contrast, bridging social capital refers to the connections that link people across a cleavage that such as race, class, or religion (Helliwell & Putnam, 2004). It is associations that "bridge" *between* or between social groups. Bridging social capital is typically associated with reciprocity. Linking social capital is an extended form of bridging social capital, typically involving networks and ties with individuals and groups represented in the public sector. There is a large literature on "quanxi," a particular type of linking social capital in the business community in Asia, China, and Vietnam.

In this study, we go beyond previous studies to investigate not only the relationship between bonding, bridging, and linking social capital with objective measure of well-being but also subjective measures using data from the Vietnam Access to Resources Household Survey (VARHS). In our study, objective well-being is measured by the real equivalized income and subjective well-being is represented by the self-reported life satisfaction. We use several econometric techniques including the linear fixed-effects model, pooled ordered logit model, and blow-up and cluster (BUC) model to simultaneously deal with the problem of unobserved heterogeneity

[1] In the literature, bonding and bridging social capital have also been characterized as strong ties and weak ties, respectively (e.g., Ellison et al., 2007).

and the ordinal nature of subjective well-being. Our study confirms a relationship between social capital and measures of the quality of life. However, there is a trade-off between the economic benefit and the subjective well-being when people invest in social capital.

The chapter proceeds as follows. Section 2 reviews the aspects of individual well-being and summarizes their key determinants, mainly focusing on the measures of social capital. Section 3 introduces the BUC method—a relatively new method to deal with fixed-effects ordered logit models. Section 4 describes the data. Econometric results and discussion are presented in Sect. 5. Section 6 concludes.

2 Literature Review

It is now commonly accepted that quality of life goes beyond economic objectives. Using Amartya Sen's (1987, 1992, 1993, 1995, 1997) capability framework under which quality of life is multidimensional, individual well-being can be viewed as the dynamic state of being well in which people can meet human needs, be satisfied with the quality of their life, and improve their contribution to the community. To capture this multidimensionality, nonincome indicators are called for (Forgeard et al., 2011; Stutzer & Frey, 2010; Lerner et al., 2009; Keyes, 2007), although (disposal) income and wealth are widely recognized as a fundamental dimension of individual well-being because economic resources help meet their human needs and pursue their life's goal (OECD, 2017; Chiappero-Martinetti, 2005). In fact, previous studies consider some measures of "reported happiness" as a critical nonmonetary indicator to assess individual welfare (Subramanian et al., 2005; Greaves, 2000). Briefly, the two measures are essential proxy indicators for the subjective and objective aspects of quality of life. They can complement one another, but none of them can replace the other (Diener et al., 2012).

As discussed above, social capital is also a multidimensional concept and has been used in a previous study of individual well-being (see, e.g., Helliwell, 2002; Helliwell & Huang, 2010). Social capital could be considered as the sum of available resources that people achieve through their social networks and their social interactions (Bourdieu, 1986; Coleman, 1988; Putnam, 1993). From the network perspective, economists often identify three dimensions of social capital including bonding social capital, bridging social capital, and linking social capital (see, e.g., Gittel & Videl, 1998; Woolcock, 2001). Bonding social capital is associated with strong social interactions between people who share similar social identities as well as demographic characteristics such as family members, close friends, neighbors, and members in primary organizations (Putnam, 2000). On the other hand, bridging social capital such as workmates or casual friends refers to more distant social ties of people who are in different groups and communities but have a broadly similar financial position and power (Putnam, 2000; Woolcock, 2001). Linking social capital is considered a relatively new type of social capital developed by scholars from the World Bank. Whereas the first two aspects refer to "horizontal" social

interactions, the linking aspect of social capital reflects the "vertical" social relations that often relate to the political and institutional structures of the community. Szreter and Woolcock (2004) defined linking social capital as relations among people "who are interacting across explicit, formal or institutionalized power or authority gradients in society" (p. 655).

The literature tends to confirm the role of social capital as a key determinant of income (Knack & Keefer, 1997) and life satisfaction (Helliwell, 2002). Knack and Keefer (1997) showed that the differences in social capital certainly lead to the differences in economic outcomes (i.e., objective well-being) between regions and countries. Additionally, numerous studies confirm the positive interdependence between social capital and welfare reform efforts as well as other indicators of economic welfare such as employment and productivity, particularly in the case of people with low-income level (see, e.g., Lévesque, 2005; Parisi et al., 2003; Adato et al., 2006; Chantarat & Barrett, 2012).

Different dimensions of social capital have different impacts on individual economic well-being. Lancee (2010) compared the effects of bonding and bridging networks of immigrants in the Netherlands and showed that only bridging networks positively affect immigrants' economic outcomes. However, Tenzin and Natsuda (2016) analyzed a case study of a community in Bhutan and concluded that social capital in all forms of bonding, bridging, and linking relations helps to facilitate the economic activities of households. Whereas bonding social capital facilitates teamwork spirit among people in the same community, bridging and linking social capital help to create new networks, and therefore, bring more economic opportunities.

Besides, a vast number of studies have measured the relationship between social capital and life satisfaction (i.e., subjective well-being), particularly focusing on Western societies (see, e.g., Bjørnskov, 2003; Elgar et al., 2011; Helliwell, 2002; Helliwell & Putnam, 2004; Helliwell & Wang, 2011; Portela et al., 2013). Although some pieces of the literature find a negative effect of social networks on well-being (Ingersoll-Dayton et al., 1997; Portes & Landolt, 1996), researchers generally confirm the positive impact of dimensions of social capital on the quality of life. Helliwell and Putnam (2004) even considered social capital as one of the "most robust correlates of subjective wellbeing" (p. 1437). Social capital in the form of trustworthy relationships such as good and close friends improves the level of self-expressiveness (Krause, 2010) and reduces stress and psychological deprivation (Biswas-Diener & Diener, 2006). As a result, these relationships help people be more satisfied with their life. Likewise, social interactions and social supports facilitate the process of dealing with conflicts and problems, and so, increase the overall life satisfaction (Cox, 2000; Pinquart & Sörensen, 2000).

By contrast with developed economies, studies on the impact of social capital on life satisfaction in transitions and developing countries have been still meager. Conflicting findings have been reported in the literature regarding the role of various dimensions of social capital. For example, while it has been reported that trust as a measure of social capital is not a significant factor for well-being by Addai et al. (2014) for Ghana and by Churchill and Mishra (2017) for China, Degutis and

Urbonavicius (2013) stated that trust should be considered a key determinant of subjective well-being in Lithuania.

Studies on the impact of social capital on individual well-being in Vietnam focus on the role of social groups rather than classifying the impacts of each social capital aspect from the network perspective. For example, Nguyen and Berry (2013) showed that the membership in social groups increases the level of life satisfaction, whereas citizenship activities and cognitive social capital do not have any significant impact. Markussen (2015) showed the role of Communist Party membership and trust in improving the real income per capita of rural households in Vietnam. Using the same data source to study the determinants of happiness, Markussen et al. (2018) also confirmed the influence of social and political groups along with other personal characteristics of self-employed people.

3 Methodology

As described in the next section, we use equivalized household income as a measure of objective well-being and reported happiness as a measure of subjective well-being. Income is equivalized because in our data income is reported for the whole household while happiness was only asked for household heads. As income in our data is reported as a continuous variable, we specify a simple OLS model in which equivalized income is regressed on three measures of bonding, bridging, and linking social capitals as well as a number of control variables commonly used in previous studies. To deal with time-invariant unobserved heterogeneity, we specify and estimate a linear fixed-effects model.

As the reported measure of subjective well-being is an ordinal variable, a simple ordered logit model is specified and estimated as well as a mixed ordered logit model. However, the fixed-effects ordered logit model has been shown to be biased. We therefore specify and estimate the blow-up and cluster fixed-effects ordered logit model. To be specific, we start with a latent variable model for $\forall i \in \{1, N\}$ and $\forall t \in \{1, T\}$:

$$y_{it}^{*} = x_{it}'\beta + \alpha_i + \varepsilon_i \tag{1}$$

where the latent variable y_{it}^{*} is measuring the well-being of individual i at the time t, x_{it} is a vector of potential observable determinants of individual well-being, and β is the vector of estimators. Parameter α_i is the unobservable time-invariant factor that may or may not correlate with x_{it}, and ε_i is the error term. The indicator variable y_{it} for the level of happiness is defined as follows:

$$y_{it} = k \; if \; \gamma_k < y_{it}^{*} < \gamma_{k+1}, \qquad k = 1, \ldots, K \tag{2}$$

The individual-specific threshold, γ_k, is assumed to be strictly increasing ($\gamma_k < \gamma_{k+1}\ \forall k$ and with $\gamma_1 = -\infty$, $\gamma_{K+1} = +\infty$). In addition, the error term, ε_i, is assumed i.i.d. with logistic cumulative distribution function as follows:

$$F\left(\varepsilon_{it}|x_{it},\alpha_{it}\right) = F\left(\varepsilon_{it}\right) = \frac{1}{1+\exp\left(-\varepsilon_{it}\right)} \equiv \Lambda\left(\varepsilon_{it}\right) \tag{3}$$

As a result, the probability of observing outcome k for individual i at time t is

$$\Pr\left(y_{it}=k|x_{it},\alpha_{it}\right) = \Lambda\left(\gamma_{k+1} - x_{it}'\beta - \alpha_i\right) - \Lambda\left(\gamma_k - x_{it}'\beta - \alpha_i\right) \tag{4}$$

The probability of observing outcome k depends not only on β and x_{it}, but also on α_i, γ_k, and γ_{k+1}.

Considering the time-invariant effects in the nonlinear relationship between individual well-being and its determinants, Baetschmann et al. (2015) showed that one can only identify the difference between the thresholds and the fixed effects, $\alpha_{ik} = \gamma_k - \alpha_i$. Moreover, the difference α_{ik} cannot be consistently estimated because of the incidental parameters problem (Neyman & Scott, 1948). In this situation, the estimation of α_{ik} is only based on the information from a finite number of observations under fixed-T asymptotics. Finally, the problem will make direct maximum likelihood estimator β substantially bias in a short panel (Abrevaya, 1997; Green, 2004). One way to overcome the incidental parameters problem is by transforming y_{it} into a binary variable and then using the conditional maximum likelihood estimation (CMLE) to achieve a consistent estimator, for example, Chamberlain estimator (Chamberlain, 1980). Baetschmann et al. (2015) presented CMLE, in which they defined d_{it}^k as a binary dependent variable result from dichotomizing an ordered variable at the cutoff value k:

$$d_{it}^k = \begin{cases} 1 & \text{if } y_{it} \geq k \\ 0 & \text{else} \end{cases} \tag{5}$$

The probability of observing a particular sequence of outcomes $d_i^k = \left(d_{i1}^k, \ldots, d_{iT}^k\right) = \left(j_{i1}, \ldots, j_{iT}\right)$ is given by

$$\mathcal{P}_i^k\left(\beta\right) \equiv \Pr\left(d_i^k = j_i \,\middle|\, \sum_{t=1}^{T} d_{it}^k = g_i\right) = \frac{\exp\left(j_i' x_i \beta\right)}{\sum_{j\in B_i}\exp\left(j' x_i \beta\right)} \tag{6}$$

The probability does not depend on α_i and the threshold components. The Chamberlain estimator $\hat{\beta}^k$ is obtained from maximizing the conditional log-likelihood:

$$LL^k(b) = \sum_{i=1}^{N} \log\left(\mathcal{P}_i^k(b)\right. \tag{7}$$

Because the Chamberlain estimator uses only one dichotomization per individual, not all available information of the dependent variable is used. In other words, the Chamberlain method would not provide the most efficient estimator. To avoid the problem of many cutoff values associated with a small sample size, Baetschmann et al. (2015) also estimated fixed-effects ordered logit model by using $(K-1)$ cutoff values simultaneously. It imposes that with $\forall k \geq 2$, $\beta^2 = \beta^3 = \ldots = \beta^K$. Practically, the method could be done by blowing up the sample size. That is, one will repeat each individual $(K-1)$ times at different cutoff points of dependent variables. Then, the efficient consistent estimator can be obtained by using the Chamberlain method with the "blowing up" sample size. Following this method, some observations will contribute to several terms in the log-likelihood function, leading to dependence between these terms. To deal with this problem, Baetschmann et al. (2015) adjusted the standard error for clustering at each individual's level.

4 Data and Descriptive Statistics

In our empirical analysis, we use a panel data constructed from the Vietnam Access to Resource Household Surveys (VARHS) from 2012 to 2014. VARHS was conducted biannually from 2006 to 2014 by the Vietnamese Government Statistical Office (GSO) with technical support from the United Nations University in rural areas of 12 provinces across all seven economic regions of Vietnam.[2] Because the question about respondent's happiness is only available in the two waves of 2012 and 2014, we restrict our analysis to a balanced two-wave panel data set of 3283 households.

We consider two aspects of individual well-being in our analysis: objective well-being is measured by real equivalized income and subjective well-being is measured by self-reported life satisfaction. From now onward, pairs of (1) equivalized income and economic well-being, and (2) happiness and subjective well-being are interchangeably used. First, we use equivalized household income as an indicator of economic resources to control the economies of scale. To calculate the indicator, we use the "OECD-modified scale" to build up the equivalence factor and then divide the total household income by this factor. The OECD-modified scale developed by the Statistical Office of the European Union (EUROSTAT) assigns a value of 1 to the household head, 0.5 to each additional adult (15 years and over), and 0.3 to each child under 15; the equivalence factor is the sum of all household members' point. In addition, the income data needs to be adjusted by the regional CPI to ensure that the equivalized household income of each year in each province is in real values. Finally, the dependent variable, which is used as a proxy indicator for economic well-being, is the logarithm of real equivalized household income.

Second, the variable of subjective well-being is directly collected from the questionnaire of VARHS. Respondents are self-reported about their life satisfaction,

[2] https://www.wider.unu.edu/database/viet-nam-data.

and the question is: "Taking all things together, would you say you are '(1)—very pleased with your life,' '(2)—rather pleased with your life,' '(3)—not very pleased with your life,' and '(4)—not at all pleased with your life'?" We simply rearrange the answer so that the people who are in the happiest rank receive the highest score. Markussen et al. (2018) analyzed that using a single-item measure of life satisfaction can reduce the cultural sensitivity that is often caused by the multiple-item approach when the level of life satisfaction is revealed through several domains, for example, job satisfaction and marital satisfaction. Note that in the survey the question on life satisfaction is collected not for each household member, but only for a representative of households (typically, the household head). Therefore, we consider only the answer from household heads in our study.

In our work, seven variables have been chosen as indicators of bonding, bridging, and linking social capital. First, bonding social capital is considered a social network among the homogenous groups, shared social norms, trust, and collaborative spirit, which could provide social safety nets to people and protect them from any external invasion as well as risky behavior. We, therefore, use the number of organizations that household head often takes part in to measure the bonding social capital. The organizations listed in the questionnaire are popular social groups in Vietnam society such as the Communist Party, Youth Union, Women's Union, irrigation cooperative, credit organization, sports club, and so on.

Second, distrust and collaboration are proxy variables for bridging social capital because bridging social capital describes the relations among people across different social cleavages. The dummy variable of distrust has two values, 1 for "yes" and 0 for "no" as answers to the statement "In this commune one has to be careful, there are people you cannot trust." The level of distrust should be considered as a negative proxy of social capital; the lack of general trust could bring risk communication efforts (Glik, 2007; Ellison et al., 2007). At the same time, the level of collaboration of respondents is created from two questions: "Suppose your household faced the following alternatives, which one would it prefer? (1). Get and farm 12 hectare of land entirely by yourself or (2) get and farm 112 hectares of land jointly with one other family from your commune (to which you are not related)." If the respondent chooses option 1, then they continuously answer the second collaborative question: "Suppose your household faced instead the following alternatives, which one would it prefer? (1) Get and farm 12 hectare of land entirely by yourself. (2) Get and farm 312 hectares of land jointly with one other family from your commune (to which you are not related)."

Based on these two questions, we rank (1) people who choose answer number 2 of the first question as the "3—extremely collaborative," (2) people who choose answer number 1 of the first question and answer number 2 of the second question as "2—somewhat collaborative," and (3) the people who choose both answer number 1 of the two questions as "1—independent." Finally, three indicators of linking social capital are dummy variables of having a household member who is a public official, having a relative who is a public official, and having a friend who is a public official. In other words, linking social capital represents social relations among normal citizens and powerful people that are established on the foundation of trust.

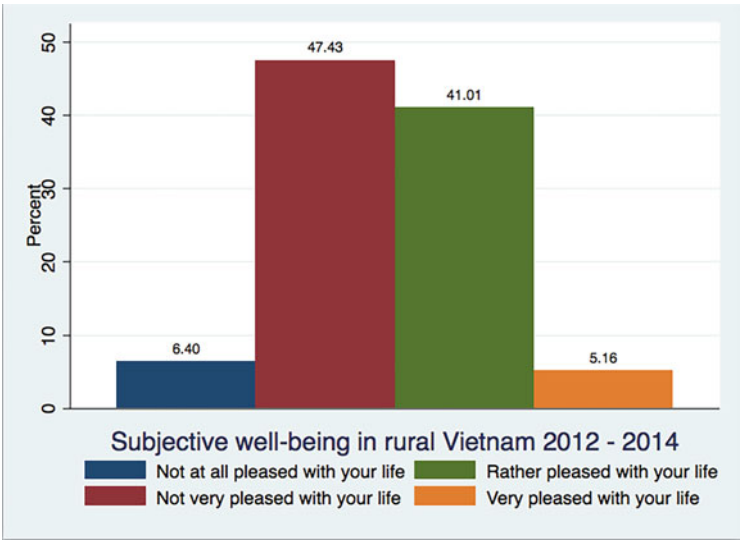

Fig. 1 Subjective well-being in rural Vietnam 2012–2014

Regarding control variables, we classify other potential determinants of individual well-being into two types: the characteristics of the head of household and the characteristics of the household itself. The characteristics of the head include age, gender, marital status, ethnicity, highest educational level, whether household head works (1) for salary, (2) in the agriculture sector, and (3) the in business/services sector, and the number off-days caused by sickness. The second type of potential determinants includes information related to household characteristics such as the number of household members who work (1) for salary, (2) in the agriculture, and (3) in the business/services sector, the number of dependent people, household size, whether or not the household head lives in an urban area, house area, whether or not the household currently borrows loans from bank, and the share of expenditure during the last Lunar New Year in annual household income.

Figure 1 presents the distribution of levels of subjective well-being in both the years 2012 and 2014. In general, one can see the answer of respondents divided into two main groups. A total of 53.83% of respondents are "not at all" and "not very" pleased with their life, whereas 46.17% are "rather" and "very" pleased. The statistics is opposite to that of Markussen et al. (2018) because of two reasons. First, our sample is slightly different from Markussen et al. (2018) because we conduct a balanced panel data of 2 years 2012 and 2014 instead of a cross-sectional data of 2012. In addition, we consider only those household heads who reported their own life satisfaction. Second, as can be seen from the macro level, the HPI of Vietnam fell from the second to the fifth place between 2012 and 2016, which is associated with the decrease in the level of life satisfaction in VARHS.

The descriptive statistics of variables are described in Table 1. Using the mean and median values of each variable, we follow the analysis of Markussen et al.

Table 1 Descriptive statistics and correlations with subjective well-being

Variables	Mean	Median	Share "rather" or "very" pleased with life	
			Low value on row variable	High value on row variable
Household total income ('000 VND)	88359.190	58,619	0.349	0.574***
Age of household head	50.426	49	0.449	0.475**
Male	0.842		0.422	0.469***
Married	0.855		0.399	0.472***
Ethnicity (Kinh)	0.650		0.357	0.518***
Education				
Household head cannot read and write	*0.014*		*0.463*	*0.344***
Household head can read and write but did not complete primary school	***0.159***		*0.488*	*0.324****
Household head completed primary school	*0.220*		*0.475*	*0.416****
Household head completed lower secondary school	*0.419*		*0.446*	*0.483****
Household head completed upper secondary school	*0.188*		*0.431*	*0.594****
Number of working days household head had to be off caused by sickness	12.220	3	0.49	0.427***
Household head works for salary	0.405		0.479	0.436***
Household head works in agriculture sector	0.787		0.516	0.447***
Household head works in business/services sector	0.155		0.443	0.568***
Total household members work for salary	1.125	1	0.467	0.452
Total household members work in the agriculture sector	2.545	2	0.491	0.423***
Total household members work in the business/services sector	0.421	0	0.437	0.538***
Number of dependent people	1.618	1	0.485	0.438***
Household size	4.505	4	0.472	0.449*
Urban	0.042		0.458	0.549***
Credit	0.378		0.478	0.434***
House area	76.382	60	0.488	0.499***
Expenditure on Tet holidays ('000 VND)	3617.777	3000	0.376	0.586***

(continued)

Table 1 (continued)

Variables	Mean	Median	Share "rather" or "very" pleased with life	
			Low value on row variable	High value on row variable
Number of organizations household head often participates in	0.570	0	0.416	0.517***
Household member works in public office	0.058		0.45	0.645***
Relative works in public office	0.180		0.444	0.541***
Friend works in public office	0.242		0.438	0.535***
Collaboration level	1.462	1	0.466	0.45
Distrust	0.427		0.465	0.458

*, **, and *** show significance levels at 10%. 5%, and 1%, respectively

(2018) and classify the sample into two subsamples including observations whose value is less than or equal to the median value, and observations whose value is higher than the median. For dummy variables, the low value is equal to 0 and the high value is equal to 1. Finally, we report the share of household heads who are either "rather" or "very" pleased with their life in each subsample. The table shows that in most cases the difference in life satisfaction between the two subsamples is statistically significant, except the cases of the total number of household members who work for salary, collaboration, and distrust.

5 Econometric Results and Discussion

The econometric results related to subjective well-being and economic well-being are shown in Tables 2 and 3, respectively. We use the fixed-effects model to measure the interdependence between social capital and economic well-being. Additionally, the OLS model is also presented as the base model. In the case of subjective well-being, we ran three models including the linear fixed-effects model (OLS FE), pooled ordered logit model, and the ordered fixed-effects model (BUC model). As shown in the previous session, although the linear fixed-effects model is more straightforward to implement and its econometric results are easier to interpret, the model requires a strong assumption of cardinality. At the same time, the results achieved from the pool ordered logit model could ease the problem related to the cardinal measure but certainly ignores the longitudinal effect from panel data. The BUC model is expected to be the most appropriate method that can be applied to the fixed-effects ordered logit model. In the discussion, we will analyze the results achieved from three methods to draw a thorough picture of well-being in Vietnam as well as to compare the effectiveness of each econometric model.

Table 2 Determinants of subjective well-being in Vietnam

	OLS FE	Pooled Ologit	Ordered FE (BUC)
Dependent variable: subjective well-being	(1)	(2)	(3)
Age of household head	−0.013*** (0.004)	−0.042*** (0.013)	−0.029 (0.097)
Age squared	0.014*** (0.004)	0.044*** (0.012)	−0.022 (0.087)
Male	0.031 (0.032)	0.1 (0.104)	0.263 (0.461)
Married	0.090*** (0.034)	0.274** (0.111)	−0.334 (0.291)
Ethnicity (Kinh)	0.057** (0.024)	0.187*** (0.07)	−0.886 (0.793)
Household head education:			
Did not complete primary school	0.078 (0.072)	0.261 (0.28)	−0.128 (0.366)
Completed primary school	0.029 (0.071)	0.088 (0.281)	0.142 (0.372)
Completed lower secondary school	0.025 (0.071)	0.083 (0.281)	−0.089 (0.417)
Completed upper secondary school	0.069 (0.073)	0.222 (0.287)	−0.275 (0.463)
Number of days household head had to be off caused by sickness	−0.042*** (0.008)	−0.126*** (0.025)	−0.113*** (0.04)
Household head works for salary	−0.047* (0.024)	−0.105 (0.073)	−0.159 (0.135)
Household head works in the agriculture sector	−0.016 (0.028)	−0.058 (0.09)	−0.137 (0.155)
Household head works in the business/services sector	0.028 (0.037)	0.073 (0.117)	0.196 (0.207)
Total household members work for salary	0.002 (0.011)	−0.009 (0.032)	0.008 (0.061)
Total household members work in the agriculture sector	0.012 (0.009)	0.049* (0.029)	0.009 (0.051)
Total household H members work in the business/services sector	0.005 (0.016)	0.022 (0.052)	0.065 (0.092)
Number of dependent people	−0.012 (0.01)	−0.036 (0.029)	−0.077 (0.091)
Log of real equivalized household income	0.244*** (0.014)	0.780*** (0.049)	0.559*** (0.093)
Household size	0.014 (0.009)	0.045 (0.028)	0.118* (0.072)
Urban	0.029 (0.043)	0.062 (0.136)	−1.610** (0.628)
Credit	−0.080*** (0.017)	−0.269*** (0.053)	−0.11 (0.089)
House area	0.001*** (0.000)	0.003*** (0.001)	0.002 (0.001)
Ratio of Tet expenditure to total income	1.102*** (0.177)	3.500*** (0.56)	3.978*** (1.016)
Number. of organizations that household head often participates in	0.083*** (0.012)	0.259*** (0.035)	0.245*** (0.072)
Household member works in public office	0.085** (0.037)	0.235** (0.113)	0.119 (0.225)

(continued)

Table 2 (continued)

Dependent variable: subjective well-being	OLS FE (1)	Pooled Ologit (2)	Ordered FE (BUC) (3)
Relative works in public office	0.059*** (0.022)	0.196*** (0.068)	0.091 (0.111)
Friend works in public office	0.045** (0.021)	0.137** (0.064)	0.158 (0.101)
Collaboration level	0.014 (0.01)	0.046 (0.032)	−0.025 (0.049)
Distrust	0.012 (0.016)	0.036 (0.051)	−0.01 (0.077)
Year	−0.086*** (0.008)	−0.262*** (0.026)	−0.202*** (0.044)
Constant cut1		−523.857*** (52.436)	
Constant cut2		−520.733*** (52.431)	
Constant cut3		−517.686*** (52.429)	
Constant	171.751*** (15.926)		
Observations	6438	6438	3920
Number of id	3283		

Robust standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Generally, econometric results are almost similar and consistent across different methods in terms of the sign of coefficients. First, considering subjective well-being, the coefficients achieved by using the BUC model tend to be less significant than the coefficients of the other ones. In other words, the BUC model result is a relatively low statistically powered estimator in comparison with the results of the fixed-effects model and pooled ordered logit model. The finding seems to be opposite to the previous research of Dickerson et al. (2014) and Baetschmann et al. (2015), which concluded that the OLS fixed-effects model and BUC model provide similar results. We compared the data of VARHS with that of previous studies to find out the root cause of the difference and realize that the key driver is the length of panel data. Whereas the panel data of previous studies include more than 10 waves (more preciously, 12 waves in Dickerson's work and 11 waves in the study of Baetschmann), the information on life satisfaction was unfortunately provided only through two waves of 2012 and 2014. Even the BUC method is theoretically considered the most proper method to deal with the fixed-effects ordered logit model; the method still reveals drawbacks in the case of the short-wave panel data. Despite the less statistical power of the BUC coefficient, the econometric results still show that once the BUC coefficients statistically become significant, they reveal similar results with the linear fixed-effects model as well as the pooled ordered logit model.

From now on, we use the econometric results of the fixed-effects model and pooled ordered logit model to analyze the relationships between the dimensions of social capital and those of individual well-being. Table 4 summarizes the significance and sign of the relationship between each pair of dimensions. In general, all three dimensions of social capital are interdependent with aspects of individual well-being. The relationships with life satisfaction are significant and

Table 3 Determinants of objective well-being in Vietnam

	Pooled OLS	Fixed effect
Dependent variable: objective well-being	(1)	(2)
Age of household head	0.023*** (0.004)	0.036* (0.021)
Age squared	−0.024*** (0.003)	−0.022 (0.017)
Male	−0.027 (0.026)	0.148 (0.107)
Married	0.121*** (0.028)	0.084 (0.062)
Ethnicity (Kinh)	0.304*** (0.019)	0.061 (0.194)
Household head education		
Did not complete primary school	−0.071 (0.061)	0.139* (0.079)
Completed primary school	0.085 (0.061)	0.168** (0.08)
Completed lower secondary school	0.209*** (0.06)	0.211** (0.089)
Completed upper secondary school	0.346*** (0.062)	0.242** (0.099)
Number of days household head had to be off caused by sickness	−0.006 (0.007)	0.019** (0.008)
Household head works for salary	0.183*** (0.01)	0.081*** (0.013)
Household head works in the agriculture sector	−0.147*** (0.02)	−0.072*** (0.028)
Household head works in the business/services sector	−0.062*** (0.024)	−0.033 (0.032)
Total household members work for salary	0 (0.032)	0.032 (0.042)
Total household members work in the agriculture sector	0.065*** (0.009)	0.092*** (0.012)
Total household members work in the business/services sector	−0.052*** (0.008)	−0.027*** (0.01)
Number of dependent people	0.109*** (0.014)	0.077*** (0.019)
Log of real equivalized household income	−0.050*** (0.008)	0.015 (0.018)
Household size	−0.052*** (0.008)	−0.114*** (0.014)
Urban	0.037 (0.035)	0.014 (0.132)
Credit	0.002 (0.015)	−0.017 (0.018)
House area	0.002*** (0.000)	0.001*** (0.000)
Ratio of Tet expenditure to total income	−6.130*** (0.132)	−5.176*** (0.155)
Number of organizations that household head often participates in	0.001 (0.01)	−0.033** (0.015)
Household member works in public office	0.210*** (0.032)	0.120*** (0.044)
Relative works in public office	0.072*** (0.019)	0.048** (0.023)
Friend works in public office	0.117*** (0.018)	0.081*** (0.02)
Collaboration level	−0.011 (0.009)	0.009 (0.01)
Distrust	−0.061*** (0.014)	−0.018 (0.016)
Year	0.026*** (0.007)	0.008 (0.01)
Constant	−44.345*** (14.399)	−7.664 (19.775)
Observations	6438	6438
R-squared	0.555	0.33
Number of id		3283

Robust standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 4 The interdependence between social capital and individual well-being

Variables of social capital	Objective well-being		Subjective well-being		
	OLS	FE	OLS FE model	Pooled order logit model	Ordered FE (BUC) model
Bonding social capital					
Number of organizations that household head often participates in	No	−	+	+	+
		(**)	(***)	(***)	(***)
Linking social capital					
Household member works in public office	+	+	+	+	No
	(***)	(***)	(**)	(**)	
Relative works in public office	+	+	+	+	No
	(***)	(**)	(***)	(***)	
Friend works in public office	+	+	+	+	No
	(***)	(***)	(**)	(**)	
Bridging social capital					
Collaboration level	No	No	No	No	No
Distrust	−	No	No	No	No
	(***)				

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

positive, but the interactions with income are mixed. First, an increase in subjective well-being due to bonding social capital is associated with a decrease in objective well-being and vice versa. Looking deeply at the blended relationship between bonding social capital and individual well-being, we find that an increase of four social organizations averagely raises the level of happiness, everything else remains unchanged. In other words, the more bonding social capital they own, the happier they are. However, people have to choose between the leisure time to participate in an organization and the earnings obtained from working due to the limitation of available time and resources. Participation in organizations may negatively affect their working productivity and therefore reduce the equivalized household income. The finding suggests a balance between working and relaxing to maximize individual well-being due to the trade-off impact of social capital on both well-being aspects.

Second, bridging social capital measured by the levels of cooperation and distrust is found to be irrelevant to individual well-being. This finding contradicts that of Markussen (2015), which confirms the positive impact of trust on income per capita in rural Vietnam due to several reasons. In his work, Markussen combined both questions measuring the level of trust and distrust in VARHS to build an index of trust. However, the question about distrust refers to a specified commune where respondents live, whereas the question about trust does not. Because the two types of trust and distrust are not consistently measured, combining these two questions

may not create an appropriate index of generalized trust. In addition, the difference in the study period may also be a cause: considering only the objective well-being, Markussen (2015) used a longer panel data from 2006 to 2014, whereas we use only two waves of the survey in 2012 and 2014. Third, linking social capital reveals positive links with both well-being aspects. It could be said that having a personal relationship with local authorities could facilitate activities in normal life as well as in business that, in turn, leads to a higher level of happiness and economic benefit. The interaction of these relationships with subjective well-being decreases to the degree of closeness; it is not true in the case of economic well-being. To improve income level, friendship with local authorities seems to be more important than having a relative working in the public office.

Unlike previous studies that primarily focus on Western countries (see, e.g., Helliwell and Wang, 2011; Portela et al., 2013; Putnam, 2002; Knack & Keefer, 1997), our study denies the link between bridging social capital and both aspects of individual well-being. In more detail, both cooperation and distrust do not reveal any significant relationship with happiness as well as income level in the rural Vietnam society. However, the finding is similar to that of developing countries such as Ghana and China (Addai et al., 2014; Churchill & Mishra, 2017). Lancee (2010) studied the individual economic well-being of immigrants in the Netherlands and concluded that both thick trust and thin trust have no effect on employment status and economic outcomes. The different role of trust/distrust and cooperation in the two types of society confirms that social capital is a highly context-dependent concept. It could be said that these two elements work better in well-established societies than in vulnerable communities.

Besides, whereas all empirical evidence agree upon the positive interaction of the number of social organizations with happiness, its relation with income level is mainly found to be positive in developed countries (see, e.g., Putnam, 2002; Knack & Keefer, 1997). Addai et al. (2014) studied social capital and income in South Africa and concluded that social networks and social relations help to stabilize income level in a short-term period rather than in a long-term period. Chantarat and Barrett (2012) developed a theoretical model of endogenous network formation among poor households and showed that a high cost of social capital would hinder households from using social capital to facilitate their activities. Additionally, the effectiveness of social capital "depends fundamentally on the broader socio-economic wealth distribution in the economy" (p. 299). This interpretation is suitable for the case of rural Vietnam, where the number of social organizations is positively associated with happiness but negatively related to the income level that can be explained by a relatively high opportunity cost of participation in social organization.

Regarding other variables, as can be seen in Tables 2 and 3, the determinants of each aspect of well-being are clearly different. Among the characteristics of household head, age has a U-shaped impact on the subjective well-being and a positive impact on the household equivalized income. Both variables of being Kinh people and getting married are associated with happier people but do not mean that they will be richer. By contrast, a higher education level of household

head corresponds to a higher level of income, but education level does not have any relationship with life satisfaction. Besides, working for salary decreases the household equivalized income. Finally, income and happiness significantly correlate with each other. Regarding household characteristics, living in a larger household and having a higher household size are associated with a higher income level but do not have any relation with happiness. A higher number of family members working for salary and business/services sectors significantly increases the income. However, if too many family members work in agriculture – the least productive sector – they may not have enough time to work in other sectors; this situation decreases the household equivalized income. Borrowing money from a bank brings a burden to the head of household, and therefore, reduces the level of life satisfaction. However, it does not improve the household equivalized income level.

6 Conclusion

In this study, we have examined the interdependence between social capital and individual well-being in rural Vietnam for the period 2012–2014. From a multi-dimensional approach, we consider three dimensions of social capital including bonding social capital, bridging social capital, and linking social capital; and two aspects of well-being measured by happiness (i.e., subjective well-being) and household equivalized income (i.e., objective well-being). The results of several econometric methods including blow-up and cluster fixed-effects order logit (i.e., BUC), linear fixed–effects, and pool ordered logit models were compared and the fixed-effects order logit is expected to appropriately deal with the ordinary variable of self-reported life satisfaction in a panel data. However, the econometric results showed that the BUC model provides less statistically powered estimators when one applies it to study a short-wave panel data. Nevertheless, when the coefficients of the BUC model turn out to be significant, one still observes the consistent results across three econometric models.

Generally speaking, our study confirms the interdependence between social capital and individual well-being. However, the interaction between each dimension of social capital and each aspect of well-being is clearly different. Bridging social capital does not reveal any significant relationship with both happiness and household equivalized income, whereas bonding and linking social capital are associated with both of these measures. It could be said that there is a trade-off between economic benefit and life satisfaction when people invest in bonding social capital. This finding suggests a balance between working time and leisure time to maximize the entire level of individual well-being. The negative interaction between bonding social capital and household equivalized income could be explained by a relatively high opportunity cost of participation in social organizations in rural Vietnam.

The findings of this study, however, have limitations. First, due to the availability of the data, we used only two waves of VARHS, leading to the inefficiency of

the BUC method. Second, by focusing on the multidimensional characteristics of social capital and individual well-being, we ignored an endogeneity problem pointed out by many other studies: not only social capital affects individual well-being, the state of well-being may also influence the investment in social capital. The complexity of measures in our study unfortunately prevents us from solving this problem. Nevertheless, it is necessary to study the relationship between social capital and individual well-being using a multidimensional approach to avoid delusive conclusions. In this context, the main contribution of our study is providing a broad framework of the interdependence between dimensions of the two concepts with a focus on Vietnam. In addition, by comparing our findings with those of previous studies, we have found that social capital may become more efficient in well-established societies than in vulnerable communities. Because social capital is also a highly context-dependent concept, one should place research results into a broad socioeconomic environment to understand the role of social capital at the micro level. An exhaustive comparison of social capital in different societies, however, is still left to future research.

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Value-Added Exports and the Local Labour Market: Evidence from Vietnamese Small and Medium Manufacturing Firms

Duc-Anh Dang and Anh Tran

Abstract The formation of global value chains (GVCs) has reshaped production processes across countries. This chapter investigates the relationship between GVCs and firms' employment by using panel data on Vietnamese small manufacturing firms for 2005–2011. The results suggest that increased foreign value added in exports results in higher wages, increased productivity, and a greater share of production workers in domestic small- and medium-sized enterprises. In addition, it brings about a lower share of professionals and makes smaller firms retrain their existing workers. At the same time, domestic value added in the export of intermediate products has negative impacts on employment and increases wages, particularly in medium-sized firms. All of these may come from the increased competition for labour from larger firms.

Keywords Trade · Small- and medium-sized enterprises · Global value chain · Viet Nam

JEL Classification: F16, O24

1 Introduction

The increasing international fragmentation of production that has occurred in recent decades has challenged the conventional wisdom on how we look at and interpret

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trade. The traditional way of measuring international trade based on gross trade flows (exports and imports) fails to reflect the complexities of the global supply chain, where the design, manufacturing, and assembly of products involve many countries (Cattaneo et al., 2013; OECD and WTO, 2012). Furthermore, since many countries have developed comparative advantages in specific parts of the value chains—not necessarily on final goods—standard trade statistics may present an inaccurate picture of the importance of trade to economic growth and employment.

For emerging and developing countries, small- and medium-sized enterprises (SMEs)[1] account for two-thirds of formal non-agricultural private employment (WTO, 2016). The fragmentation of production has created new opportunities for developing economies and SMEs to access global markets as components or services suppliers, without having to build the entire value chain of a product. Even if they cannot participate directly in global value chains (GVCs), they can benefit from subcontracting for incumbent firms or foreign companies.

Despite their importance for developing economies, the effects of GVCs on SME employment are understudied because of the difficulty in obtaining data on intranetwork transactions. Most of the extensive research that has been carried out in other disciplines on GVCs and related concepts tend to be based on case studies, rather than data and quantification (Shepherd, 2013). Only recently there have been a few studies that examine the impacts of GVCs on the labour market. There have been Banga (2016) examined the industry-level impact of linking into GVCs for the Indian labour market, spanning 1995–2011. Using methodologies of fixed effects and the generalised method of moments estimations, Banga analysed the employment impacts of value added, which are foreign value added (FVA) in exports (backward linkages) and domestic value added (DVA) in exports of intermediate goods and services (forward linkages). The results showed that while backward linkages have negatively impacted employment in India, forward linkages did not have any statistically significant impact. Jakubik and Stolzenburg (2018) used the value-added decomposition of exports to study the US local labour market impact of increased trade with China. They found evidence that Chinese value added drives negative labour market impacts. Similarly, Shen and Silva (2018) investigated the effects of Chinese export value added on the US labour market. They showed that an increase in US exposure to value-added exports from China has negative effects on the share of manufacturing employment in more downstream industries while the same effect is not present in the case of low downstream industries. Their results also suggest that the effects of an increase in US exposure to value-added exports from China—on average wages and unemployment levels—depend on the position of the Chinese industry in the GVC.

[1] The definition of SMEs in this study is based on the World Bank classification. The World Bank divided firms into three groups: micro-, small-, and medium-scale. Micro-enterprises have up to 10 employees, small-scale enterprises have up to 50 employees, and medium-sized enterprises have up to 300 employees.

The purpose of this chapter is to describe the evolution of GVCs in Viet Nam. At the same time, this study examines firm-level impacts by linking GVCs with Vietnamese small manufacturing firms. Viet Nam is not different from other countries as its SMEs account for 98% of all enterprises, 40% of gross domestic product, and 50% of employment (Vietnam Briefing, 2017). In addition, Viet Nam has emerged as an Asian manufacturing powerhouse (Nakamura, 2016). Viet Nam grew its own DVA, embodied in gross exports, by 16.6% annually from 1995 to 2011, just below what had been achieved by China. Participation in GVCs also plays an important role in structural transformation, contributing to the creation of more productive, higher-quality, and higher-earning jobs. Viet Nam is making GVCs more inclusive by moving up the value chain into higher value-added functions (Hollweg et al., 2017). However, reaping the benefits of GVC integration does not come automatically, and the dynamics shaping the emergence and development of GVCs may also represent a threat to sustainable, quality employment, particularly for people without portable skills or who face labour market segmentation. GVC integration is also likely to have distributional impacts, both through employment effects as well as through effects on wages and working conditions (Farole, 2016).

This analysis uses a unique data set, combining two Viet Nam Enterprise Surveys with trade in value-added data to construct a panel for about 16 manufacturing industries, covering 2005–2011. The panel allows for a firm-level analysis of the causal relationship between GVCs and employment while controlling for firm and time fixed effects. In particular, this chapter analyses the employment impact of FVA in exports (backward linkages) and DVA in exports of intermediate goods and services (forward linkages). The analysis also attempts to break down the available results according to skill level, which makes it possible to look not just at aggregate effects on employment levels and payments received by workers, but also at issues such as changes in labour composition (skilled and unskilled labour), labour productivity, training, and female workers. The results suggest that FVA in exports results in higher wages, increased productivity, and a greater share of production workers in domestic SMEs. In addition, it brings about a lower share of professionals and makes smaller firms retrain their existing workers. At the same time, DVA in exports of intermediate products has negative impacts on employment and increases wages, particularly in medium-sized firms. All of these may result from increased competition for labour from larger firms.

This study is expected to add to the existing literature in two important ways. First, it supplements the few empirical studies that estimate the effects of GVCs on labour demand using firm-level data. Second, it provides evidence on the effects of GVCs on different aspects of SME employment such as wages, employment, labour composition, and productivity in Viet Nam.

This chapter is organised as follows. Section 2 begins by describing the trends of trade in value added in Viet Nam's manufacturing sector. Section 3 illustrates the conceptual framework. Section 4 discusses our data, along with the descriptive analyses of trends in the main variables, while Sect. 5 presents the empirical strategy and estimation results. Section 6 summarises the key findings and concludes.

2 Trade in Value Added by Small Manufacturing Firms

2.1 Trade in Value Added in the Manufacturing Sector

Since 'Doi Moi', Viet Nam has actively participated in international economic integration and increased access to foreign markets for socio-economic development.[2] It signed a trade agreement with the European Union in 1992 and joined the Association of Southeast Asian Nations (ASEAN) and the ASEAN Free Trade Area in 1995, and Asia-Pacific Economic Cooperation (APEC) in 1998. The process of economic integration has accelerated since 2000, when Viet Nam and the United States signed a bilateral trade agreement. That was Viet Nam's first comprehensive trade agreement, which brought higher levels of trade and investment liberalisation. Accession to the WTO in 2007 and the negotiation and implementation of a number of regional free trade agreements continued to strengthen the confidence of both the domestic and international investor community regarding Viet Nam's trade liberalisation and international integration.[3]

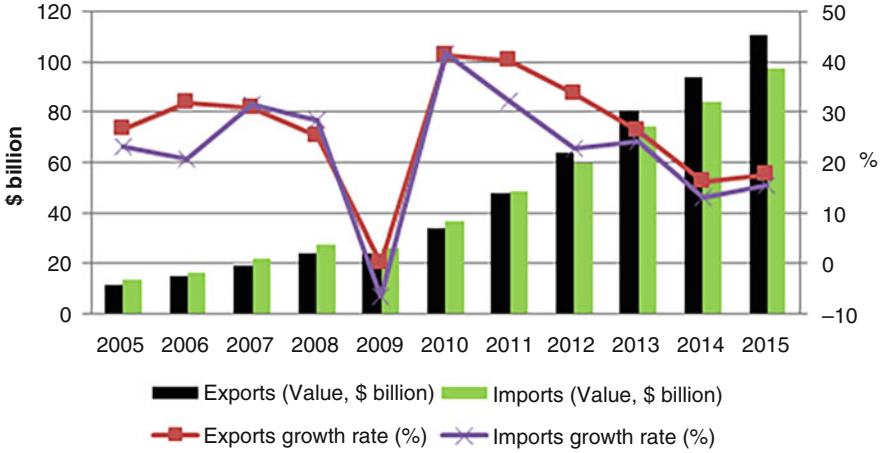
As a result of liberalisation, international trade had been expanding rapidly. As shown in Fig. 1, exports grew at an average annual rate of 26.4% from 2005 to 2015 while imports grew by 22.5% over the same period, increasing the share of trade turnover to nearly 170% of the gross domestic product in 2015. The effects of the global financial crisis and economic recession led to a drop in import and export growth in 2009, before their recovery in the following years.

As for exports, manufactured goods accounted for 50.3% in 2005 (Fig. 2). Their share increased to 81.3% by 2015, mainly attributable to the expansion of light industrial and handicraft exports, particularly textiles and garments, footwear, and electronic products. Primary commodities decreased their share in exports from 49.7 to 18.7% in the same period, primarily owing to the decline in all food items and the decreased exports of fuels. Manufactures accounted for about 82.2% of Viet Nam's total merchandise imports in 2015, up from 72.5% in 2005. According to data from the General Statistics Office of Viet Nam (GSO), the main components of imports were iron and steel, ores, metals, fuels, machines and devices, and electronic and computer spare parts. The dependency on imports of industrial raw materials and equipment, whose ratio to imports is about 90%, reflects the low level of Vietnamese industrial development and low international competitiveness in capital goods.

At the same time, an important cause of Viet Nam's rapid growth in recent years has been the interrelated increases in international trade and multinational

[2] 'Doi Moi' refers to the economic reforms initiated in Viet Nam in 1986 to transform its centrally planned economy to a socialist-oriented market economy

[3] These free trade agreements include the ASEAN–Australia–New Zealand Free Trade Agreement, the ASEAN–Japan Comprehensive Economic Partnership Agreement, the formation of the ASEAN Economic Community, the Comprehensive and Progressive Agreement for Trans-Pacific Partnership, the European Union–Vietnam Free Trade Agreement, and the Regional Comprehensive Economic Partnership.

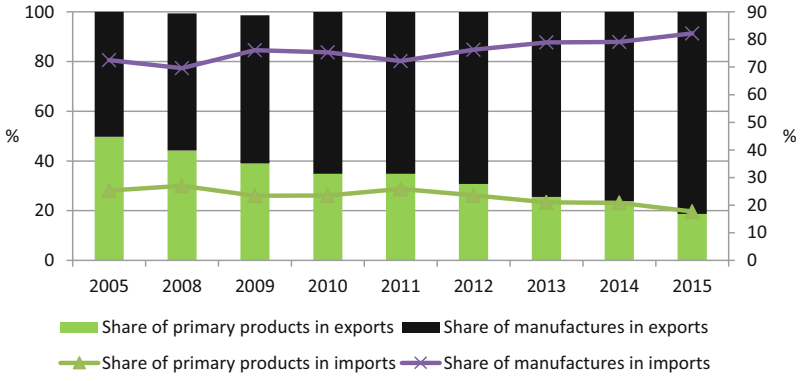


Notes:

1. The value of exports and imports are presented on the left-hand axis.
2. The exports and imports growth rates are presented on the right-hand axis.

Source: General Department of Vietnam Customs.

Fig. 1 Viet Nam's exports and imports, 2005–2015. The values of exports and imports are presented on the left-hand axis. The export and import growth rates are presented on the right-hand axis. (Source: General Department of Vietnam Customs)

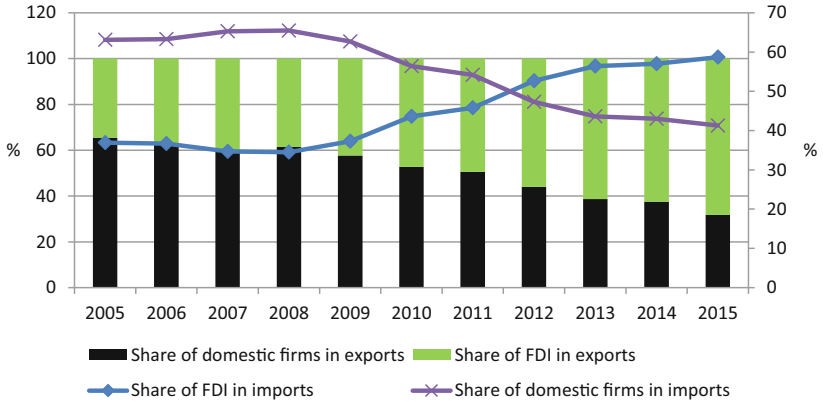


Notes:

3. The share of primary products in exports and the share of manufactures in exports are presented on the left-hand axis.
4. The share of primary products in imports and the share of manufactures in imports are presented on the right-hand axis.

Source: General Statistics Office of Viet Nam.

Fig. 2 Composition of merchandise trade. The share of primary products in exports and the share of manufactures in exports are presented on the left-hand axis. The share of primary products in imports and the share of manufactures in imports are presented on the right-hand axis. (Source: General Statistics Office of Viet Nam)



FDI = foreign direct investment.
Notes:
1. The share of FDI in exports and the share of domestic firms in exports are presented on the left-hand axis.
2. The share of FDI in imports and the share of domestic firms in imports are presented on the right-hand axis.
Source: General Department of Vietnam Customs.

Fig. 3 Contribution of FDI and domestic firms in imports and exports. *FDI* foreign direct investment. The share of FDI in exports and the share of domestic firms in exports are presented on the left-hand axis. The share of FDI in imports and the share of domestic firms in imports are presented on the right-hand axis. (Source: General Department of Vietnam Customs)

corporations (MNCs) (Dollar & Kraay, 2004). According to Athukorala (2006), whose paper examined the role of MNCs in the expansion of manufacturing exports from newly industrialised countries (the Republic of Korea, Taiwan, and Hong Kong) and latecomer exporting countries in Asia (including Viet Nam), there is a close positive relationship between the entry of MNCs and export growth.[4] MNCs have been responsible for a larger share of exports from latecomers to export-led industrialisation in Asia than the historical experience of East Asian newly industrialised countries.

Figure 3 indicates that foreign firms emerge as an important exporter. Their share in total exports increased from 34.5% in 2005 to 68.2% in 2015. This trend follows a boom in export-led foreign direct investment projects. The increased share of MNCs in exports that correspond to a larger export value—such as clothing and footwear; and electronics, parts, and component assembly—is important since it is initially labour-intensive but becomes skill-intensive as the country moves up the value chain, and the role of MNCs is relevant in terms of knowledge spillover. According to Viet Nam's Enterprise Census, the ratio of foreign firms' exports is about 60% of total sales in 2014. The share of imports by foreign firms also increases

[4] On average, the 1% increase in the share of foreign firms in total manufacturing exports is associated with a 0.96% increase in the degree of penetration of these countries in world manufacturing markets (Athukorala, 2006).

in the same period, from 36.9% in 2005 to 58.7% in 2015. Most increased imports were inputs for production, such as raw materials, machines, and equipment. This reflects the fact that foreign firms are taking advantage of cheap labour and financial incentives to assemble and export their products, especially in textiles, footwear, and electronics.

2.2 Trade in Value Added by SMEs

SMEs and private firms are seen as the engine of Viet Nam's economic growth and have shown impressive growth. According to the GSO, the number of enterprises in the manufacturing sector increased three times during 2003–2013 (GSO, 2007, 2014). Non-state enterprises accounted for about 59.3% of total business employment in 2013—a threefold increase from 2003. The number of workers in the manufacturing sector increased from 2.6 million in 2003 to 5.3 million in 2013 (CIEM; Department of Economics, University of Copenhagen; Institute of Labour Science and Social Affairs; and UNU-WIDER, 2016). However, the Vietnam Chamber of Commerce and Industry reported that most SMEs cannot access the world market, and only 21% of them can participate in GVCs (Vietnamnet, 2017). Difficulties in gaining access to credit, as well as lack of technology and management skills, are major barriers preventing them from joining supply chains. Links amongst producers and distributors in supply chains are weak, making it more difficult for Vietnamese firms to participate in foreign markets. According to the Vietnam Small and Medium Enterprise survey, only 6% of local firms have exports and more than half of them export indirectly to foreign markets. Only about 3% of firms directly import materials from foreign markets for their businesses.

3 Conceptual Framework

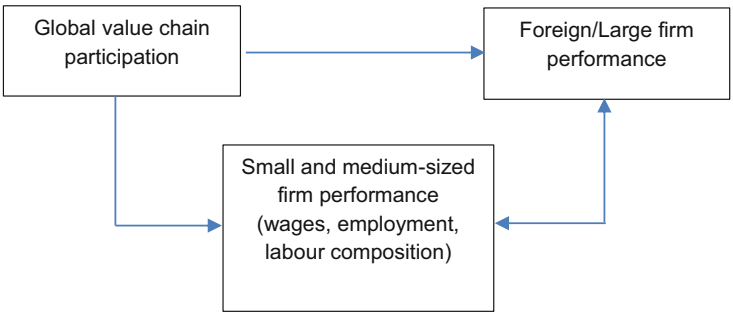
GVCs may affect SMEs through different channels and perspectives. First, GVC participation increases demand for skilled labour, especially in developed countries, to provide specialised services such as research and development and branding. At the same time, labour-intensive manufacturing activities have been outsourced to developing countries with cheap labour costs, which could increase low-skilled jobs in developing countries (Taglioni & Winkler, 2016). Jiang and Milberg (2013) found that the jobs created as a result of trade in GVCs accrue more to low- and medium-skilled workers than high-skilled labour. Of the jobs generated globally by GVCs in 2009, they found that only 13% were high-skilled while 44% were medium-skilled and 43% were low-skilled.

Second, women may benefit from GVCs because a large share of jobs is created when firms participate in labour-intensive value chains. Almost all sectors most intensely traded in GVCs—such as apparel, footwear, and electronics—have

a large share of lower-skilled, young, female workers (WTO; the Institute of Developing Economies (IDE-JETRO); OECD; Research Center of Global Value Chains, University of International Business and Economics (RCGVC-UIBE); and World Bank, 2019).

Third, the labour market may work more effectively as a result of higher competition in demand for labour. This reduces the job-seeking time and increases employment matching and stability in the labour market. Fourth, the shift in labour composition has been accompanied by changes in wages and the bargaining power of workers, especially low-skilled workers. Participation in a GVC can lead to the creation of better jobs through higher wages and better working conditions as firms seek to comply with global standards on health, safety, and treatment of workers (WTO; the Institute of Developing Economies (IDE-JETRO); OECD; Research Center of Global Value Chains, University of International Business and Economics (RCGVC-UIBE); and World Bank, 2019). GVC participation also promotes learning and skills development. Lead firms in GVCs provide training in technology and skill development to SME firms (Gyeke-Dako et al., 2017) while knowledge from the labour force of participating firms disperses to other local firms. Learning effects also occur as employees use more sophisticated technology (MacGarvie, 2006). All of these contribute to increased productivity and higher wages. The summary of this mechanism is presented in Fig. 4.

However, if SMEs do not have the capacity to engage in GVCs, they may suffer negative impacts from GVCs. First, SMEs may have to compete with imported substitution products. Second, large firms or MNCs may compete with SMEs to attract employees, so the number of employees in SMEs may decrease. Higher demand for labour pushes up market wages, which increases the production costs of SMEs. This may make small and less competitive firms close down or reduce their employment. In addition, more efficient firms survive and tend to be more skill-intensive. This results in an increase in the relative demand for high-skilled workers, widening the wage gap between low- and higher-skilled workers (Helpman et al.,



Source: Authors' compilation.

Fig. 4 Impact of global value chains on labour market. (Source: Authors' compilation)

2010). Therefore, whether SMEs can take advantage of GVC integration depends on their competitiveness as participants in the GVCs.

4 Empirical Methodology

4.1 Data Description

4.1.1 Trade in Value-Added Data

To understand the impact of trade in GVCs, trade in value-added data are measured by two types of trade flows: backward and forward linkages. The Trade in Value Added (TiVA) database launched by the OECD and the WTO in 2016 provides the source for 2005–2011.[5] Data collected from TiVA are matched to enterprise surveys for 16 manufacturing industries, using concordance matrices, and then used to analyse the impact of increasing GVC linkages on employment across all sectors.

In the TiVA database, backward linkage is defined as FVA embodied in gross exports, which reflects the FVA content of intermediate imports embodied in gross exports (i.e. other countries' DVA in intermediates used in exports). Forward linkage is defined as the DVA in the gross exports of intermediate products that can become part of the exports or consumption of a partner country, as a share of gross exports.

Table 1 shows the pattern of FVA in the total exports of the manufacturing sector. As can be seen, the largest sources of FVA in exports in 2011 are in machinery and equipment. The figures show the highest growth in the share of FVA in electrical and optical equipment, from 59.8% in 2005 to 69.2% in 2011; and computer, electronic, and optical equipment, from 60.5% in 2005 to 70.4% in 2011. The share of FVA in textiles, textile products, leather, and footwear increases in the first year and then declines over time, from 49.7% in 2005 up to 54.4% in 2006 and down to 37.5% in 2011. This shows the relative expansion in the domestic value content of Vietnamese exports in these products. In general, although the manufacturing sector accounts for a large share of exports, domestic value made moderate contributions to the value added of exports.

The DVA in the gross exports of intermediate products that can become part of the exports or consumption of a partner country, as a share of gross exports, is presented in Table 2. It is important to note that while gross exports have grown substantially, the growth of forward linkages has been much slower. In fact, for some sectors, the share of DVA in the gross exports of intermediate goods and services fell considerably in 2005–2011, such as in electrical and optical equipment and computer, electronic, and optical equipment. The figures in Table 2 reveal that

[5] TiVA statistics should be treated with great caution. As Nenci (2014) points out, the high level of industry aggregation in TiVA limits its analytic usefulness and can lead to erroneous interpretations if not supplemented by additional research. However, it is the best available data set to date.

Table 1 Share of foreign value added embodied in total exports of the manufacturing sector

Sectors	2005	2007	2009	2011
C17T19: Textiles, textile products, leather, and footwear	49.69	53.11	42.91	37.47
C20: Wood and products of wood and cork	44.37	45.90	39.88	43.23
C20T22: Wood, paper, paper products, printing, and publishing	44.29	45.29	40.13	42.72
C21T22: Pulp, paper, paper products, printing, and publishing	44.04	44.05	40.60	41.32
C23: Coke, refined petroleum products, and nuclear fuel	65.53	57.37	56.84	58.21
C23T26: Chemicals and non-metallic mineral products	60.14	58.17	53.66	57.72
C24: Chemicals and chemical products	67.25	68.86	61.04	64.07
C25: Rubber and plastics products	59.30	58.67	53.89	60.44
C26: Other non-metallic mineral products	48.51	41.93	35.63	38.44
C27: Basic metals	73.31	71.71	65.94	68.39
C27T28: Basic metals and fabricated metal products	62.82	64.30	60.80	64.48
C28: Fabricated metal products	57.52	61.12	54.15	58.73
C29: Machinery and equipment	66.09	70.57	69.30	71.10
C30T33: Electrical and optical equipment	59.82	68.70	66.46	69.16
C30T33X: Computer, electronic, and optical equipment	60.53	70.74	68.08	70.40
C31: Electrical machinery and apparatus	58.69	65.63	64.07	66.39
C34: Motor vehicles, trailers, and semitrailers	54.87	55.10	51.54	55.05
C34T35: Transport equipment	55.64	56.31	53.92	58.01
C35: Other transport equipment	56.17	60.97	55.73	59.74
C36T37: Manufacturing; recycling	45.53	39.29	34.76	37.75
C40T41: Electricity, gas, and water supply	15.92	11.39	10.45	11.28
Average	**54.76**	**55.68**	**51.42**	**54.00**

Source: Authors' calculations from the Organisation for Economic Co-operation and Development–World Trade Organization, Trade in Value Added (TiVA) database. https://stats.oecd.org/Index.aspx?DataSetCode=TIVA_NOWCAST (accessed 24 July 2019)

the DVA for electrical and optical equipment fell by almost 5.2 percentage points. Similar results can be seen for computer, electronic, and optical equipment. The fall in the DVA of this sector has been smaller—about 5 percentage points.

4.1.2 Employment Data

This study uses two enterprise surveys—the VSME survey and the Enterprise Census—for the empirical analysis. This section describes the two surveys and the sample selection.

Table 2 Share of domestic value added in exports of intermediate products embodied in total exports

Sectors	2005	2007	2009	2011
C17T19: Textiles, textile products, leather, and footwear	14.06	14.33	15.32	18.34
C20: Wood and products of wood and cork	52.53	51.26	56.97	53.81
C20T22: Wood, paper, paper products, printing, and publishing	50.43	47.18	53.03	51.96
C21T22: Pulp, paper, paper products, printing, and publishing	44.34	38.96	45.76	46.86
C23: Coke, refined petroleum products, and nuclear fuel	16.84	22.46	30.21	28.11
C23T26: Chemicals and non-metallic mineral products	32.60	34.93	37.81	33.95
C24: Chemicals and chemical products	24.53	23.63	29.86	27.87
C25: Rubber and plastics products	35.91	35.98	39.59	33.83
C26: Other non-metallic mineral products	46.81	53.58	59.83	57.36
C27: Basic metals	25.63	27.59	33.45	30.24
C27T28: Basic metals and fabricated metal products	26.16	30.92	32.35	29.18
C28: Fabricated metal products	26.43	32.35	30.94	27.63
C29: Machinery and equipment	13.52	14.10	16.16	14.21
C30T33: Electrical and optical equipment	23.48	18.36	19.38	18.25
C30T33X: Computer, electronic, and optical equipment	21.91	16.62	17.44	17.02
C31: Electrical machinery and apparatus	25.96	20.99	22.26	20.96
C34: Motor vehicles, trailers, and semitrailers	22.83	16.25	24.32	22.68
C34T35: Transport equipment	21.72	16.50	22.54	19.63
C35: Other transport equipment	20.95	17.47	21.19	17.86
C36T37: Manufacturing; recycling	17.94	20.32	27.56	26.37
C40T41: Electricity, gas, and water supply	5.90	5.83	0.99	0.46
Average	**27.16**	**26.66**	**30.34**	**28.42**

Source: Authors' calculation from the Organisation for Economic Co-operation and Development–World Trade Organization, Trade in Value Added (TiVA) database. https://stats.oecd.org/Index.aspx?DataSetCode=TIVA_NOWCAST (accessed 24 July 2019)

VSME Sample

The VSME survey is conducted every 2 years to assess the characteristics of Viet Nam's business environment.[6] The survey is conducted in 10 provinces: Ho Chi Minh City, Hanoi, Hai Phong, Long An, Ha Tay, Quang Nam, Phu Tho, Nghe An, Khanh Hoa, and Lam Dong. The population of manufacturing enterprises is based on the Establishment Census in 2002 and the Industrial Survey, 2004–2006. The random sample was stratified by ownership type to include household establishments, private enterprises, collectives or cooperatives, and limited liability and joint stock

[6] The survey was conducted in collaboration between the CIEM of the Ministry of Planning and Investment; the Institute of Labour Science and Social Affairs of the Ministry of Labor – Invalids and Social Affairs; the Development Economics Research Group of the University of Copenhagen; and the United Nations University World Institute for Development Economics Research (UNU-WIDER).

Table 3 Descriptive statistics of employment variables (Viet Nam small and medium enterprise survey)

Variables	2005	2007	2009	2011
Log of real wage	1.91 (0.73)	1.31 (0.67)	1.47 (0.73)	1.80 (0.66)
Log of labour productivity	3.94 (1.01)	3.52 (0.85)	3.49 (0.94)	3.75 (0.95)
Log of total labour force	2.00 (1.11)	2.02 (1.14)	2.03 (1.17)	1.91 (1.14)
Share of female labour force	0.36 (2.75)	0.36 (0.27)	0.37 (0.26)	0.37 (0.26)
Share of professionals	0.01 (0.04)	0.03 (0.06)	0.03 (0.06)	0.03 (0.07)
Share of production workers	0.53 (0.27)	0.66 (0.20)	0.66 (0.20)	0.62 (0.22)
Training for existing workers	0.05 (0.22)	0.06 (0.24)	0.04 (0.19)	0.06 (0.24)
Job rotation	0.28 (0.45)	0.15 (0.35)	0.07 (0.25)	0.12 (0.32)

Note: Wage and productivity variables are deflated using annual gross domestic product deflators
Source: Authors' calculations from the Viet Nam Small and Medium Enterprise Surveys, 2005–2011

companies. It includes only firms active in the manufacturing sector and with less than 300 employees. However, the survey may over-sample micro- and household firms. In total, the panel data cover the micro-information of about 1230 businesses in 22 manufacturing industries over 2005–2011, including food products, textiles, basic metals, other non-metallic products and apparel, and wood processing.

The surveys' section on employment includes detailed information on wages, the number of workers, labour productivity, the share of skilled and unskilled workers, the percentage of female workers, the stability of the labour force, on-the-job training, job rotation, difficulties in recruiting workers with the required/appropriate skills, and contributions to social insurance and other benefits.[7]

Table 3 reports the summarised statistics of employment variables for the VSME sample. Real wages decreased in 2007 and recovered in 2009 and 2011. Labour productivity—measured by the total firm's output over the number of employees—also declines in 2005–2009. The share of female workers is almost unchanged in 2005–2011 and accounts for 36%. Only 5% of local firms conduct training for existing workers in the same period.

Enterprise Census Sample

The GSO conducts Viet Nam's Enterprise Census annually. It is a national survey compiled across all 63 provinces and is used as part of the GSO's national accounts determination. The survey takes a census of firms with more than 30 employees and a representative sample of firms with less than 30 employees. However, to focus on small domestic manufacturing firms, this analysis is limited to SMEs with less than 300 employees.

The employment variables from the Enterprise Census sample are reported in Table 4. The evolution of employment variables is similar to those in the VSME

[7] Variables used in the analysis are defined in the Appendix.

Table 4 Descriptive statistics of employment variables (enterprise census)

Variables	2005	2007	2009	2011
Log of real wage	1.81 (0.73)	2.40 (0.71)	3.06 (0.61)	3.64 (0.76)
Log of labour productivity	3.97 (1.40)	4.52 (1.26)	5.00 (1.37)	5.64 (1.39)
Log of total labour force	3.35 (1.17)	3.34 (1.15)	3.67 (1.16)	3.33 (1.20)
Share of female labour force	0.34 (0.23)	0.29 (0.21)	0.30 (0.21)	0.32 (0.21)

Note: Wage and productivity variables are deflated using annual gross domestic product deflators
Source: Authors' calculation from Enterprise Census, 2005–2011

sample, except real wages and labour productivity. The figures in Table 4 show that real wages and productivity increase over time. One possible explanation for these differences is the sampling between the two surveys. The VSME survey contains more micro- and informal enterprises, whereas the Enterprise Census includes more SMEs.

4.2 Empirical Model

This chapter's econometric specification, which considers the effects of GVCs in employment and wage levels, is represented by the following equation:

$$y_{ijt} = \alpha + \beta \text{Trade VA}_{jt-1} + X'_{ijt}\tau + \lambda_i + \theta_t + \varepsilon_{ijt} \quad (1)$$

where y_{ijt} is the firm-level outcome of interest of firm i in industry j at time t, and Trade VA_{jt_1} is the trade in value added of industry j at time $t-1$. β is the coefficient of this study's main measures, which indicates the relationship between GVCs and firms' employment outcomes. The main variable is included in the estimated specification with a one-period lag to reduce potential simultaneity bias. At the same time, it reflects the possibility that firms' employment does not react immediately to trade shocks. The term X is a vector of interaction of dummies of firm sizes and trade in value added. λ_i and θ_t are firm and year dummy fixed effects, of which year dummies capture time-specific factors that are common to all firms while firm dummies control for time-invariant firm-specific characteristics. Standard errors are clustered by firm levels.

The challenge in estimating these equations is the potential endogeneity between outcome variables and the trade in value-added variables. The source of this endogeneity could be due to omitted variable biases. It is possible that unobserved characteristics of the firms will correlate with trade in value-added variables and affect the firms' employment. Using firm-level fixed effects eliminates the potential for any time-invariant characteristics of firms to act as confounding factors in our analysis. Of course, it is possible that some omitted time-varying variable biases remain. However, with our main explanatory variable at the industry level and lagged by one period, we expect these potential biases to be small.

5 Empirical Results

The effects of trade linkages on firm employment shown in Eq. (1) are expected to have a different direction. The impact of higher backward linkages is expected to depend on the kind of backward linkages formed. If the FVA in exports leads to increases in total exports, by complementing the domestic firms, it may lead to higher demand for labour and wages in an industry. However, if it substitutes domestic production, it can lead to lower labour demand.

Table 5 presents the results of our analysis of the impact of FVA in total exports on different employment outcomes. All models include time dummies. To deal with potential contamination of the models by unobservable firm characteristics that may correlate with both trade in value-added variables and employment outcomes, we use fixed-effects estimation to control for potential time-invariant firm-specific omitted variables that may bias our results.

In the first column, the estimated coefficients for backward linkages are positive and significant. These indicate that FVA in exports increases wages. The coefficients suggest that a 10 percentage point increase in FVA in total exports is associated with a 1.9% increase in wages. The effects of FVA on wages may be either through higher demand for labour from small firms or more competition from larger firms in attracting labour, which increases wages. The results shown in columns 2 and 3 indicate that backward linkages have positive effects on the productivity and size of employment, although the signs of the coefficients are not statistically significant. This shows that higher wages may come from higher demand for labour from larger firms. All of these are consistent with the hypothesis that FVA in exports complements the domestic sector and increases domestic employment and wages through expanding country exports.[8] These results are also consistent with other empirical studies, which document that firms participating in trade tend to be more productive, larger, and pay higher wages (e.g. McCaig & Pavcnik, 2018).

The estimated coefficient in column 6 shows that backward linkages increase the share of production workers. This indicates that small firms can only participate in low value-added chains and low-skilled jobs. However, there is no evidence of the impact of backward linkages on job training and rotation.

The estimates of forward linkages are reported in Table 6. The results show that the forward linkages negatively affect wages and employment, but not significantly. Forward linkages only significantly affect the labour composition. The estimate reported in column 6 shows that forward linkages are associated with lower shares of production workers. A 10 percentage point increase in DVA in intermediate exports is associated with a 0.5 percentage point decrease in the share of production workers. This could be because higher DVA in exports of intermediate goods may hurt domestic firms, especially small ones, when they cannot compete with large firms or MNCs in purchasing fewer inputs. However, the impacts are rather small.

[8] The increase in FVA in total exports reflects that FVA grows faster than total exports.

Table 5 Effects of backward linkages on employment outcomes (Viet Nam small and medium enterprise survey)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln (real wage)	ln (labour productivity)	ln (employment)	Share of female workers	Share of professionals	Share of production workers	Training existing workers	Job rotation
Backward linkages	0.187** (0.089)	0.007 (0.097)	0.064 (0.083)	0.020 (0.030)	−0.000 (0.009)	0.104*** (0.034)	−0.005 (0.039)	0.047 (0.068)
Observations	3600	3600	3600	3600	3600	3600	3600	3600
R-squared	0.216	0.143	0.009	0.003	0.048	0.160	0.005	0.095
Number of firms	1229	1229	1229	1229	1229	1229	1229	1229
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses are robust to heteroscedasticity and clustered at the firm level., **, and *** indicate statistical significance at the 10%, 5%, and 1% levels

Source: Authors' calculation from the Viet Nam Small and Medium Enterprise Surveys, 2005–2011.

Table 6 Effects of forward linkages on employment outcomes (Viet Nam small and medium enterprise survey)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln (real wage)	ln (labour productivity)	ln (employment)	Share of female workers	Share of professionals	Share of production workers	Training existing workers	Job rotation
Forward linkages	−0.014 (0.046)	0.059 (0.058)	−0.010 (0.044)	−0.015 (0.015)	−0.006 (0.004)	−0.051*** (0.018)	0.013 (0.020)	0.003 (0.034)
Observations	3600	3600	3600	3600	3600	3600	3600	3600
R-squared	0.214	0.143	0.008	0.003	0.049	0.160	0.005	0.095
Number of firms	1229	1229	1229	1229	1229	1229	1229	1229
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses are robust to heteroscedasticity and clustered at the firm level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels

Source: Authors' calculation from the Viet Nam Small and Medium Enterprise Surveys, 2005–2011

At the same time, firms may have different capacities in engaging in GVCs, depending on their size. Firms with less advanced technologies or small firms may find it hard to join GVCs. Therefore, larger domestic firms may benefit more from increasing imports because of their generally more sophisticated technology and business processes while smaller firms benefit less. The estimates in column 1 of Table 7 show that micro- and small manufacturing firms tend to suffer less from backward linkages than medium-sized firms, although the coefficients are insignificant. In addition, micro- and small firms have a lower share of professionals and have to give more training to existing workers as participating GVCs.

The results in Table 8 show that the forward linkages do not have a significant impact on employment outcomes, except the interaction of dummies for small firms and the size of the employment share of female workers and job rotation. The increase in the share of DVA in the export of intermediate products leads to lower levels of employment in small firms than other firms. This indicates that employees in small firms can be hurt more when increased DVA in the export of intermediate products. However, in other estimation specifications, joining GVCs has small and insignificant effects on the composition of workers.

5.1 Robustness Check

A concern with our finding of the effects of trade in value added on firms' employment is that the VSME sample may not be nationally representative and may over-represent micro-firms. To check the robustness of these results, we replicate the estimations in Eq. (1) with the national sample—the Enterprise Survey. The estimates are reported in Table 9, where we examine the impacts of trade linkages and break them into different firm sizes.

Columns 1–4 of Table 9 report the impacts of backward linkages on wages, labour productivity, employment, and the share of female employees. The FVA in total exports increases wages, productivity, and the share of female workers. The increase in labour productivity could be because SMEs are becoming more capital-intensive in response to rising wages. These findings are consistent with the findings in the previous estimations shown in Table 5. Columns 5–8 report estimates for different types of firms. The results in columns 5 and 6 show that backward linkages have higher impacts on the wages and productivity of micro- and small firms than medium-sized firms. Higher demand for workers from larger firms creates more competition in attracting employees and pushes up wages in smaller firms. The result in column 8 also indicates that micro-firms may suffer more from backward linkages as they have negative effects on the number of employees.

Table 10 reports the effects of forward linkages on employment outcomes using a nationally representative sample. The findings in column 3 also show that an increase in the share of DVA in the export of intermediate products has negative

Table 7 Effects of backward linkages on employment outcomes by firm sizes (Viet Nam small and medium enterprise survey)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln (real wage)	ln (labour productivity)	ln (employment)	Share of female workers	Share of professionals	Share of production workers	Training existing workers	Job rotation
Backward linkages	0.340* (0.197)	0.262 (0.265)	−0.114 (0.102)	−0.004 (0.058)	0.044* (0.023)	0.106 (0.065)	−0.249* (0.145)	0.247* (0.139)
Backward linkages × micro-firms	−0.278 (0.201)	−0.462* (0.268)	0.173 (0.107)	0.019 (0.058)	−0.047** (0.023)	−0.000 (0.063)	0.274* (0.144)	−0.217 (0.135)
Backward linkages × small firms	−0.087 (0.178)	−0.084 (0.248)	0.156 (0.097)	0.031 (0.055)	−0.049** (0.023)	−0.002 (0.061)	0.247* (0.146)	−0.228* (0.125)
Dummy for micro-firms	1.216 (0.771)	2.344** (1.027)	−2.502*** (0.404)	−0.066 (0.221)	0.187** (0.087)	−0.062 (0.244)	−1.018* (0.552)	0.728 (0.516)
Dummy for small firms	0.462 (0.679)	0.674 (0.956)	−1.642*** (0.368)	−0.113 (0.212)	0.198** (0.086)	−0.028 (0.238)	−0.913 (0.562)	0.854* (0.480)
Observations	3601	3601	3601	3601	3601	3601	3601	3601
R-squared	0.219	0.166	0.488	0.003	0.054	0.163	0.010	0.100
Number of firms	1230	1230	1230	1230	1230	1230	1230	1230
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses are robust to heteroscedasticity and clustered at the firm level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels

Source: Authors' calculation from the Viet Nam Small and Medium Enterprise Surveys, 2005–2011

Table 8 Effects of forward linkages on employment outcomes by firm sizes (Viet Nam small and medium enterprise survey)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln (real wage)	ln (labour productivity)	ln (employment)	Share of female workers	Share of professionals	Share of production workers	Training existing workers	Job rotation
Forward linkages	−0.063 (0.099)	−0.031 (0.139)	0.087 (0.086)	0.034 (0.032)	−0.001 (0.013)	−0.106** (0.042)	0.052 (0.059)	0.112 (0.086)
Forward linkages × micro-firms	0.043 (0.114)	0.065 (0.151)	−0.055 (0.093)	−0.049 (0.034)	−0.008 (0.013)	0.044 (0.046)	−0.036 (0.060)	−0.110 (0.092)
Forward linkages × small firms	0.043 (0.102)	0.101 (0.142)	−0.157* (0.091)	−0.067** (0.034)	−0.004 (0.012)	0.066 (0.045)	−0.068 (0.060)	−0.142* (0.083)
Dummy for micro-firms	0.027 (0.379)	0.391 (0.514)	−1.664*** (0.310)	0.173 (0.117)	0.034 (0.045)	−0.212 (0.161)	0.145 (0.209)	0.271 (0.313)
Dummy for small firms	−0.014 (0.335)	0.016 (0.477)	−0.520* (0.302)	0.228** (0.115)	0.024 (0.041)	−0.257 (0.160)	0.255 (0.212)	0.463 (0.286)
Observations	3601	3601	3601	3601	3601	3601	3601	3601
R-squared	0.217	0.162	0.489	0.005	0.052	0.165	0.007	0.100
Number of firms	1230	1230	1230	1230	1230	1230	1230	1230
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses are robust to heteroscedasticity and clustered at the firm level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels

Source: Authors' calculation from the Viet Nam Small and Medium Enterprise Surveys, 2005–2011

Table 9 Effects of backward linkages on employment outcomes (enterprise census)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln (real wage)	ln (labour productivity)	ln (employment)	Share of female workers	ln (real wage)	ln (labour productivity)	ln (employment)	Share of female workers
Backward linkages	0.024**(0.011)	0.034**(0.017)	−0.004(0.011)	0.007***(0.002)	−0.017(0.018)	−0.035(0.024)	0.005(0.013)	0.009**(0.003)
Backward linkages × micro-firms					0.088***(0.022)	0.126***(0.033)	−0.038**(0.016)	−0.003(0.005)
Backward linkages × small firms					0.038*(0.020)	0.080***(0.028)	0.001(0.015)	−0.004(0.004)
Dummy for micro-firms					−0.007(0.085)	0.399***(0.127)	−1.932***(0.061)	0.065***(0.019)
Dummy for small firms					0.072(0.076)	0.212**(0.106)	−1.078***(0.057)	0.024(0.016)
Observations	63,301	63,301	63,301	63,301	63,301	63,301	63,301	63,301
R-squared	0.654	0.402	0.008	0.016	0.660	0.432	0.600	0.030
Number of firms	21,488	21,488	21,488	21,488	21,488	21,488	21,488	21,488
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses are robust to heteroscedasticity and clustered at the firm level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels

Source: Authors' calculation from Enterprise Census, 2005–2011

Table 10 Effects of forward linkages on employment outcomes (enterprise census)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln (real wage)	ln (labour productivity)	ln (employment)	Share of female workers	ln (real wage)	ln (labour productivity)	ln (employment)	Share of female workers
Forward linkages	−0.001 (0.005)	0.011 (0.009)	−0.019*** (0.006)	0.000 (0.001)	0.049*** (0.009)	0.126*** (0.013)	−0.084*** (0.007)	0.018*** (0.002)
Forward linkages × micro-firms					−0.076*** (0.011)	−0.171*** (0.016)	0.118*** (0.008)	−0.033*** (0.002)
Forward linkages × small firms					−0.055*** (0.009)	−0.134*** (0.012)	0.077*** (0.007)	−0.015*** (0.002)
Dummy for micro-firms					0.515*** (0.032)	1.302*** (0.047)	−2.371*** (0.023)	0.139*** (0.006)
Dummy for small firms					0.354*** (0.026)	0.851*** (0.035)	−1.268*** (0.019)	0.047*** (0.005)
Observations	63,301	63,301	63,301	63,301	63,301	63,301	63,301	63,301
R-squared	0.654	0.402	0.009	0.016	0.660	0.433	0.603	0.036
Number of firms	21,488	21,488	21,488	21,488	21,488	21,488	21,488	21,488
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Standard errors in parentheses are robust to heteroscedasticity and clustered at the firm level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels

Source: Authors' calculation from Enterprise Census, 2005–2011

effects on employment. This could result from more competition for workers from larger firms. The findings in column 7 show that forward linkages mainly result in a reduction in employment at medium-sized firms. This result is associated with a decline in wages and productivity at micro- and small firms, as indicated in columns 5 and 6.

6 Conclusion

This chapter examines the impact of linking into GVCs on SME employment in Viet Nam. GVCs offer a number of potential benefits to firms, including the potential for output and export growth and productivity spillovers. Along with this, GVCs may deliver jobs and earnings growth. However, the employment effects—even assuming growth in output and exports—are not always obvious. Therefore, with the impact of linking into GVCs on labour demand being multifold, it is important to analyse which type of backward and forward linkages a country should encourage. At the same time, the effects of GVCs on domestic firms, especially SMEs, depend on the extent to which firms can directly or indirectly participate in GVCs. Effective participation in value chains may increase labour production, wages, and employment. In contrast, GVCs may have negative impacts on employment, particularly on small enterprises.

Using fixed-effects estimation, we find that forward linkages (DVA in the export of intermediate products) lower employment and increase wages, especially in medium-sized firms. They also reduce the share of production workers. Backward linkages (FVA in exports) that are complementary to the existing domestic resources may encourage more value addition to exports, leading to an increase in wages, productivity, and a higher share of production workers in domestic SMEs. In addition, backward linkages result in a lower share of professionals and make smaller firms retrain their existing workers. All of these may come from increased competition for labour from larger firms.

This empirical analysis shows that it may be less advantageous for SMEs than larger firms to participate in GVCs. It also implies that policies which improve the competitiveness of SMEs and assist them to take more advantage of participating in GVCs may benefit from the development of domestic firms and the whole economy.

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Appendix

Variable	Description
Trade in value-added measures	
Backward linkages	Share of foreign value added embodied in gross exports (FVA) over gross exports
Forward linkages	Share of domestic value added (DVA) in gross exports of intermediate products over gross exports
Employment measures	
ln (employment)	Log of total number of workers
ln (real wage)	Log of real labour wages per capita
ln (labour productivity)	Log of output per worker
Share of professionals	Share of professionals over the total regular workforce
Share of production workers	Share of production workers over the total regular workforce
Share of female workers	Share of female workers over the total regular workforce
Train existing workers	Dummy indicator for whether firms train existing workers
Job rotation	Dummy indicator for job rotation

Source: Authors' compilation

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Why Does Productivity Matter?

Cuong Le Van and Ngoc-Sang Pham

Abstract Productivity is a key concept in economics and crucial for economic growth. By using different theoretical models, we show the role of several kinds of productivity, including the total factor productivity (TFP) and labor productivity.

Keywords Productivity · TFP · Labor productivity · Competitiveness · Growth

JEL Classifications E2, O4

1 Introduction

Productivity is a key concept in economics. It is crucial for economic growth. Since the total output, generally measured by gross domestic product (GDP), is produced by different inputs (such as capital, labor, land, raw materials, . . .), there are different ways to measure productivity. We can use capital productivity, which is defined as the output per unit of capital used in the production process during a given time reference period.

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$$\text{Capital Productivity} \equiv \frac{\text{Output}}{\text{Capital input use}}, \tag{1}$$

or labor productivity defined as the output per unit of labor (measured in terms of the number of workers or hours worked):

$$\text{Labor Productivity} \equiv \frac{\text{Output}}{\text{Labor input use}}. \tag{2}$$

There is another measure of productivity: the total factor productivity (TFP) that is the portion of growth not explained by growth in inputs used in the production process. The TFP measures the efficiency with which factor inputs are combined and is often used to proxy technological progress.

Looking back to history, Solow (1957) estimated that TFP growth accounted for 87.5% of the growth in output per worker of the USA over the period 1909–1949.[1] Zhu (2012) estimated that the contribution of TFP growth to economic growth is 78% of the growth in GDP per capita of China during 1978–2007.[2]

The goal of this chapter is to explore the role of different kinds of productivity on economic growth from a theoretical point of view. We will focus on TFP and labor productivity.

2 Total Factor Productivity

2.1 TFP and Economic Growth

Let us start our exposition by investigating the relationship between TFP and economic growth. Solow (1957), using the data of the US economy of the 50 beginning years of the twentieth century, ran a regression

$$\Delta \ln(Y_t) = B + \alpha \Delta \ln(K_t) + \beta \Delta \ln(N_t), \tag{3}$$

where Y_t, K_t, N_t are, respectively, the GDP, physical capital, and the number of workers. Solow (1957) found that TFP growth accounted for 87.5% of the growth in output per worker over that period.

This regression is derived from a production function (Cobb–Douglas function)

[1] Solow was awarded the Nobel Memorial Prize in Economic Sciences in 1987 for his contributions to the theory of economic growth. The paper Solow (1957) is an important part of these contributions.

[2] Estimating contribution to growth of different factors is not an easy task. See Hulten (2009) for a great treatment of growth accounting.

$$Y_t = A_t K_t^{\alpha} N_t^{\beta}. \tag{4}$$

Obviously, $B = \Delta \ln(A_t)$ in the regression. B is called *Solow residual*, while A_t is called technical progress or total factor productivity (TFP). TFP is the portion of growth in output not explained by growth in traditionally measured inputs of labor and capital used in production. TFP is measured as the ratio of aggregate output (e.g., GDP) to aggregate inputs (here, this is the quantity $k^{\alpha} N^{\beta}$ when $\beta = 1 - \alpha$). The rate of TFP growth is calculated by subtracting the average growth rates of labor and capital inputs from the growth rate of output.

In the following, we explore the role of TFP by using different growth models. Let us start with the Harrod model. Consider an infinite-horizon closed economy starting with an initial capital stock $k_0 > 0$:

$$\begin{aligned} \textbf{Harrod model}: \quad & c_t + S_t = Y_t \\ & I_t = S_t \\ & k_{t+1} = k_t(1-\delta) + I_t \\ & S_t = sY_t \\ & Y_t = A_t k_t, \end{aligned}$$

where c_t, S_t, I_t are consumption, saving, investment at date t ($t = 0, 1, \ldots, +\infty$), $s \in (0, 1)$ is the exogenous saving rate, k_t is the physical capital at date t ($k_0 > 0$ is given), $\delta \in [0, 1]$ is the capital depreciation rate, and Y_t is the output.

The production function in this model ($Y_t = A_t k_t$) can be interpreted in several ways: (i) it is a special case of the general form of Cobb–Douglas function with $\beta = 0$, (2) the labor N_t has an exogenous rate of growth $N_t = N_0(1+n)^t$. In this case, the TFP becomes $A_t N_0^{\beta}(1+n)^{\beta t}$, (3) if $\beta = 1-\alpha$, the function can be written as:

$$\frac{Y_t}{N_t} = A_t \left(\frac{k_t}{N_t}\right)^{\alpha},$$

i.e., we consider the output per capita as a function of capital per capita.

From the above system, we obtain that, for any $t \geq 0$,

$$\begin{aligned} Y_t &= A_t((1-\delta)k_{t-1} + sY_{t-1}) \\ \text{and } \frac{\Delta Y_t}{Y_t} &= \frac{A_{t+1}}{A_t}(1-\delta) + sA_{t+1} - 1 \\ \text{where } \Delta Y_t &\equiv Y_{t+1} - Y_t. \end{aligned}$$

Therefore, we have the following result.

Proposition 1 *Consider the above Harrod model. Suppose $A_t \to A > 0$ when t tends to infinity. We have that:*

1. $\frac{\Delta Y_t}{Y_t} \to sA - \delta$.
2. *If* $sA - \delta > 0$, *then* $Y_t \to +\infty$.
3. *If* $sA - \delta < 0$, *then* $Y_t \to 0$.

According to this result, the economy may grow or collapse, depending to the TFP A: if A is high enough ($A > \delta/s$), then we have economic growth without bounds.

We now consider a model à la Solow. This model is quite similar to the Harrod model, excepted the production function,

$$\begin{aligned}
\textbf{Solow model}: \quad & c_t + S_t = Y_t \\
& I_t = S_t \\
& k_{t+1} = k_t(1-\delta) + I_t \\
& S_t = sY_t \\
& Y_t = A_t k_t^{\alpha} L_t^{1-\alpha}, \alpha \in (0,1) \\
& A_t = a(1+\gamma)^t \\
& L_t = L_0(1+n)^t.
\end{aligned}$$

Here $\gamma > -1$ is the rate of growth of the TFP A_t, while $n > -1$ is the rate of growth of the labor force. Both of them are assumed to be exogenous.

From the above system, we obtain that, for any $t \geq 0$,

$$\begin{aligned}
Y_t &= a(1+\gamma)^t k_t^{\alpha} L_t^{1-\alpha} \\
\frac{Y_{t+1}}{Y_t} &= (1+\gamma)(1+n)^{1-\alpha}\Big(\frac{k_{t+1}}{k_t}\Big)^{\alpha} \\
k_{t+1} &= k_t(1-\delta) + sa(1+\gamma)^t k_t^{\alpha} L_t^{1-\alpha}.
\end{aligned}$$

Therefore, we obtain the following result:

Proposition 2 *Consider the above Solow model. We have that:* $\frac{\Delta Y_t}{Y_t} \to g$ *where* g *satisfies*

$$1 + g = (1+n)(1+\gamma)^{\frac{1}{1-\alpha}}.$$

The long-term rate of growth g of the output depends strongly on the rate of growth of the TFP A_t. The higher A, the higher the rate of growth g.

Although the Harrod and Solow models help us to explain the role of TFP, they have two limits: (1) the rate of saving is exogenous and (2) the rate of growth of the output is also exogenous. With the Ramsey model, we can endogenize the rate of

saving, but we do not resolve the question of the exogeneity of the rate of growth of the output. This question will be resolved with endogenous growth models.

We now present a Ramsey model. We assume there exists a representative consumer who lives for an infinite number of periods. She/he maximizes her/his intertemporal utility under sequential constraints

$$\textbf{Ramsey model}: \max_{(c_t,k_t,I_t)} \sum_{t=0}^{+\infty} \beta^t u(c_t)$$
$$\text{subject to: } c_t + I_t \leq F_t(k_t)$$
$$k_{t+1} = k_t(1-\delta) + I_t,$$

where $k_0 > 0$ is given, and $\beta \in (0,1)$ represents the rate of time preference. The instantaneous utility function u is strictly increasing, strictly concave, differentiable, $u'(0) = +\infty$. The production function F_t is concave, strictly increasing, differentiable, and $F_t(0) = 0$. Note that this function is time-dependent.[3]

Remark 1 As in the Harrod model, in the Ramsey Model, implicitly, either we consider the number of workers is exogenous and has an exogenous rate of growth, or we consider in fact the output per capita and capital per capita.

As usual, if $(c_t^*, k_{t+1}^*, I_t^*)_{t\geq 0}$ is the list of the optimal solutions of the above Ramsey problem, the optimal rates of saving are $s_t^* = \frac{I_t^*}{F_t(k_t^*)}$ and we have Euler equations:

$$u'(c_t^*) = \beta u'(c_{t+1}^*)\big(1 - \delta + F'_{t+1}(k_{t+1})\big). \tag{5}$$

In general, finding solutions of the Ramsey problem is not easy. To explore the importance of the TFP, we consider two examples where we can explicitly compute the optimal paths and rate of growth.

Example 1 (AK Model) Suppose $u(c) = \ln(c)$, $F_t(k) = A_t k$. Let us denote $A'_t = A_t + 1 - \delta$. We can prove that the optimal path (k_t) is given by $k_{t+1} = \beta(1-\delta+A_t)k_t$ $\forall t$. Then the optimal output y_t^* satisfies

$$y_t^* = \beta^t (A'_0 A'_1 \dots A'_t) y_0,$$

with $y_0 = A'_0 k_0$. The optimal rate of saving is

$$s_t^* = \frac{\beta A_t + (1-\delta)(\beta - 1)}{A_t} \leq \beta < 1,$$

which is increasing in A_t. Moreover, if $A_t \leq A_{t+1}$, then $s_t^* \leq s_{t+1}^*$.

[3] See Le Van and Dana (2003) for a detailed presentation of optimal growth models.

We can also compute the rate of growth by $\frac{y^*_{t+1}}{y^*_t} = \beta(A_t + 1 - \delta)$.

Now suppose $A_t \to A > 0$ as $t \to +\infty$. In this case $\frac{y^*_{t+1}}{y^*_t} \to \beta(A + 1 - \delta)$ and $s^*_t \to s = \frac{\beta A + (1-\delta)(\beta-1)}{A}$. Let us look at two cases:

- If $\beta(A + 1 - \delta) > 1 \Leftrightarrow sA - \delta > 0$, then $\frac{y^*_{t+1}}{y^*_t} \to +\infty$.
- If $\beta(A + 1 - \delta) < 1 \Leftrightarrow sA - \delta < 0$, then $\frac{y^*_{t+1}}{y^*_t} \to 0$.

We get the same results as in the Harrod model: the TFP plays a crucial role on the economic development.

Example 2 Assume that $u(c) = \ln(c)$, $F_t(k) = Ak^\alpha$, $\alpha \in (0, 1)$, and $\delta = 1$. In this case, we can prove that the optimal path is given by $k_{t+1} = \beta\alpha A k_t^\alpha \ \forall t \geq 0$, and the saving rate is $\alpha\beta$. Therefore, the optimal output is

$$y^*_{t+1} = A^{\frac{1-\alpha^{t+2}}{1-\alpha}} (\alpha\beta)^{\frac{\alpha-\alpha^{t+2}}{1-\alpha}} k_0^{\alpha^{t+2}}.$$

When t goes to infinity, the output y^*_{t+1} converges to a steady state

$$y^s = A^{\frac{1}{1-\alpha}} (\alpha\beta)^{\frac{\alpha}{1-\alpha}}.$$

There is no growth. It is due to the fact the production function is of strictly decreasing returns to scale. However, observe when A increases, the steady state becomes higher.

2.2 How to Increase TFP and Obtain Economic Growth?

So far the TFP A_t seems to be a black box in a production function of the type

$$y_t = A_t k_t^\alpha N_t^\beta,$$

where k_t, N_t are the number of machines and the number of workers. In this modeling, we do not take into account the quality of the machines, nor the skill of the workers. Actually, the production function should be written as

$$y_t = a m_t (\mathcal{K}_t)^\alpha (\mathcal{N}_t)^\beta,$$

where m_t is the quality of the management, the macroeconomic environment (stability, law rule), $\mathcal{K}_t$ is the effective capital stock, and $\mathcal{N}_t$ is the effective labor. Let ζ_t denote the technology embedded in the machines, θ_t denote the working time,

and h_t the human capital (education, training, health) of the workers. We then have

$$\mathcal{K}_t = \zeta_t k_t \text{ and } \mathcal{N}_t = \theta_t h_t N_t.$$

The production function now is $y_t = A_t k_t^{\alpha} N_t^{\beta}$, where the TFP is $A_t \equiv \left[a m_t \zeta_t^{\alpha} (\theta_t h_t)^{\beta}\right]$. If we assume θ_t depends positively on wages or bonus (incentive mechanism), then

$$y_t = A_t k_t^{\alpha} N_t^{\beta} \tag{6}$$

$$\text{where the TFP} \quad A_t = \left[a m_t \zeta_t^{\alpha} (\theta(w_t) h_t)^{\beta}\right]. \tag{7}$$

Now, the TFP is not anymore a black box. If we invest in the quality of management,[4] technology, training, education, health and if the salaries of the workers are sufficiently incentive, we will have a high TFP. Using endogenous growth models (Lucas, 1988; Romer, 1990), we can prove that there may be economic growth even with strictly decreasing returns to scale production function.

In the following, we present a simple endogenous growth model. The representative household maximizes her intertemporal utility $\sum_{t=0}^{\infty} \beta^t u(c_t)$ subject to sequential constraints: $c_t + S_{t+1} = G_t F(k_t)\ \forall t \geq 0$, where c_t, S_{t+1} are consumption, saving.

We now assume that the saving S_{t+1} is shared in investment in physical capital k_{t+1} and in investment T_{t+1} in TFP, i.e., $k_{t+1} + T_{t+1} = S_{t+1}$. G_{t+1} is a function of T_{t+1}, and we write $G(T_{t+1})$. We rewrite the model as follows:

$$\max \sum_{t=0}^{\infty} \beta^t u(c_t)$$

$$\text{for } t \geq 1 \quad c_t + S_{t+1} = H(S_t) \equiv \max\{G(T_t)F(k_t) : T_t + k_t = S_t, \text{ and } T_t, k_t \geq 0\}$$

$$\text{where } k_{t+1} + T_{t+1} = S_{t+1}.$$

For the sake of tractability, we assume that $F(k) = k^{\alpha}, \alpha \in (0,1), G(T) = (\lambda T + 1)^{\xi}, \xi > 0$, and $\lambda > 0$.[5] The parameter ξ measures the quality of the TFP investment technology. The higher ξ the more efficient the TPF investment. The parameter λ measures the utilization of T_t. For instance λ is small because of diversion of T_t.

[4] Bloom et al. (2013) ran a management field experiment on large Indian textile firms and provided free consulting on management practices to randomly chosen treating plants. By comparing the performance of these plants to a set of control plants, they found that adopting these management practices raised the TFP by 17% in the first year.

[5] Here, we implicitly assume that u is continuously differentiable, strictly increasing, concave, $u'(0) = \infty$ and $\sum_{t=0}^{\infty} \beta^t u(D_t) < \infty$, where the sequence (D_t) is defined by $D_0 = H(S_0)$, $D_{t+1} = H(D_t)$.

We first look at the static problem and the properties of the function H. Under our specifications, we have $H(S_t) \equiv \max\{(\lambda T_t + 1)^{\xi} k_t^{\alpha} : T_t + k_t = S_t, \text{ and } T_t, k_t \geq 0\}$. Solving this problem is equivalent to solving the following problem whose objective function is strictly concave

$$\max\{\xi ln(\lambda T_t + 1) + \alpha ln(k_t) : T_t + k_t = S_t, \text{ and } T_t, k_t \geq 0\}.$$

(T_t, k_t) is an optimum point if and only if there are non-negative values μ_1, μ_2 such that

$$\frac{\alpha}{k_t} = \mu_1, \quad \xi \frac{\lambda}{\lambda T_t + 1} + \mu_2 = \mu_1, \quad \mu_2 T_t = 0.$$

If $T_t = 0$ at optimal, then we have $\lambda\xi = \mu_1 - \mu_2 \leq \mu_1 = \alpha/k_t = \alpha/S_t$. Thus, we have $S_t \leq \alpha/(\lambda\xi)$.

If $T_t > 0$ at optimal, the FOC implies that $\frac{\alpha}{k_t} = \xi \frac{\lambda}{\lambda T_t + 1}$, i.e., $(\lambda T_t + 1)\alpha = \xi\lambda k_t = \xi\lambda(S_t - T_t)$. So, we can compute that

$$T_t = \frac{\xi\lambda S_t - \alpha}{\lambda(\alpha + \xi)}, \quad k_t = \frac{\alpha(\lambda S_t + 1)}{\lambda(\alpha + \xi)}$$

$$H(S_t) = \Big(\frac{\xi(\lambda S_t + 1)}{\alpha + \xi}\Big)^{\xi} \Big(\frac{\alpha(\lambda S_t + 1)}{\lambda(\alpha + \xi)}\Big)^{\alpha} = \frac{\xi^{\xi}\alpha^{\alpha}}{(\alpha + \xi)^{\alpha+\xi}} \frac{(\lambda S_t + 1)^{\alpha+\xi}}{\lambda^{\alpha}}.$$

Of course, $T_t > 0$ is equivalent to $\xi\lambda S_t - \alpha > 0$.

Summing up, we obtain the following result:

Lemma 1

- *If $S_t \leq \frac{\alpha}{\xi\lambda}$, then $T_t = 0$. It is not optimal to invest in TFP, when S_t is small. In this case, $S_t = k_t$ and $H(S_t) = S_t^{\alpha}$.*
- *If $S_t > \frac{\alpha}{\xi\lambda}$, then $T_t > 0$. (If S_t is high enough, then it is worthwhile to invest in TFP.) In this case,*

$$H(S_t) = a_h \frac{(\lambda S_t + 1)^{\alpha+\xi}}{\lambda^{\alpha}},$$

where $a_h \equiv \frac{\xi^{\xi}\alpha^{\alpha}}{(\alpha+\xi)^{\alpha+\xi}}$ depending on (α, ξ).

The function H is increasing in λ when $S > \frac{\alpha}{\xi\lambda}$. The lower the level of diversion, the higher the total output.

Notice that the function $H(S)$ is increasing return to scale and convex for any $S > \alpha/(\xi\lambda)$. This is one way to introduce increasing return to scale technology in growth models (see Romer (1986) for more detailed discussions).

We now show the dynamics of the optimal path. It is easy to see that the optimal path (S_t) is monotonic. We then have the convergence of optimal paths.[6]

Proposition 3 *Assume that* $\beta\alpha^{\alpha}\xi^{1-\alpha}\lambda^{1-\alpha} > 1$ *and* $\alpha + \xi \geq 1$. *Then any optimal sequence* $\{S_t^*\}_t$, *and hence, any optimal sequence of outputs* $\left\{y_t^* = H(S_t^*)\right\}$ *converges to infinity.*[7] *By consequence, there is a date* τ *such that the country invests in TFP from date* τ *on (i.e.,* $T_t > 0\ \forall t \geq \tau$*).*

According to our result, if the utilization of investment in technology (parameter λ) and the quality of the TFP investment technology (parameter ξ) are high, and we have increasing return to scale ($\alpha + \xi \geq 1$) technology, we get growth without bounds.

The rate of growth ($\frac{y_{t+1}^*}{y_t^*} - 1$) is now endogenous. It is obtained by an optimal share between investing in physical capital and investing in HC, technology, management quality, incentive mechanisms. For that reason, we call these types of models endogenous growth models.

The above results (Lemma 1 and Proposition 3) deserve some comments:

- The country will wait until some date τ, when the optimal output generates enough saving $S_\tau > \frac{\alpha}{\xi\lambda}$, before investing in TFP.
- If the diversion of the T_t is high (i.e., λ is low), the country may never invest in TFP and will not have growth.
- If λ is lower (the diversion exists), the date τ becomes larger. The country has to wait longer before starting to invest in TFP.

2.3 TFP and Competitiveness

2.3.1 Competition Between Physical Capital and Financial Asset

The financial market has been considered as one of the main causes of recession or/and fluctuation. But does the financial market always cause a recession in the productive sector? To address this question, let us consider a two-period economy with one consumer, one producer. In period 0, the consumer has a revenue R_0 and consumes c_0 and saves s_0. She wants to invest k_1 in capital stock, ξ_0 in financial

[6] We do not provide a full analysis in this chapter. However, more dynamic properties may be obtained by adopting the method in Kamihigashi and Roy (2007), Bruno et al. (2009).

[7] Proof: If $S < \frac{\alpha}{\xi\lambda}$, then we have $H'(S) = \alpha S^{\alpha-1} > \alpha\left(\frac{\alpha}{\xi\lambda}\right)^{\alpha-1} = \alpha^{\alpha}\xi^{1-\alpha}\lambda^{1-\alpha}$.

If $S > \frac{\alpha}{\xi\lambda}$, then we have

$$H'(S) = a_h(\alpha+\xi)\lambda\frac{(\lambda S_t + 1)^{\alpha+\xi-1}}{\lambda^{\alpha}} > a_h(\alpha+\xi)\lambda\frac{(\lambda\frac{\alpha}{\xi\lambda} + 1)^{\alpha+\xi-1}}{\lambda^{\alpha}} = \alpha^{\alpha}\xi^{1-\alpha}\lambda^{1-\alpha}. \quad (8)$$

Since $\beta\alpha^{\alpha}\xi^{1-\alpha}\lambda^{1-\alpha} > 1$, by applying Proposition 4.6. in Kamihigashi and Roy (2007), we have that every optimal path increasingly converges to infinity.

asset. We suppose the numéraire is the consumption good. Let r_1 denote the return of asset in period 1. The consumer wants to maximize the revenue R_1 in period 1. We have $R_1 = Ak_1^\alpha + r_1\xi_0$, $\alpha \in (0, 1)$. She solves the problem

$$\max_{k_1 \geq 0, \xi_0 \in \mathbb{R}} \{Ak_1^\alpha + r_1\xi_0 : k_1 + \xi_0 = s_0\}.$$

The optimal value ξ_0^* solves the equation

$$A\alpha(s_0 - \xi_0^*)^{\alpha-1} = r_1.$$

It is easy to see that ξ_0^* is a decreasing function of the TFP A (crowding out effect). In particular, when A is very small, the optimal value k_1^* is also very small.

If the consumer anticipates a high value of asset return r_1 (speculation), then she invests in the financial asset (ξ_0^* is close to s_0) and reduces the physical capital (k_1^* is small). Whether people invest more in physical capital or financial assets strongly depends on the TFP of the production sector and the asset return. See Le Van and Pham (2016) for the interaction between the financial market and the production section in an infinite-horizon general equilibrium model.

2.3.2 Competition Between Two Countries

We now investigate the role of TFP in the context of globalization. Assume we have two countries a, b. Country a has the production function $A_a k^\alpha$ and its saving in period 0 is s_0. Country b has the production function $A_b k^\alpha$ and its saving in period 0 is s_0. We assume that $A_a > 0$, $A_b > 0$, and $\alpha \in (0, 1)$.

Each country maximizes its revenue in period 1: $A_a k_{a,1}^\alpha + r_1\xi_{a,0}$, $A_b k_{b,1}^\alpha + r_1\xi_{b,0}$.

The two countries exchange consumption good and financial assets. We investigate the equilibrium, i.e., a list of allocations and price $(k_{a,1}^*, \xi_{a,0}^*, k_{b,1}^*, \xi_{b,0}^*, r_1^*)$ such that:

1. For each $i = a, b$, given r_1^*, the pair $(k_{i,1}^*, \xi_{i,0}^*)$ solves the following problem:

$$\max_{k_1 \geq 0, \xi_0 \in \mathbb{R}} \{A_i k_1^\alpha + r_1^*\xi_0 : k_1 + \xi_0 = s_0\}.$$

2. The financial market clears: $\xi_{a,0}^* + \xi_{b,0}^* = 0$.

We then obtain the equilibrium return r_1^* from these equilibrium relations. The following result shows the impact of TFP on the equilibrium outcomes.

Proposition 4 *If the TFP A_a of country a is smaller than the one of country b, A_b, then at equilibrium we have:*

- $\xi_{a,0}^* > 0$ *(country a buys financial asset), and* $\xi_{b,0}^* = -\xi_{a,0}^* < 0$ *(country b sells financial asset).*

- $k^*_{a,1} < k^*_{b,1}$.
- $c^*_{a,1} = A_a(k^*_{a,1})^\alpha + r^*_1\xi^*_{a,0} < c^*_{b,1} = A_b(k^*_{b,1})^\alpha + r^*_1\xi^*_{b,0}$, *i.e., the consumption of country a is lower than the consumption of country b.*

Our result suggests that the TFP matters in the context of globalization: The higher the TFP, the higher the input quantity used for production and hence the higher the income of the country.

3 Labor Productivity

We consider the following definition of labor productivity:

$$\pi^L \equiv \frac{y}{N},$$

where y is the output and N is the number of workers.

In general, the number of workers can be calculated as follows:

$$N = (1-u)r_p w_a P, \tag{9}$$

where P is the total population, w_a is the proportion of the working age population (often defined as 15–64 year old) to the total population, r_p is the participation rate (in other words, $1 - r_p$ is the fraction of the working age population does not participate in the labor market), and u is the unemployment rate.

We have the following relationship between labor productivity and per capita GDP:

$$\underbrace{\frac{y}{P}}_{\text{GDP per capita}} = (1-u)r_p w_a \underbrace{\frac{y}{N}}_{\text{Labor productivity}}. \tag{10}$$

If w_a, r_p, u are unchanged, then, *by definition*, increasing labor productivity is equivalent to increasing GDP per capita. In reality, however, all factors, including labor productivity and per capita GDP, are inter-dependent. Hence, the very issue is to understand determinants of labor productivity and GDP as well as TFP. To do so, go back to relations (6), (7) with $\beta = 1 - \alpha$. We obtain

$$y_t = A_t k_t^\alpha N_t^{1-\alpha}, \tag{11}$$

$$\text{where the TFP is} \quad A_t = \left[a m_t \zeta_t^\alpha \left(\theta(w_t)h_t\right)^{1-\alpha} \right]. \tag{12}$$

From these relations, we obtain

$$\pi_t^L = \frac{y_t}{N_t} = \left[am_t\zeta_t^{\alpha}\left(\theta(w_t)h_t\right)^{1-\alpha}\right]\left(\frac{k_t}{N_t}\right)^{\alpha}. \tag{13}$$

According to this expression, the labor productivity depends on (1) physical capital per worker k_t/N_t, (2) quality of machines ζ_t, (3) human capital (education, training, health) h_t of workers, (3) quality of management m_t, and (4) incentive mechanism (wages, bonus, for instance).

This observation is consistent with that in Baumol et al. (1989): "Historically, labor productivity growth has been driven by innovation, better education, and investment in physical capital. Innovation and investment by private sector require a growth-friendly environment, with supportive institutions and policies, including policies that promote macroeconomic stability and the rule of law." Here, we contribute by mentioning the role of incentive mechanisms (w) for the short term.

We now look at the connection between labor productivity and economic growth by using a supply side view. Assume that the total output is produced by a Cobb–Douglas production function: $y_t = A_t k_t^{\alpha} N_t^{\beta}$, where $0 < \alpha, \beta < 1$. We then obtain

$$y_t^{1-\beta} = A_t k_t^{\alpha}\left(\frac{N_t}{y_t}\right)^{\beta} = A_t k_t^{\alpha}\left(\pi_t^L\right)^{-\beta}.$$

Hence,

$$\left(\frac{y_{t+1}}{y_t}\right)^{1-\beta} = \frac{A_{t+1}}{A_t}\left(\frac{k_{t+1}}{k_t}\right)^{\alpha}\left(\frac{\pi_{t+1}^L}{\pi_t^L}\right)^{-\beta}.$$

This equation leads to an interesting observation: If the TFP and physical capital remain unchanged ($A_{t+1} = A_t$, $k_{t+1} = k_t$), an increasing of labor productivity ($\pi_{t+1}^L > \pi_t^L$) does decrease the GDP ($y_{t+1} < y_t$). Therefore, we should focus not only on labor productivity but also on TFP and physical capital.

4 Conclusion

We have presented several models showing how productivity matters for economic growth. However, economic growth is not an outcome of a single factor but several factors. Moreover, many factors, for instance, TFP and labor productivity, are not separable. Focusing only on one indicator may be misleading. It is important to find an optimal share between the purchases of machines with new technology, the expenditures for training, education, and the wage policy (in the labor market). In this regard, we cannot say that labor productivity (respectively, capital productivity) is crucial for growth. A good combination of both of them is crucial for economic growth.

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Productivity Spillovers from Export Destinations to Domestic Firms: A Networks Analysis

Steven A. Kauffman and Van Pham-Hoang

Abstract An economy can gain productive knowledge through exporting. How much is gained could vary by export destination. Once the information is infused in the economy, that knowledge can spillover to other domestic firms. Using data from the small and medium enterprise surveys for Vietnam, we construct networks based on industry and geography and calculate alpha centrality for each firm. Alpha centrality as a network measure captures both the effect of the external influence, information from the export market, and the centrality of firms within the network. Exporting to Japan and the U.S.A.—or being close to firms that do—results in robust productivity gains, while exporting to the E.U., China, and ASEAN countries does not.

Keywords Export destinations · Networks · Spillovers · Vietnam

JEL Codes

1 Introduction

Since Solow (1956) and Solow (1957), it has been widely recognized that sustained economic growth can come only from sustained technology or productivity gains (see for example Le Van and Pham (2022) and Tung and Wan, Jr. (2022) in this volume). Research and development attempt to discover new technologies, but this expensive activity is undertaken almost exclusively in industrialized countries. In developing countries, firms can achieve productivity gains in two possible ways. First, productive knowledge can come about as an information externality through

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activities such as international trade, foreign direct investment, labor movements, and education where workers, managers, engineers come in contact with the outside world. Second, firms can gain productive knowledge from other domestic firms through some connection facilitated by sector similarity or geographic proximity.

In this chapter, we study exports, specifically export destination, as a channel through which local firms can gain productivity. For small and medium enterprises in Vietnam, we find that exporting to Japan has a robust positive effect on a firm's productivity and being located closer to firms that export to Japan also increases firms' productivity. We also find a similar positive effect of exporting to the U.S.A. and locating close to firms that export to the U.S.A. Exporting to the E.U., China, or ASEAN does not have a significant effect on productivity in our sample.

Since the seminal papers by Aitken and Harrison (1999) and Javorcik (2004) on foreign direct investment (FDI), much work has looked for the presence of spillovers. These papers attribute to an industry a certain level of productive knowledge infusion from FDI presence in the industry and then ask whether firms that are in an industry or sell to or buy from an industry experience productivity growth that is associated with the level of FDI in an industry. While we explore a similar mechanism of productivity spillovers across firms, we take an explicitly network theoretic approach. We construct networks of firms whose connections are based on industry classifications or based on both industry and geography. From this networks formulation, we calculate firms' alpha centrality that is a network measure that incorporates both the effect of the external influence—information from the export market—and the spillovers across firms within the network.

Our paper is related to a literature exploring the effects of different foreign partners on productivity and growth. Some of these papers study different sources of FDI. Using a propensity score matching strategy, Kamal (2015) found that the total factor productivity in Chinese firms with investors from OECD countries was higher than that in firms with foreign investors from Hong Kong, Macau, and Taiwan by 11.7% in year two after investment and by 27.8% in year three; labor productivity was 16.5% higher in year two and 25.1% in year three. Javorcik and Spatareanu (2011) also found differences in productivity spillovers in Romania by origin of the investing firms. There were positive spillovers of FDI of firms from the Americas in downstream industries to upstream domestic firms. No such spillovers existed when the investors came from Europe or from Asia.

A number of papers explored how productivity gains by the firm can be affected by export destination. Ketterer (2017) studied Lithuanian firms, Reggiani and Shevtsova (2018) studied Ukrainian firms while Vacek (2010) studied Czech firms. These papers, however, did not study the spillover to other firms in the economy. We are also not aware of other papers that use a networks framework to study spillovers from export or FDI. To our knowledge, our paper is also the first to use alpha centrality as a network measure that combines spillovers and external influence together.

The remainder of this chapter is organized as follows. In the next section, we present the networks framework used in our analysis, and Sect. 3 describes the data and estimation strategy. Section 4 presents the results and Sect. 5 concludes.

2 A Networks Framework to Study the Diffusion of Information from Export Destinations

Information sharing and learning occur by interactions across firms. The notions of "horizontal linkages" (Aitken and Harrison, 1999) and "vertical linkages" (Javorcik, 2004) have been commonly used to study these inter-firm spillovers. The idea behind these linkage measures is of one firm being connected to an aggregate entity such as an industry. For example, a horizontal linkage envisions a connection between a firm and an aggregate of all firms in the same industry. A backward linkage captures the connection between a firm and an aggregate of a weighted average of industries the firm sells to, while a forward linkage is an analogous concept for an aggregate of the industries that sells to the firm. An alternative formulation, which we apply in this chapter, is to explicitly model the interaction of firms in a network where each firm-to-firm connection can be included into measures that might affect the flow of information.

A simple network shown in Fig. 1 illustrates the idea behind the analysis in this chapter. Domestic firms are shown as nodes labeled A, B, C, D. The interactions between two firms are represented as edges. In the figure, these edges are two-way arrows suggesting the general case when information or influence is directed and flows in both directions. The strength of an interaction is usually represented by a numerical value attached to an edge. Figure 1 also shows a representation of domestic firms' interactions with the outside world. Nodes outside the dotted enclosure can represent export destinations, import or foreign investor sources, or any other sources of production knowledge external to the country. In this chapter, we consider export markets as the source of productive information and proceed with the discussion for this context.

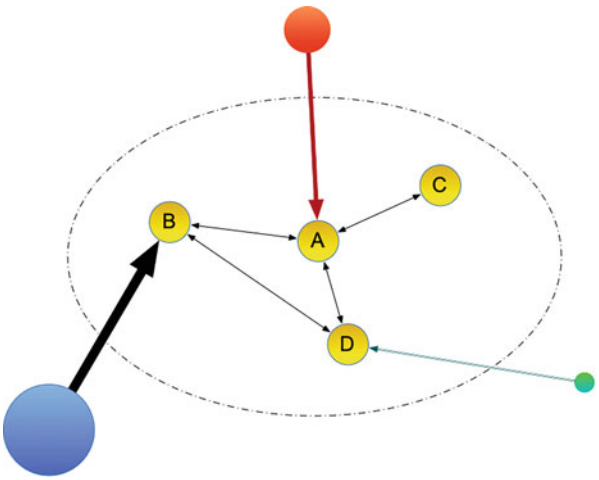

Fig. 1 Knowledge from abroad and spillovers though domestic networks

Assuming productive knowledge is potentially acquired from a firm's exporting activities, firm B is shown to export to a destination with the most productive knowledge represented by the largest size node, firm A exports to a destination with less productive knowledge, firm D exports to a destination with even less knowledge, and firm C does not export at all. While firm C does not have direct access to information from an export market, it is connected to firm A that does export and hence could indirectly benefit from firm A's information source. Similarly, firm D could benefit from firm A's and firm B's exporting activities. By this mechanism, firm A has an important role in the transmission of information because of its central location in the network, and hence, firms connected to firm A will also benefit.

2.1 Defining a Network

How we define a network depends on the channels through which we think information can flow. If information is industry-specific and flows across firms within the same industry, then the connection between two nodes exists if the two firms belong to the same industry. For example, an electronics firm could acquire knowledge of a better design by observing a rival firm selling to the same export market. That knowledge might spillover to other domestic firms in the electronics industry but might have little benefit to a textile firm. In this formulation, a firm that is 10 kilometers away from an exporter will receive the same benefit as a firm 1000 kilometers away as long as all three are in the same industry.

Alternatively, we could define a network based solely on geography. Here, the idea is that firms that are closer to exporters should have higher productivity than those that are farther away. Implicit in this setup is that the information is not industry-specific and its transfer is facilitated by geographical proximity. For example, exporting electronics to a particular market reveals general information about quality demands and quality control that could be of value to an apparel manufacturing firm, and the information is transferred by networks of managers socializing in the same district. One definition of this geographical network would be if two firms operate in the same district, the edge connecting them has a strength of 1. If two firms are located in different districts, the strength of the connection is the reciprocal of the distance between the two districts. The farther apart the districts are, the weaker the connection between firms and the smaller the spillover.

A third network formulation can be defined by both geography and industry. The knowledge is industry-specific and can be transferred across firms in the same industry, but the strength of the spillover decays with geographical distance. In this formulation, a firm will only be connected to other firms in the same industry. The weight of these connections is 1 if the two firms are in the same district and equal to the reciprocal of the distance in kilometers between the districts if they are located in different districts.

2.2 Network Measures

A firm's position in a network can determine how much information can flow to the firm. For example, in Fig. 1, firm A and firm B are likely to acquire more productive knowledge than firm C because the latter is less "central" in the network or less "close" to firms in the network. A number of candidate network measures quantify these ideas. A very simple measure is the *closeness* of a node that counts the average number of steps it takes to reach other nodes. Another even simpler measure called *degree centrality* counts the number of nodes that is connected to a node. If the edges are weighted, then *weighted degree centrality* sums the weights of each edge connected to a node.

Degree centrality's appeal is its simplicity, but by merely counting the number of connections a node has, the measure ignores potentially important information in the characteristics of the connected nodes. For example, a firm connected to one very central firm might accumulate more information than a firm connected to many less central firms. A class of "self-referential" measures defines a node's centrality based on the centrality of other proximate nodes in the network. One often used measure is *eigenvector centrality* defined as (see Bonacich, 1987)

$$\lambda e_i = \sum_{j \neq i} a_{ij} e_j,$$

where e_i is the eigenvector centrality of node i, a_{ij} is the weight of the edge connecting node i to node j, and λ is a constant. If the network is undirected, that is connections between two nodes do not have direction, $a_{ij} = a_{ji}$. This says that a node's eigenvector centrality is proportional to a weighted sum of the other nodes' eigenvector centrality. Because this measure is self-referential, the values for all nodes must be calculated (solved for) simultaneously. In matrix form this is written as

$$\lambda \mathbf{e} = \mathbf{A}\mathbf{e}, \tag{1}$$

where $\mathbf{e}$ is a column vector of eigenvector centralities for each node in the network and $\mathbf{A}$ is the network's *adjacency matrix* the elements of which are the a_{ij} denoting the weight of the connection from node i to node j. If there are n nodes in the network, then the n λ values solving equation (1) are the eigenvalues of the adjacency matrix $\mathbf{A}$ and the n $\mathbf{e}$ are the associated eigenvectors. To guarantee positive values, we typically choose the largest value λ to calculate the eigenvector centralities $\mathbf{e}$.

Eigenvector centrality incorporates both the number of connections a node has and the importance of the nodes that it is connected to. This measure of a node's internal importance should reflect the spillover of information across nodes within the network. It does not, however, reflect influence from outside the network, which in this chapter is the productive knowledge that could come from the destinations

the firms export to. *Alpha centrality* is an extension of eigenvector centrality that is appropriate for settings where there are both external and internal influences on a node (see Bonacich and Lloyd, 2001). Alpha centrality is defined as follows:

$$x_i = \alpha * \sum_{j \neq i} a_{ij} x_j + u_i,$$

where x_i is the alpha centrality of node i, u_i is the value of the external influence on node i, and $\alpha \in [0, 1]$ is a parameter representing the importance of the internal network influence relative to the external influence. In this chapter, the external influence comes from the exporting activity; u_i takes a value of 1 if firm i exports to a destination in question and zero otherwise. In matrix notation,

$$\mathbf{x} = \alpha \mathbf{A}\mathbf{x} + \mathbf{u},$$

where $\mathbf{x}$ is the column vector of alpha centralities of the n nodes, and $\mathbf{u}$ is a vector of external influences. We can rearrange to solve for the alpha centralities, where $\mathbf{I}$ is an $n \times n$ identity matrix:

$$\mathbf{x} = (\mathbf{I} - \alpha \mathbf{A})^{-1} \mathbf{u}.$$

3 Data and Methodology

This chapter uses data from the small and medium enterprises surveys in Vietnam conducted by the Central Institute for Economic Management, the Institute of Labour Science and Social Affairs of the Ministry of Labour, Invalids and Social Affairs, and the Development Economics Research Group of the University of Copenhagen. Each survey covers roughly 2500 small and medium enterprises in 10 provinces: Ha Noi, Ha Tay, Hai Phong, Ho Chi Minh City, Khanh Hoa, Lam Dong, Long An, Nghe An, Phu Tho and Quang Nam. We use data from 2004, 2006, and 2008. After matching the firm's identification numbers and opening dates across surveys, there are a total of 5054 observations. We calculate investment assuming a depreciation rate of 10%. Dropping firms that have no employees and no capital stock as well as any firms that have a negative investment leaves 1397 observations. Figure 2 shows a geographical distribution of the firms in the study.

The surveys include data on a firm's location and industry. We analyze two types of networks in this chapter. For the industry-based networks, if two firms are in the same ISIC two-digit industry, then the nodes representing the firms are connected by an edge with weight 1. The nodes are not connected otherwise. A second network representation is defined by both geography and industry. A firm will only be connected to other firms in the same industry. The weight of these connections is 1 if the two firms are in the same district and equal to the reciprocal of the distance in kilometers between the districts if they are located in different

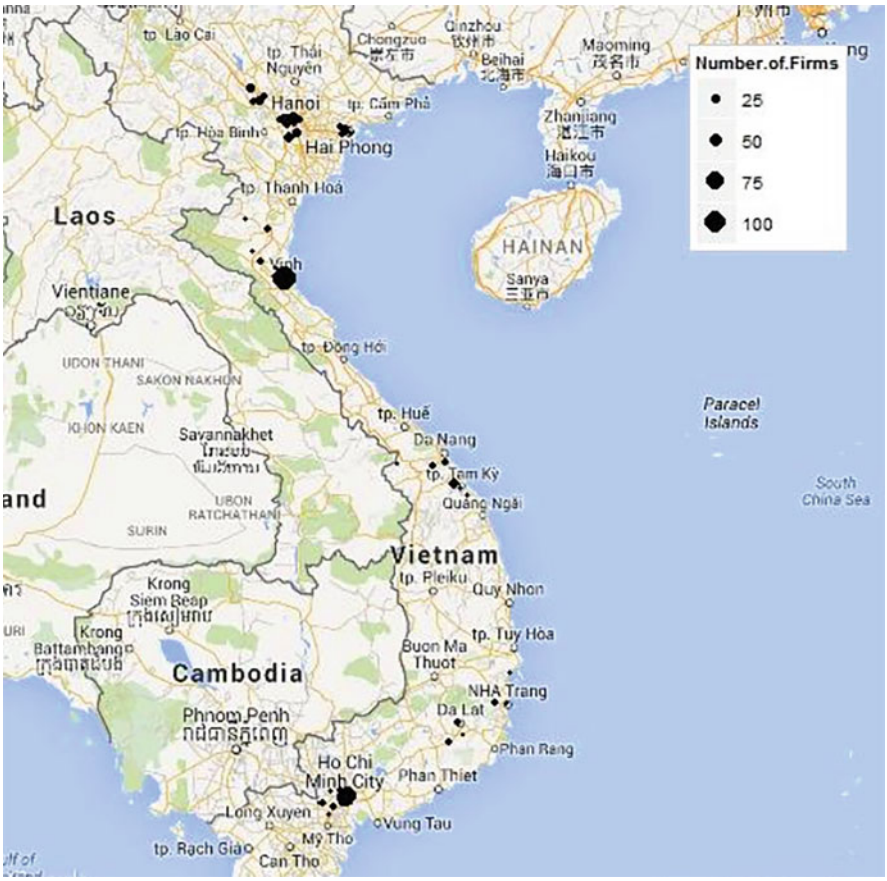

Fig. 2 Locations of small and medium enterprises

districts. From these network definitions, we can calculate the network measures such as eigenvector centrality. We calculate alpha centrality for each firm separately for each export destination. An indicator variable is equal to 1 if a firm exports any positive amount to the country in question. We calculate alpha centrality for each firm for exports to China, Japan, ASEAN countries, the European Union, and the U.S.A.

Since a firm's alpha centrality captures both the effect of the productive knowledge from an export destination and the spillover of that knowledge within the network, we estimate the effect of a firm's alpha centrality on firm productivity. To estimate firm productivity, we first estimate a firm-level production function. Assuming a Cobb–Douglas form production function and taking logs,

$$\log Y_{it} = \beta_0 + \beta_K \log K_{it} + \beta_L \log L_{it} + \beta_M \log M_{it} + \mu_{it}, \tag{2}$$

where Y_{it} is the output of firm i in year t, L is the number of employees, M is the raw materials used, K is the capital, and μ is an error term that will include firm-level productivity. The log of firm's total factor productivity ($\log TFP$) is calculated as the residual to this estimation. It is well documented that estimating a firm-level production function using ordinary least squares (OLS) can be biased because the error term is potentially not orthogonal to the other regressors, in particular, capital. Firms that are more productive are likely to be the firms that get more investment. Hence, OLS estimation of equation (2) will attribute too much output to capital and not enough to TFP. We use the methodology introduced by Olley and Pakes (1996) to estimate the production function from which to calculate TFP. This methodology requires the age of the firm that is available in the data.

Finally, we estimate the effect of alpha centrality on a firm's TFP in the following:

$$\log TFP_{it} = \alpha_0 + \alpha_x x_{it} + \alpha_a a_{it} + \text{Fixed Effects} + v_{it}, \tag{3}$$

where a_{it} is the age of the firm, x_{it} is the alpha centrality, and v_{it} is an error term assumed independently identically distributed normal. The regressions include two-digit industry, district, and year fixed effects.

4 Results

To see if information does indeed flow through our definition of a network and associated with our network centrality measure, we first conduct a simple test. In the SME survey conducted in 2009, firm managers are asked if they are aware of the Agency for Small and Medium Enterprise Development, or ASMED. This is a government agency that helps coordinate policies to support SMEs. It has a website containing information on the appropriate licenses and permits required to operate a business, how to acquire financing, information for submitting tax forms, as well as contact information for other SME support institutions. It is likely that if someone knows about this program, they are likely to tell others about it, such as neighbors, friends, and family members. If information does flow through our defined network, then firms with a higher centrality should have a higher probability of knowing about this program.

This hypothesis can be tested by running a probit regression of knowledge of ASMED as the outcome with a firm's centrality as a regressor. A firm's eigenvector centrality is calculated using the geographical network. It does not make sense to include industry in the network as knowledge about ASMED could be used by construction firms as easily as textile firms. A number of covariates are also included in the probit. Table 1 reports the result of this regression. The coefficient on the centrality measure is positive and significant in each of the three specifications that can include controls for age of the firms and the number of employees. Firms that are more central are more likely to know about ASMED. This is important because

Table 1 Does information flow through a network?

	(I)	(II)	(III)
Eigenvector centrality	0.82**	0.77*	0.74*
	(2.71)	(2.43)	(2.27)
The number of employees		0.0082***	0.0080***
		(7.60)	(7.41)
Age			−0.019**
			(−3.02)
Observations	2232	2232	2232

Probit regressions with a dependent variable dummy = 1 if manager is aware of the Agency for Small and Medium Enterprise Development
Eigenvector centrality defined on network based on geography
Regressions include province fixed effect
t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2 Spillovers from exports: Network defined by industry

	$\alpha = 0$	$\alpha = 0.1$	$\alpha = 0.2$	$\alpha = 0.3$	$\alpha = 0.4$	$\alpha = 0.5$
Export anywhere	0.088**	0.043	0.036	0.040	0.041	0.042
	(3.11)	(1.50)	(1.33)	(1.47)	(1.54)	(1.56)
Export to ASEAN	0.037	0.008	0.016	0.023	0.026	0.028
	(1.31)	(0.30)	(0.58)	(0.84)	(0.97)	(1.04)
Export to China	0.045	0.047	0.018	0.006	0.003	0.002
	(1.72)	(1.71)	(0.63)	(0.20)	(0.10)	(0.08)
Export to E.U.	0.049	0.047	0.018	0.015	0.015	0.015
	(1.81)	(1.58)	(0.64)	(0.53)	(0.52)	(0.53)
Export to Japan	0.068*	0.070*	0.040	0.031	0.030	0.029
	(2.57)	(2.51)	(1.41)	(1.11)	(1.06)	(1.04)
Export to U.S.A.	0.033	0.041	0.028	0.028	0.028	0.028
	(1.23)	(1.42)	(0.98)	(0.99)	(1.00)	(1.00)
Observations	1291	1291	1291	1291	1291	1291

Dependent variable is log(TFP)
Each cell is a separate regression reporting coefficient of firm's alpha centrality in a network with industry links
All regressions include age of firm, and district, industry, year fixed effects
t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

it supports the idea that information and knowledge can flow from firm to firm and the centrality measure is associated with the flow of information.

Table 2 shows results of the diffusion model of networks based on industry. Each cell in the table shows the coefficient estimate and t-statistic on the alpha centrality variable for different values of alpha ranging from 0.1 to 0.5 and different export destinations. Recall that alpha represents the importance of the spillover across firms within the network relative to the direct effect of exporting. Alpha equal to 0.5 means that the direct effect of exporting is assumed to be twice as much as

Table 3 Spillovers from exports: Network defined by industry and geography

	$\alpha = 0$	$\alpha = 0.1$	$\alpha = 0.2$	$\alpha = 0.3$	$\alpha = 0.4$	$\alpha = 0.5$
Export anywhere	0.088**	0.101***	0.119***	0.122***	0.108***	0.099***
	(3.11)	(3.53)	(4.12)	(4.24)	(3.78)	(3.46)
Export to ASEAN	0.037	0.034	0.031	0.028	0.027	0.022
	(1.31)	(1.21)	(1.09)	(0.97)	(0.94)	(0.76)
Export to China	0.045	0.043	0.041	0.039	0.037	0.035
	(1.72)	(1.66)	(1.58)	(1.51)	(1.43)	(1.34)
Export to E.U.	0.049	0.048	0.046	0.045	0.042	0.038
	(1.81)	(1.77)	(1.71)	(1.64)	(1.55)	(1.38)
Export to Japan	0.068*	0.076**	0.086**	0.097***	0.093***	0.084**
	(2.57)	(2.86)	(3.21)	(3.60)	(3.46)	(3.13)
Export to U.S.A.	0.033	0.047	0.071**	0.068*	0.056*	0.050
	(1.23)	(1.77)	(2.63)	(2.49)	(2.05)	(1.82)
Observations	1291	1291	1291	1291	1291	1291

Dependent variable is log(TFP)
Each cell is a separate regression reporting coefficient of firm's alpha centrality in a network with geography–industry links
All regressions include age of firm, and district, industry, year fixed effects
t-statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

the internal network effect; alpha of 0.2 means the direct exporting effect is five times the internal network effect. For the industry-based networks, in none of the regressions do we find a significant effect of alpha centrality on firm TFP. To the extent that productive knowledge is gained from exporting, it is not passing to other firms in the same industry. Our results are consistent with studies that do not find horizontal spillovers from FDI (see for example Javorcik, 2004).

Table 3 shows results from the model where networks are based on both geography and industry. This formulation assumes that information flows to firms in the same industry, but the information attenuates with geographic distance. The effect of alpha centrality with exporting anywhere as the external influence is positive and significant for all levels of alpha from 0.1 to 0.5. Interestingly, this effect seems to be coming almost entirely from exporting to Japan. Alpha centrality has a positive and significant effect for all levels of alpha when exporting to Japan is the external influence. Point estimates on this effect are only slightly smaller than the export anywhere regressions. When exporting to the U.S.A. is the external influence, the effect of alpha centrality on productivity is positive and significant when alpha takes values of 0.2, 0.3, and 0.4. Alpha centrality based on exporting to ASEAN does not have an effect on productivity. The same is true for exporting to the E.U. This last result is surprising in light of the positive results for Japan and the U.S.A. The E.U. and the U.S.A. (and even Japan) as export markets are arguably more similar than they are different vis-a-vis a country like Vietnam. Our results here warrant further investigation for an explanation.

Finally, exporting to China as the external influence shows no significant effect on productivity for any level of alpha in any network. Alternatively, regressions with a dummy variable for exporting to China in place of alpha centrality also show no significant effect on productivity. Vietnamese firms do not seem to be getting any productive knowledge externality by exporting to China. This is consistent with the results found by Baliamoune-Lutz (2011) for exports of African countries to China.

5 Conclusion

In this chapter, we analyzed the effect of exporting on the productivity of small and medium enterprises in Vietnam. We hypothesize that the stock of useful productive knowledge varies by export market. A firm can gain productive knowledge either by directly exporting to a market or can acquire information indirectly from other domestic firms in the economy that directly export or which also acquired information indirectly from other domestic firms. We estimate the effect of this mechanism through an explicitly network theoretic framework. We construct networks with firms as nodes and edge connections based on industry classifications or based on both industry and geography. We find that exporting to Japan has a robust positive effect on a firm's productivity and being located closer to firms that export to Japan also increases firms' productivity. We also find a similar positive effect of exporting to the U.S.A. and locating close to firms that export to the U.S.A. Exporting to the E.U., China, or ASEAN does not have a significant effect on productivity.

Our results warrant further exploration, with different datasets and alternative estimation strategies. But at face value, the implication is that trading partners matter because of the effects on productivity and thus long-run growth. The network spillover effects also suggest benefits to clustering of firms around firms that export to favorable destinations.

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Lessons from East Asian Growth: Innovation Matters

An-Chi Tung and Henry Wan

Abstract *Growing fast as PRC* is desired throughout the developing world. But PRC's growth was neither predicted *ex ante* nor explained *ex post* in most theories of economic growth or trade. Left alone in the policy forum, development economists often comment and make comparison with their own economies, for example, Basu and Binh for India and Vietnam. We augment Basu's discussions to apply as far as possible by comparing with East Asian economies over per capita GDP, back to 1950 or into history, gaining novel perspective.

PRC's trajectory is often not replicable: lacking market size to bargain like China, on terms about high-speed rail, for Vietnam; hard to reform with TVEs, under current parliamentary institutions, for India.

Studying other East Asian economies with fast growth allows us to ask how much Chinese growth depends on Hong Kong and Taiwan (while India could not, on Goa)? Would PRC's growth peak out soon? Is China closing in on Korea, like Korea on Japan? Must India forswear its parliamentary democracy for a Chinese trajectory, rather than a Korean or a Japanese one?

We emphasize that innovation, more than imitation, is the root for GDP growth. It is necessary for leapfrogging or graduating from being underdeveloped.

Keywords Innovation · Intra-East Asia interactions · Growth of PRC and prewar China · India · Market orientation · East Asian growth

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1 Introduction

Currently, *growing fast like China* appears to be the aspiration of many economies, by many economists, with key principles for actionable programs. Such a stance should be universally applauded. It is far superior, for example, to attempt to contain Chinese growth by a new cold war for "geopolitical rebalance" that would not only slow down global growth, but also be detrimental to the developing economies.[1]

China has both served as the world's workplace and leading trader, and achieved fast growth with poverty reduction in recent decades. Such accomplishments were neither predicted *ex ante* nor focused for explanation *ex post,* in most mainstream theories of trade and growth, where the positions of the United States at the end of WWII are assumed as permanent in all aspects, perhaps for analytic convenience. Left rather alone in the policy forum, leading development economists focused their researches on specific issues, typically on their own homelands. There are two salient examples: one is on India, a country with a similar population size of China, by Professor Kaushik Basu[2] (Basu, 2009, 2019; Mukherjee, 2020); the other is on Vietnam, a country with institutions similar to China and betted on for fast future growth in Basu (2021), by Professor Binh Tran-Nam (Binh, 2003; Le & Binh, 2018), whose achievements this volume is to celebrate.

The fact that these two countries differ in both size and institution illustrates the need for the augmented analysis proposed here. Such a study extends Basu's researches in three dimensions: target for comparison, type of data, and period of coverage. To be more specific, Basu's studies focused on India vis-à-vis PRC in total GDP comparison over the last four decades, whereas this study looks into all high-growth East Asian economies, mainly in the postwar period, but also back into history. Hopefully, the results are useful for many developing economies in the present world.

These comparisons allow us to get a deeper understanding of how a latecomer catches up and leapfrogs the leaders. As examples, we can ask how much the growth of PRC depends on Hong Kong and Taiwan (whereas India could not depend on Goa)? Would PRC's growth peak out soon? Is China closing in on Korea, like Korea on Japan? Must India forswear its parliamentary democracy for a Chinese, rather than a Korean or a Japanese, trajectory with even higher per capita growth? And what might be the range of viable option for Vietnam, without the mass population of China?

[1] For a statement with a somewhat similar sentiment, one might refer to the comment of TSMC founder Morris Chang, on the likelihood of the "chip war." He said that chips that are vital to national security should be made domestically, but "all the other civilian-use semiconductors should be traded freely internationally." Moreover, for nations seeking to bring chip production onshore, he added, "What may happen is that after hundreds of billions and many years have been spent, the result will still be a not-quite-self-sufficient and high-cost supply chain" (Cheng & Li, 2021a).

[2] Professor Basu has served as the president of the International Economic Association, chief economist of World Bank, and chief economic adviser to the Government of India.

It turns out, for the last question, size is not as important as one would think, considering the cases of many European countries or Israel. Once an economy is sufficiently innovative, international cooperation and cross-border division of labor can resolve most issues of scale.

Due to space constraints, we do not review the grand history of catching up, but will highlight historical facts and theoretical arguments most potent to real-world development. Section 2 reviews briefly a few key concepts relevant to East Asia's growth, such as innovation and learning-by-doing. Section 3 studies the high growth of China since the late 1970s and why its success may not always be a model for others to follow. Section 4 presents the records of Japan since over 1000 years ago, illustrating how a technology latecomer rose to world excellence by innovation, not just imitation. Section 5 turns to Korea and Taiwan, demonstrating how growth is path-dependent, and what alternative an economy can take under financial stringency, a typical conundrum for the developing world. Section 6 concludes the chapter with some comments on how East Asian growth records may benefit the development of India, in particular, and other developing economies, in general. Finally, an epilogue is appended in the back to offer further thoughts on the innovation as the source of economic growth.

2 Theoretic Implications

We shall review the concepts of a number of recurring themes in East Asian development. To begin with, the teachings of Solow (1957, 2007) ascertained that the main source of growth is technology advance, which come from a birth-and-death process called "creative destruction." As implied by Schumpeter (1911), the Darwinian market competition selects entrepreneurs to unleash major innovations in organization, then benefits society by its successes spread through imitation, while former winners might be undermined and swept away.

Since major innovations do not take place regularly or frequently, learning-by-doing provides an engine of long-run growth as productivity may increase with the learning curve.[3] The literature was started by Arrow and Arrow (1950), Arrow (1962), and Alchian (1950, 1963), who all focus on a single product or sector.[4] In the developmental context, Clemhout and Wan (1970) introduced the multisector model structure to the literature. This is convenient both to analyze aspects of trade between two or more goods for *home and abroad* and to promote the role of strategic intent regarding *now and future*, where the dynamics for development is path-dependent.

[3] For a discussion of learning-by-doing, see Stiglitz and Greenwald (2014), with comments of Arrow, Solow and others.

[4] Scott-Kemmis and Bell (2010) questioned the accuracy of the learning-curve formulation of Alchian or Arrow relative to the facts of war production in WWII. They pointed out that a host of other factors were also involved, for instance, various forms of active engineering and technical changes.

Neither innovation nor learning-by-doing takes place by itself, but requires "strategic intent" at firm level or macro level. Firms with strategic intent usually set stretch targets, which force them to compete in innovative ways (Hamel & Prahalad, 1989).[5] Without strategic intent, success can hardly be expected (which will be commented on in the last section). Yet sufficiency for success calls for much more: information, persistent and effective effort, as well as luck (which might favor only one among all equal rivals). In addition, at the societal level, good institutions would help to ensure that there are enough incentives.[6]

One important mechanism to get innovation or learning-by-doing going continuously is the market competition, where only the excellent wins (Schumpeter, 1911). Excellence is often achieved through concentration and specialization for building up comparative advantages. This explains why competing in global market through export usually stimulates growth, and import substitution may, at times, be against the interest in development.

To be pertinent over the complexities and dynamics in real life, we follow the approach in Dertouzos et al. (1989), seeking out a profile of evidence for policy reference. This approach resembles the case method often applied in law school, medical profession, defense studies, or business training. We shall go through a sequence of selected examples about how sector-specific strengths stacked up.

3 China's Recent Economic Rise

We begin by reviewing China's remarkable economic success in recent decades by comparing with other East Asian economies. Then, we look into the source of its growth momentum and influences from Taiwan and Hong Kong. Although the Chinese experience is a gigantic success, five specific examples show that it may not always be copied lightly by others, and whether the growth momentum will continue in the coming decades is not yet certain.

[5] Hamel and Prahalad (1989) found that Japanese corporations leverage resources by accelerating the pace of organizational learning and try to attain seemingly impossible goals, whereas Western companies often focus on trimming their ambitions to match resources. However, one should bear in mind that firms with strategic goals are not limited to those from Japan. For example, it was in 2007 that Apple launched iPhone, which had not been visualized by anyone else, but revolutionized the smartphone industry by turning a handset into a computer.

[6] The patent system is a two-edged sword. Here is an example. Without it, Watt might stay as a Scottish surveyor—no steam engine of any type; with the system, Watt would abuse it with minor inventions forever, to complicate the life of Trevithick—delaying the arrival of any steam locomotive. Wise parliament finally refused to renew Watt's patent, and steam locomotives soon appeared (see Wan 2006, p. 11–15).

3.1 Growth Records

The PRC has enjoyed high and continuous growth in recent decades. By 1960, its GDP per capita was only US$89.5, rising to $195 in 1980, $959 in 2000, and $10,500 in 2020. To put this rapid rise in perspective, Fig. 1 compares China with the United States (the technology leader), three early latecomers (Japan, Korea, Taiwan), and two other late latecomers (Vietnam and India) using data from World Bank's World Development Indicators.

In the upper panel of Fig. 1, GDP per capita in USD of the United States and six Asian economies are juxtaposed in log scale.[7] The growth of China is impressive when compared with India, whose growth rate in the last two decades was already not bad. But when compared with Japan, Korea, and Taiwan, China's boom is clearly not unprecedented and is paralleled by Vietnam after the Doi Moi reform in 1986, with a much lower start regarding income level.

In the lower panel of Fig. 1, we focus on the latecomers, with their growth rate listed by decade average. There appears a very rough "Flying Geese" pattern among the countries (Tung, 2003; Ozawa, 2011): Japan is the first one to have high growth, followed by Korea and Taiwan, then Vietnam and China. The graph suggests that an economy may eventually decelerate after a major growth spurt when it gets closer to the technology frontier.

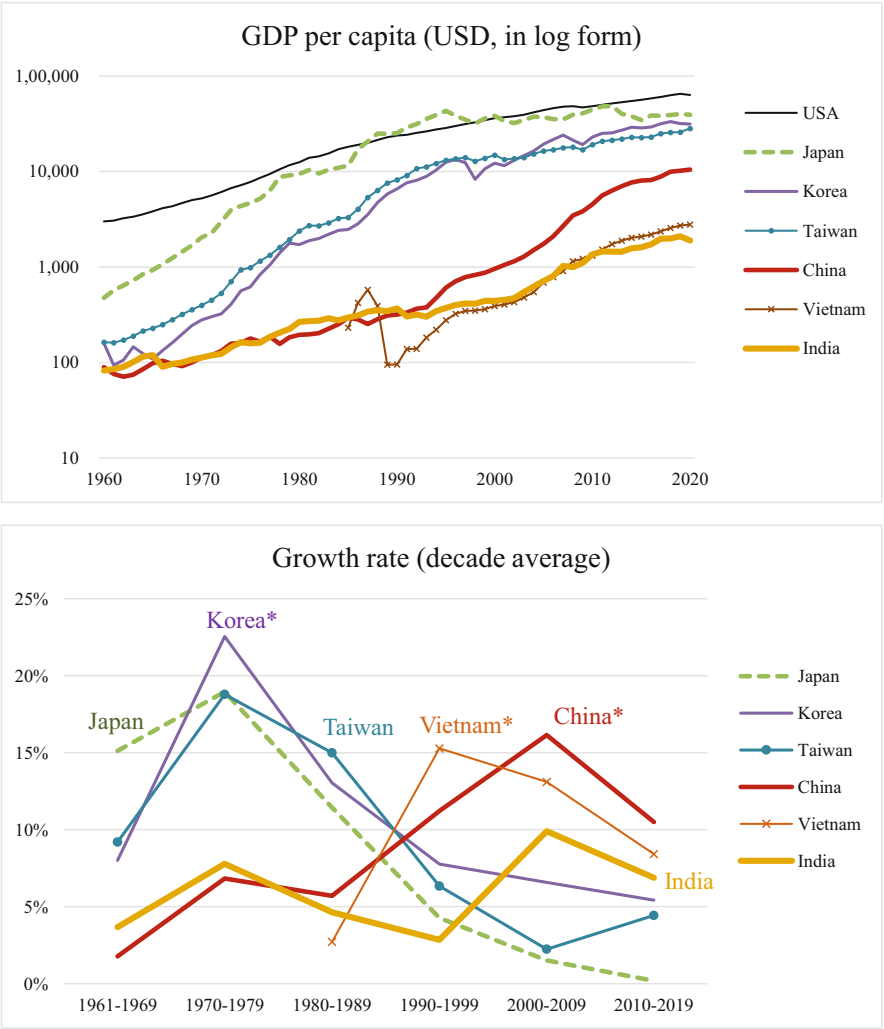
From these observations,[8] we might ask an often-asked question: will China, Vietnam and India grow out of the middle-income trap soon? For China, it is quite likely to become a high-income economy in a few years, even with somewhat reduced growth momentum, since its GDP per capita at $10,500 in 2020 is not so far from the threshold of "high-income economies" set by the World Bank ($12,696 in 2021). As for Vietnam and India, with GDP per capita at $2786 and $1901 in 2020, respectively, both need to grow into an "upper-middle income country" ($4096–$12,695) first.

What remains to be observed is how soon China and other late latecomers will catch up with their predecessors. In 2019, the per capita income of China was about 1/3 of Korea's. For Korea, it was in 1996 that its income ratio to Japan was about 1/3, in 2019 the ratio rose to almost 80%, and is predicted to rise above 1 within a decade (e.g., Basu, 2021). Whether it will also take two or three decades for China to close in to Korea like Korea did to Japan shall depend on how China would continue to move up the product ladder.

In this and the following sections, the issues to explore are how China achieved its remarkable growth record in the past and what lessons to obtain from its once rapid-growing East Asian neighbors.

[7] The per capita income is expressed in USD rather than in local currency, then that growth rate includes the impact of exchange rate changes, along with other internal and external shocks.

[8] For all economies, the 2020 figures are affected by the Covid-19 and US–China trade war. The persistent effect of neither shock is analyzed here.



* If a listed country reaches its peak and tops all listed in the same decade, a star is attached to its name

** For Vietnam, the statistics start from 1986

Data source: World Bank and Directorate-General of Budget, Accounting and Statistics, Taiwan

Fig. 1 Comparison of GDP per capita

3.2 Partial Liberalization with Special Economic Zones

We now compare the growth experience of PRC since its opening up in the late 1970s to the historical records of Japan and Korea. One common feature is the crucial role of trade. By imports, foreign technology ignites the domestic fervor for emulation; by export, domestic production sustains the continued expansion and meets competition from the world.

Slightly before China opened up to the outside world, by 1972–1973, Premier Zhou Enlai had already been amazed about how Taiwan could export almost as much as Mainland China. From the information collected, he found that Taiwan had set up a Kaohsiung Export Processing Zone (KEPZ), almost like the free port of Hong Kong, then under the British rule, which successfully attracted foreign investment for export processing. He shared his appreciation of this idea when meeting with Australian Prime Minister Gough Whitlam and with American banker David Rockefeller (Chen, 2008).

However, the replication of such a scheme in PRC was delayed until after the passing of both Zhou and Chairman Mao due mainly to left-wing ideology in the Cultural Revolution. In 1979, Deng Xiaoping delegated Xi Zhongxun, the Party Secretary of Guangdong Province (also the father of Xi Jinping), with full discretion (but no subsidies from the central government), "to hack out a bloody path, if needed" (Chen, 2008). This led to the creation of a series of Special Economic Zones (SEZs),[9] which are a sort of partial liberalization with the advantage of flexible application varying in time or space. Shenzhen is the most salient example (Tung & Wan 2014, 2019).

3.3 Influences from Taiwan and Hong Kong

The growth of PRC depends on Hong Kong and Taiwan in two aspects: institution transplantation and massive input flows.[10] This is quite unique, considering that India did not get similar resources from Goa, a Portuguese colony until 1961.

[9] In China, although job creation was the initial purpose of the SEZs, technology transfer became a more important objective, like the Meiji Japan explained by Uchida (1990). Ultimately, under the top-down control, the government derived much revenue from its SEZ operations, which helped to finance its infrastructure projects and urbanization programs.

[10] Elsewhere, we have dealt with the mutual benefits and dynamic interactions across the Taiwan Strait (e.g., Tung & Wan, 2012, 2013) and will not repeat here due to space constraints.

3.3.1 Institution Transplantation

In 1949, the Kuomintang (Chinese Nationalist Party, or KMT) retreated to Taiwan and took various emergency measures to preserve the public resources and stop corrupt, opportunistic officials from siphoning foreign exchange reserves abroad as their own. The economy then sank into a controlled economy at low efficiency. American economic aid came with the Korean War as a temporary support, but with a planned termination date by 1965.

At the same time, overseas Chinese were suspected as pro-Communists in Southeast Asia and looked for a safe haven to invest their savings. With the over-regulation in Taiwan hence high cost of doing business, they invariably selected Hong Kong over Taiwan in spite of the overcrowded investment scene in the British colony.

K. T. Li, as finance minister for Taiwan, visited both the industrial park in Shannon, North Ireland, and the free port of Trieste, Italy, and obtained authorization to invest public funds for the KEPZ in the Kaohsiung Harbor, to employ rural labor and process imported inputs for exports in 1966 (Tung & Wan, 2014). He dispensed with four laws and four administrative regulations for KEPZ, which were what potential investors complained most about. He also appointed a trusted subordinate, M. T. Wu, as the administrator, who was renowned for efficiency and drive. The project blossomed to earn foreign exchanges and create employment. Two more export processing zones were set up as local replicas.

There are also foreign emulations. The Mauritian Export Processing Zone, for example, was set up in 1970 in an African state in the Indian Ocean. It was a well-known success, under certain institutional modifications (Wellisz & Saw, 1993).[11]

Subsequently, a series of science-based industrial parks were set up in Taiwan to attract foreign high-tech investors. The first Science Park in Hsinchu is backed by various government-supported facilities, including two universities to train technical staff, and a government laboratory, Industrial Technology and Research Institute (ITRI), to provide consultant services. Occasionally, ITRI has spun off industrial firms in selected sectors, including TSMC, the world's premiere dedicated IC foundry (Tung, 2001). These science-based industrial parks also attracted various small multinational corporation investors. Some larger multinationals would establish their branch firms outside these export zones and industrial parks, under more favorable arrangement with the government.

3.3.2 Massive Input Flows

With Shenzhen established as a growth pole on the Chinese Mainland since 1980, opposite to KEPZ in Taiwan, the *institution transplantation* means that rather

[11] With a Westminster-style parliament, Mauritius only needs to label applicable firm as "export-processing zone firms," and no physical zone is even needed.

similar pro-trade institutions are present on both sides of the Taiwan Strait. However, there were huge differences in the availability of land and labor. By basic economics, this inevitably induced torrential movements in both investment funds and skilled administrative personnel from one side of the Strait to the other, so that labor-intensive products, such as textiles and consumer electronics, expanded by leaps and bounds first in Shenzhen as a test case, and next elsewhere. A parallel flow from Hong Kong to China proper had occurred even earlier. Together, these flows helped to shape the rise of the Chinese economy.

3.3.3 The Taiwan and Hong Kong Nexuses

In most industrial sectors that China has a significant export surplus today, from the light industries (like textiles, clothing, and footwear) to the high-tech industries (like microelectronics), records show that firms from Taiwan used to have significant roles decades earlier in the world market (e.g., Hsing, 1998).

Conversely, in many of the industries Taiwan has little success in export, such as automobile and memory chips (in which Korea is strong) or aircraft (in which Brazil excels), the PRC does not yet have much comparative advantage in the world market either, even with government help and a huge domestic market. The aircraft example will be explained in more detail in Sect. 3.4.

3.3.4 Some Remarks

Two points stand out from the series of stylized facts above. First, they suggest that the fast growth of PRC has its hard-to-replicate historical background. But this does not preclude the possibility that China may do well in memory chips or other areas in the years to come. In fact, Chinese innovation in certain new sectors has been impressive. For example, the TikTok algorithm is superior to similar social media platforms and is popular all over the world.

Second, these facts bring to mind that, while the rapid growth of PRC is accompanied by the slowdown in Taiwan, Korea, or Japan during their interaction, none of these predecessors suffered from negative growth by decade average (see Fig. 1). Take Taiwan as an example. One industry after another "migrated" from Taiwan to China, and Taiwan's Foxconn became the world's largest provider of electronics manufacturing services mainly because of its huge production base in China.[12] Yet Taiwan did not "hollow out" as has taken place in many other

[12] Another example is Pou Chen, the world's top maker of branded sports footwear, who produces shoes in Vietnam, Indonesia, and China, and does R&D in Taiwan. For a more extensive analysis refuting any simplistic claims of hollowing-out and de-industrialization, see Tung (2015).

economies by continuous innovating[13] and upgrading. That is to say, the rapid growth of China is possible to lead to net global gains.

3.4 Special Choices by China

We now turn to some specific policies or strategies that China employed, which are only feasible with its huge market size or top-down political systems.

Example 3A Town and village enterprises (institutional adaptation for efficiency)

According to Yao (2011), the success of PRC reform in the 1980s relied on the town and village enterprises (TVEs), each with a private entrepreneur managing efficiency improvement. Although this institutional adaptation might lead to some "extra-legal" returns under unclear ownerships, it made government officials into stakeholders. One major result is that entrepreneurship was stimulated and cultivated, as the industries strived.[14] Along with the rapid growth in employment, exports, and foreign exchange reserves, China far outperformed all East European transition economies like Russia in various dimensions.

Remark Moreover, the gradualist reform through TVEs was helpful in preserving the stability and equity of the society. Over a decade after the reform, Jiang (1990)[15] insisted that social security, broadly defined, must be maintained, while economic efficiency needed further improvement to make the pie bigger.[16] In the language of welfare economics, what he advocated is precisely the idea of John Rawls to have no one hurt while the welfare of all citizens improves. When the Jiang (1990) paper is read together with Yao (2011) and illustrative cases such as that of Duan Yongping in footnote 14, it becomes clear that the PRC system is rather astute relative to the

[13] In fact, the rise of TSMC shows that Taiwan is neither overly dependent on PRC nor hopelessly dominated by Korean chaebols like Samsung as Mody (1990) has predicted. Taiwan's slowdown of growth may be partly demographic.

[14] For instance, Duan Yongping, founder of BBK, joined a TVE to manage an ailing factory that made cheap video consoles in 1989. By 1995, the business achieved an annual profit of 1 billion yuan compared with a loss of two million yuan in 1989. Despite that success, Duan left in 1995 because his proposal of firm reorganization was rejected. He then founded BBK, which is behind smartphone brands Oppo, Vivo, OnePlus, Realme, and others (Tao, 2019). In 2021, Oppo and Vivo ranked fourth and fifth in world smartphone market.

[15] The Chinese economy has already become the world's second largest, but its operation in a top-down fashion is different from the West and most East Asian economies. Hence, literature in the Chinese language, like Jiang (1990), and newly released documents, like Chen (2008), are extremely helpful to offer insights into the outlooks of China's decision-making, and the terms of debate in academia.

[16] Jiang (1990) made an interesting observation that by total GDP comparison, an isolated PRC had fallen rapidly relative to Japan, from 1 to 1 in 1960, to 1/4 in 1980, then down to 1/6 in 1988. Although these numbers vary somewhat with World Bank statistics, his main point remains valid that China's economic efficiency was low and relatively falling, therefore needed to improve.

"big bang" type of reform that instantly dismantled Eurocommunism. This was so even for East Germany, bankrolled by the West German government.

Example 3B High-speed railway (operation of the Prisoners' Dilemma)

China's high-speed rail (HSR) is generally considered a big success, though with growing domestic financial woes in recent years due to overinvestment (Desai, 2021). Its start in the mid- to late 2000s deserves attention. As an economy with a giant home market, the PRC decided to exert its monopsonistic power. Kawasaki from Japan came to corner Siemens of Germany when the latter refused to transfer technology to China. Siemens gave in immediately because if it had held out, Kawasaki, Bombardier, and Alstom would divide up its share of revenues (McKinsey & Company, 2011).

Example 3C Solar panel industry (growth through massive subsidies)

Solar panel is another booming Chinese industry growing from scratch, whose export has swept away all rivals in the international market. By 2020, at 252.2 gigawatts, the Chinese cumulative solar photovoltaic capacity outnumbers the next four countries added together: the United States, Japan, Germany, and India,[17] and thus Chinese firms have lowered the unit cost through scale economy in production (Rapoza, 2021). The speedy production expansion resulted from heavy subsidies, but the subsidized power generation at home sometimes comes from locations too far to transmit cheaply to population centers.[18] Yet then again, the development of the industry might have been the only alternative for the Chinese government, given the severe pollution coming with rapid growth.

Example 3D Belt and Road Initiative (uncertain long-term cost and benefit)

China announced its Belt and Road Initiative (BRI) in 2013. The BRI, which connects Asia with Africa and Europe, is an updated version of the earlier China–Africa Nexus, where infrastructure is treated as a traded good, rather than a non-traded good (Chua & Wan, 2014).[19] As it is of a cross-continental scope, and the streams in cost–benefit would span decades, the impact and effect are hard to evaluate at this stage.[20]

Example 3E Commercial aviation (growth based on large domestic market)

China is designing and making its own passenger planes as part of the "Made in China 2025" initiative, and the state has employed industrial policies, formal and informal, to help foster this industry (Crane et al., 2014). As the country is both

[17] For data, see https://www.statista.com/statistics/264629/existing-solar-pv-capacity-worldwide/ (retrieved on July 1, 2021).

[18] However, with future technical improvement, matters might well improve.

[19] It is found in sources such as Tang (2014) that there were surpluses in both foreign exchanges and experienced Chinese contractors who learned by doing African projects, while both had been in short supply for the African host countries.

[20] One may be tempted to offer the answer of Prime Minister Zhou Enlai gave on the merit of the French Revolution: "Too early to tell." This is especially so in view of the fact that the current arrival of the trade conflict may be partially due to how the fine terms are decided.

strong in spatial science and experienced in making drones and military aircraft, its first large passenger jet, *C919*, is soon to be delivered by state-owned Commercial Aircraft Corp of China (COMAC). The company has already received nearly 1000 provisional orders for the *C919*, mostly from state-owned carriers-leasing firms. Domestic demand could grow further as China's aviation market is soon to overtake the United States as the world's largest by traffic. COMAC also has its sights set on emerging markets in Africa and Asia, given that the list price of *C919* is just about half that of Airbus's *A320neo* it competes with (Harrison, 2019).

However, 40% of the core components of *C919*, including the engine, come from American and European suppliers. Also, the opportunities for exports may be limited. First, it needs to get certifications to fly outside of China, yet the de facto standards that many countries follow are set by regulators in the United States and Europe. Second, it needs to compete with Boeing and Airbus, who have developed a worldwide network of knowledge, people, and support for their product decades ago (Hinata & Kawakami, 2021).

Remark A contrasting example is Canada's Bombardier. It had to sell its C-Series product line to Airbus because Bombardier could not count on massive domestic demand, and few customers would take the risk from Bombardier without a worldwide support network (Baldanza, 2021).

3.5 Some Lessons from China

In Panagariya's terms (Panagariya, 1995), PRC's rapid growth was by both luck and design, but perhaps more of the former than the latter.

It is by "luck" because the temporary loss of Hong Kong and Taiwan after the Opium War served the purpose of PRC better than what one could have designed. In particular, Hong Kong, one of the world's major transportation and finance center, provided the best instrument to transfer resource to PRC while it itself underwent a fast de-industrialization. Taiwan, with its growth miracle a couple of decades before China, also became a conveyor belt for PRC. From the perspective of trade, industry by industry, what comparative advantage Hong Kong and Taiwan had during their high growth periods remains what the PRC has, from textile to consumer electronics, then to microelectronics.

This natural co-evolution remains important until today and is largely cheered on by the rest of the world in the belief that it would bring political changes like in Taiwan and Korea (Steinfeld, 2010). The rise of the "Foxconn city" in Shenzhen and "iPhone city" in Zhengzhou supported by multinational corporations, including Apple, is representative of the universal applause to the growth of PRC, until halfway into the Trump presidency in the United States. These factors interact, and their separate effects are hard to isolate.

As for "design," China has accelerated its rise as suspected by Rodrik (2006) with industrial policies. The SEZs work fine; the policies such as the "vacating

the cage to change birds" strategy[21] have helped with industrial upgrading. For example, Luxshare has succeeded to become Apple's new assembler of iPhone 13 Pro, winning orders away from Taiwanese rivals Foxconn and Pegatron (Ho, 2021).[22]

Yet China's industrial policies are not always successful. As mentioned above, for some sophisticated products, such as memory chips and automobiles, China has not yet succeeded in exporting[23] even with strenuous trying. And for passenger jets (Example 3E), it has not yet found a satisfactory substitute for foreign-made engine.

Moreover, as pre-warned by Professor Justin Lin, former chief economist and senior vice president of World Bank, these industrial policies may run the risk of leading eventually to the Thucydides Trap, if the leader economy feels overly threatened (Tung & Wan, 2019).

Hence, the Chinese growth trajectory is not always readily duplicable. Specifically, Vietnam lacks the market size in HSR bargaining, and India cannot reform through TVEs under its parliamentary institutions. *Growing exactly like China* may be neither feasible nor advisable for most developing economies.[24]

3.6 Alternative Views on PRC's Growth?

Huang (2009) has suggested that the economic success of the PRC is not so much due to FDI or infrastructure as widely believed, but because the country has invested heavily in human capital since the 1950s.[25] Dreze and Sen (1999, 2013) held a similar view that India was much behind China not only in income level, but also in education, basic health, and gender equity. Sen (2011) advised the Indian

[21] The industries are the "birds," and the regions are the "cages." This initiative began with a state-driven value-chain-upgrading strategy in Guangdong in 2008, known as "double relocation" to shift labor categorized as "low-skilled" and firms categorized as "high in pollution, high in energy use and low in efficiency" from the more advanced areas to the underdeveloped regions (Lim, 2016). The strategy is subsequently employed by many other provinces throughout the country.

[22] Luxshare, founded by a former Foxconn production-line worker, will only build up to 3% of the iPhone. Yet it is quite unusual for Apple to outsource a premium model to a first-time assembler, though it is already a key assembler of AirPods and Apple Watch. Market experts surmise that Apple does so because Luxshare has acquired assembly plants with previous experience in assembling the iPhone from Pegatron and Wistron, and is willing to charge less than rivals (Ho, 2021).

[23] Exporting is a critical test for the success of innovative effort, as Sweden succeeded for a period with Volvo, with emphasis on safety, resale value, maintenance, but India did not achieve with Tata.

[24] In fact, to copy any existing model closely is not advised by Beijing about its own development. For example, Chen Yun, an influential leader in China and a colleague of Deng Xiaoping's, has been quoted as saying in 1990 that, "Do not just follow instructions, do not stick to books, only the facts; communicate, compare, and repeat" (News of Communist Party of China, n.d.).

[25] A somewhat more nuanced picture of this will be included in Sect. 6.

Table 1 GDP per capita and "quality of life" in 2019

	GDP per capita, in USD	Life expectancy at birth, in years All (female, male)	Adult literacy (age 15+), in % All (female, male)	Infant mortality rate, in ‰ All (female, male)
United States	65,280	78.8 (81.4, 76.3)	–	5.6 (5.1, 6.0)
Japan	40,778	84.4 (87.5, 81.4)	–	1.8 (1.7, 1.9)
Korea	31,846	83.2 (86.3, 80.3)	–	2.7 (2.5, 2.9)
Taiwan	25,941	80.9 (84.2, 77.7)	–	3.8 (–, –)
China[a]	10,217	76.9 (79.2, 74.8)	96.8 (95.2, 98.5)	6.8 (6.3, 7.2)
Vietnam	2715	75.4 (79.5, 71.3)	95.8 (94.6, 97.0)	15.9 (13.7, 18.0)
India[a]	2101	69.7 (71.0, 68.5)	74.4 (65.8, 82.4)	28.3 (28.2, 28.3)

Data source: World Bank; Directorate-General of Budget, Accounting and Statistics, Ministry of Interior, and Ministry of Health and Welfare, Taiwan

[a] Adult literacy rates of China and India are 2018 figures

government to spend more on education and basic health, which will enable strong growth, rather than on infrastructure, which will be self-financed by the growth itself.

To put things in perspective, Table 1 updates some of the comparisons made by Sen in earlier years. In 2019, China was ahead of Vietnam and India in both basic education and health. It is worth noting that there has been improvement in India over time, though not quite in dimensions such as the gender gap in adult literacy.

Moreover, China also leads India or Vietnam in the high-skill human capital, though it is behind its East Asian neighbors: China has 1307 researchers in R&D per million people in 2018 (from World Development Indicators) as compared with 253 in India, 708 in Vietnam (in 2017), 4412 in the United States (in 2017), 5331 in Japan, and 7980 in Korea.

These figures show that China is indeed better prepared to move up from simple to sophisticated industries, with a sufficient and skilled workforce, relative to India or Vietnam.

However, there has been speculation that China's demographic trends, shaped largely by the one-child policy in 1979–2015, will weigh on its future prosperity.[26] Since population aging is commonly thought as one major factor of Japan's economic stagnation (Shirakawa, 2019), the threat to China's economic growth is credible and around the corner. But there is no consensus yet on how severe the demographic impacts are,[27] and there are many other interrelating factors at

[26] In the newly released population census conducted in 2020, working-age population (between 15 and 59 years) of China has declined as compared to the last census in 2010 while the number of elderly (aged 60 or above) increased significantly.

[27] For example, a report by People's Bank of China (Chen et al., 2021) admits that advances in education and technology would only partially make up for the decline of population. But a recent study by Marois et al. (2021) finds that China's GDP may still grow even under population decline, when factoring in the effects of education attainment and labor force participation on productivity.

work, such as world terms of trade. While more extensive studies, and perhaps some calibration or simulations are called upon, we shall keep focusing on the economic explanations here.

4 Some Structured Samples of East Asian Facts from Japan, Korea, and Vietnam

We now go beyond post-reform China and delve into the records of Japan, which is the first economy to develop in East Asia in modern times. This exploration may offer some hints about, in general, what it takes to rise from a technology latecomer to world excellence and sustain the competitiveness through one industry to another.

Eight examples of Japan are presented, among many more relevant examples. The first two date back centuries ago, and the next six are contemporary cases. Most of these examples involve strong strategic intent, and all are about innovation and learning-by-doing, throughout the centuries, with efforts cumulating over previous ones. These examples are then augmented by episodes from Korea and Vietnam, showing that Japan is not unique, but has a more complete record available.

4.1 Examples in Early Times

The first example is about innovation on cost and market structure, and the second is about the more subtle matter of product or process designs.

Example 4A Sericulture (production and market innovation)

Silk weaving was one of the technologies that were transferred to Japan from China.[28] But Japan has decisively leapfrogged China by superior information, process innovation, and multisector coordination (Ma, 1996, 2004).

To recount, in 1873, China exported three times as much raw silk as Japan, but Japan's export surpassed that of China in 1905, and it tripled that of China by 1930. The dramatic success of Japan was largely derived from the capacity of its sericulture sector to develop appropriate technology and institutions through adapting cutting-edge European technologies in sericulture to its own situation and by abolishing the merchant guild system. These innovations brought Japanese sericulture decisive advantages in productivity and Japan leapfrogged China in sericulture (Ma, 2004).[29]

[28] Uchida (1990) reported that "the transfer of metalwork technology, silk weaving and other know-how from China contributed to the founding of Japan as a nation."

[29] These innovations happened notwithstanding the internal condition of the Japanese state: the rice riots, and the repeated assassination of prime ministers. Finally, there was the rebellion of an army faction besieging the Emperor, with an atmosphere eventually leading to WWII.

Qing China faced a similar Western Imperialist challenge. Yet China did not build up the necessary physical and social infrastructure like Japan did during its own reform movement. There had been partial recovery, but that was abruptly brought to a halt with the intensification of the Sino-Japanese War in 1937.

Remark Ma (2004) concluded that what made Japan, but not China, successful was the opening up of the country to trade and the opening up of the minds of its populace, which made technological and institutional innovations possible. These, in turn, made Japan to develop earlier than all its East Asian neighbors in modern days.

Remark This is a classic example by its economic importance in history. But, as Uchida (1990) noted, the success of Japan in raw silk is atypical over the entire industrial range. Industrial technology transfer can be very complex.[30] This remains so even after WWII.[31]

Example 4B Metallurgy and weaponry (from independence to leapfrog)

Historically, swords and other ironware were imported from China via Korea to Japan since around 300 B.C. (Naumann & Miller, 1995, p. 373). With continuous advances in both metallurgy and sword-making, Japan became an exporter of *Nihonto* (Japanese swords) to China in the eleventh century. The reverse of the direction of trade, prior to the intervention by the European Industrial Revolution, is studied in four steps.

(a) *Input substitution*. Iron ore is scarce in Japan, but iron sand (*tesatsu*) is abundant. To produce iron or steel domestically, old-fashioned manufacture used iron ore imported from Korea. A unique method, *tatara*[32] iron manufacturing method, was developed to use the cheap local resource. The iron sand is reduced by the heat of pine charcoal in combustion from the clay oven (*tatara*) (Hitachi, n.d.). This technology yields both steel (for sharpness) and iron (for durability) as joint outputs. This is convenient since both are needed as inputs to be processed into the final products as composites with varied properties to suit desired needs.

[30] In the dynamos industry, Uchida (1990) reported that, due to the lack of a long scientific tradition in Japan, domestic products were not usable under Japan's import substitution, even though the appearance of the industry in the United States and Germany was just half a dozen years ahead of this effort. More specifically, it was the presence of school training or researchers, rather than the length of time making the dynamo itself, that mattered. The problem was mitigated with the arrival of foreign investment under "tariff jumping," after Japan gained rights over tariff independence from Western powers, following the victory over Qing China on the battlefield.

[31] For example, the transfer of the technology of Nylon after WWII was still a complex process with heavy government involvement (Ozawa, 1980). The second author thanks Professor Hoshimi Uchida for bringing to our attention, in personal communication, the role played by the license terms from Dupont in the complex negotiation.

[32] In etymologically, *tatara* is not a Japanese word, but with Sanskrit roots from India, *tātala*, the origin of Wootz steel (from which the famous Damascus Blade is made of), thus presumably transmitted to East Asia along with Buddhism (and through China).

(b) *Output evolution*. High-quality steel using the *tatara* method is then made into many products, including *Nihonto*. As mentioned already, both the swords and sword-making techniques were imported from China to Japan early on. But through successive upgrading in both steel-making and sword manufacturing, *Nihonto* started to export to Chinese connoisseurs at a dear price by the eleventh century (Ma, 2000).[33]
(c) *Product redesign*. The *Nihonto* we know today is the end result of a fourfold *adaptive* redesign, on its shape, proportion, structure, and refinement, in a series of improvements over the centuries (Kapp et al., 1987). The continued evolution was spurred mainly by demands in war. Thus, when fending off the Mongolian invaders who wore hard-boiled leather armors that were difficult to cut through, the samurai warriors found their blades breaking or chipping. Hence, swordsmiths began experimenting with different designs in width, thickness, curvature, and so on to improve effectiveness in battle (IHCSA, n.d.).
(d) *Reverse of direction of trade*. By Ming Dynasty (1368–1644) in China, *Nihonto* was exported to China as military equipment in large quantities. When Chinese generals began to emulate both the making and using of Japanese swords (Ma, 2000), this is clearly an example of the reversal of the "revealed comparative advantage" in military equipment achieved by Japan.

Remark The Linder Hypothesis (Linder, 1961) states that countries export what they used to consume. But for Japan, most of what they export were initially introduced from abroad. Behind the reversal of trade flow, there often is a story of leapfrog.

Remark (A conceptual revisit to Sect. 2) The observation, experimentation, and redesign involved in the incremental innovation of the *tatara* method as well as the making of *Nihonto* are under similar engineering principles like building modern fighter planes. It supports Scott-Kemmis and Bell (2010) that, descriptively, a sequence of steps, such as observation, experimentation, and redesigning, are generally involved in war production rather than simply repeating exactly the same process to achieve progress (see footnote 4). This is different from the initial "learning curve process" observed around WWII giving rise to the learning-by-doing literature by Alchian (1963) or Arrow (1962).

Remark Examples 4A and 4B show the roots of Japan's continuous growth within and across industries, *Kaizen*, which means incremental advances literally, through learning-by-doing. An elemental truth is that technological progress is path-dependent and is fundamental to economic research. This is known also from the rise of steam power by James Watt through sequential improvement (see footnote 6). So, readers of Scott-Kemmis and Bell (2010) should not be misled by the title of their paper "The Mythology ..." and dismiss the path dependence of

[33] In the poem "The Song of Nihonto" by the famous polymath-statesman Ouyang Xiu (1007–1072) of Song China, *Nihonto* was described as a curiosum recently imported from overseas by Chekiang merchants for trendsetters, with supposed sharpness capable of cutting jade.

technological change, where learning-by-doing is the reduced form description of path dependence.

Remark In these two examples, the conceptual basis of Japan's economic rise is *strategic intent*: to select only the best among the multiple optimal solutions, perhaps along a nonconvex possibility frontier implied in Clemhout and Wan (1970). In practice, the anchor of their strength seems to be the tradition of learning-by-doing through information collection and round and round redesigning by "improvement engineering."

4.2 Examples in Recent Decades

The following are more recent episodes of innovation in different perspective, showing that the traditional Japanese strength is equally powerful in market contests, in the presence of American or European contestants, who may be either technological leaders to leapfrog over, rivals to compete against, or allies to cooperate with.

Example 4C Shimano (design-intensive innovation)

Shimano was originally a supplier of bicycle parts and grew on its strategic intent.

It represents the Japanese strength *from emulation to innovation*. After WWII, it neither relied on the support of the MITI in the shadow of the Japanese Inc., nor enjoyed the sheltered Japanese home market, and was never a part of the *keiretsu*[34] system. By its own research, it developed an excellent derailleur system for changing speeds and won many patents (Wan, 2004, p. 119).

Shimano started as a firm experienced in metallurgy. After WWII, it sampled gravels on roads of both Europe and the United States, which was an important preparation in designing a key component for safety and convenience. It then outcompeted the domestic rival, the Sun Tour, and next required all of its clients, bicycle manufacturers, to buy entire sets from it, making its name known to final buyers of bicycles. Finally, it gradually reduced the distinction among individual bicycle manufacturers to improve its own bargaining power relative to each client and become known as "the Intel of the bicycle industry" (Wan, 2004, p. 119). By 2020, it holds a global market share of about 80% for bicycle drivetrains, and its market capitalization has surpassed automaker Nissan (Shibata, 2021).

Example 4D YKK (meticulous care assured dominance)

Zippers were first invented in the United States in the early twentieth century, but it is YKK of Japan that gained global domination with strategic intent.[35] This

[34] A *keiretsu* is a set of companies with interlocking business relationships and shareholdings. It arose out of the prewar *zaibatsu*, which were family-owned conglomerate businesses that were dissolved after WWII by General MacArthur.

[35] The success of YKK zippers is not due to exports like in the other examples, but through FDI abroad.

company controls meticulously the design and fabrication in-house, over the dozen and half components, and offers quality zippers with reliability. A zipper costs very little, but should it fail, the garment (say a pair of $200 trousers) may be unusable, and the garment maker will be blamed. Since garment makers value high reliability over low cost, YKK dominates the market (Stevenson, 2012). When faced with strong competition from Chinese rivals, often with much lower prices, YKK still held a 40% share of the global market by value, though only 20% in volume by 2019 (Lévêque, 2019).

Example 4E Automobile (leapfrogging by scientific system with innovative organization)

The American engineer Deming brought statistical control to post-WWII Japan,[36] especially to revive the automobile production. Japanese firms absorbed the lessons and implemented with their own insight and organizational and manufacturing innovations. This evolved into systems like just-in-time (JIT) scheduling and total quality control (TQC) (Liker, 2004). With these innovations on organization to make sure those statistical standards are enforced to the mutual benefit of workers and management, Toyota of Japan has dominated the General Motors (GM) of the United States in quality and cost,[37] and influenced German practice on the global market in this major industrial sector of the modern age.

Remark Development of the *tatara* method (Example 4B) laid the foundations of Japanese strengths in metallurgy for Shimano (Example 4C), YKK (Example 4D), and Toyota (Example 4E), to be exploited with new circumstances, even when the *tatara* technique was no longer in use.

Example 4F Microelectronics (rapid leapfrogging through inter-firm cross-subsidy)

In the microelectronics industry, Intel invented the DRAMs as memory chips. By the early 1980s, Japanese competition came under their *keiretsu* system: the artisanal skill from camera-makers supplied superior lenses, and the electronics firms mass-produced the DRAMs. As a result of the "vintage goods" plan played by the Japanese (Okada, 2006),[38] Intel saw its profit slashed from $198 million in 1984 to $2 million in 1985, threatening corporate survival. The redoubtable Andy Grove had to yield that field to the Japanese, to specialize in CPUs instead, with $180 million written as loss and 8000 workers fired. The experience became a classic in managerial science: *Only the Paranoid Survives* (Grove, 1996).

[36] This is seen in Deming's Lecture to Japanese business leaders in 1950 (Hunter, 2012).

[37] Even as the US government forced Toyota to join GM in making cars under the NUMMI project to transfer managerial practice, GM management failed to learn fast and went bankrupt due to the toxic management–labor relations (Langfitt, 2010).

[38] By this plan, the newer DRAMs were produced with better technical standards than the United States; the older ones were sold to Koreans and Taiwanese to raise profit, to finance the R&D for competition.

Remark For Japan, despite the short economic victory, there was the need for the American nuclear umbrella, so its exports of DRAM had to be moderated.[39] On the economic and technical side, the United States formed the SEMATECH consortium, an R&D consortium that helped accelerating critical science-based techniques to leapfrog the artisanal skill of the Japanese chip makers. In addition to the collapse of the vintage-good strategy in DRAM, Japan had to agree to measures such as "voluntary export restraint" during the US–Japan trade war, which started in the early 1980s, and Yen appreciated against USD by 31% in 1981–1986 (period average).

Example 4G Murata manufacturing (incessant upgrading)

Murata has managed to remain as a market leader till today, while many Japanese firms lost their comparative advantage in producing electronics parts and components (Thorbecke, 2019). It supplies 40% of the world's demand for multilayered ceramic capacitor (MLCC), of which up to 1000 units are used in a single smartphone nowadays. It is also the market leader of a few other electronic parts and components, which account for 70% of its total sales. To enhance its competitiveness when facing intensified competition, from Korea, Taiwan, and China, it continues to move up to the higher end by developing new products, which contribute to over one-third of its revenue every year. Murata also manufactures its own production equipment, like YKK (Example 4D) does, so as to keep well its trade secrets ("blackboxing" its production process) to widen the technology gap with its rivals (Wu, 2020).

Example 4H *Origami* engineering (from emulation to modern innovation)

In Japan, the traditional Chinese paper folding to amuse children gradually evolved into a sophisticated art, *origami*. Then in the twentieth century, by deductive reasoning in mathematics, Japanese researchers and European scholars developed axiomatic systems to characterize *what* and *how* forms can be done by folding. The *origami engineering* was born and is applied innovatively to certain existing products, mostly in the United States, from coronary stents, to air bags, solar power collectors for spaceships, and so on (Wertheim & Lang, 2005). It stands as a model for all economies with any population size, with or without the ability to finance costly equipment.

4.3 Examples from Other Asian Economies

The next two examples show that Japan is not unique among East Asian countries in leapfrogging in economic development. One is about modern Korea, the other is

[39] In Japan, the movement of the "Japan that can say no" (Ishihara, 1991) also lost support, with Sony's Chairman Morita somewhat backed down from the coauthorship of the book (Lewis, 1991).

from Vietnam in the fifteenth century, at that time a Confucian state not different from Korea, Japan, and China itself.

Example 4I Koreans adopted CDMA mobile phones (taking calculated risks)

By the three-stage theory of Kim (1997), Korea went from "duplicative imitation" to "creative imitation" after the period of using cheap labor to attract foreign direct investment and receive technology transfer on standard products from such foreign firms. Korea then faced challenges to go into the third stage, "innovation," as foreigners would not transfer more technology on easy terms to their future rivals. To innovate, it requires funding for both conceptual research at the start, and then the design of specialized parts to be assembled into the final product. After much study, the government and the industry then took the calculated risk and joined Qualcomm for the latter's more efficient CDMA in telecommunication, at a time when Europe used the TDMA system and the United States still stayed with the analog system. Korea succeeded in leapfrogging (Lee & Lim, 2001).[40]

Example 4J A Vietnamese captive developed cannons for China (Vietnam leapfrogging China)

Prince Ho Nguyen-Trung was a Vietnamese scholar of Chinese descent. In the confusingly dynastic struggles of the fifteenth century, Emperor Yung-Lo of Ming China took the throne from his own nephew, then denounced the father of Prince Ho in Vietnam for exactly the same behavior, besides deceiving him. War came, and Prince Ho was brought to China as a prisoner of war. To the great surprise of his captors, they found the Vietnamese as far better cannon makers than themselves. Since Prince Ho was the best, he ended up as a minister-designer for the Ming Chinese Navy (Ming Shi Lu, n.d.).

Remark Both Example 4B on *Nihonto* and Example 4J on Vietnam technology are proofs that Ming China was leapfrogged by both their Japanese and Vietnamese neighbors in the sensitive technology of armament. Although weaponry is not an "ordinary" manufacturing industry, it suggests the lack of strategic intent and continuous effort in China before the modern age. This implication echoes both Ma's observation (Ma, 2004) in our remark of Example 4A on why it is Japan, not China, that became the first country to develop in East Asia, and also the Brandt et al. (2014) explanation on how the imperial system constrained growth.[41]

[40] Such selection of business partner is also carried out in Taiwan, by TSMC, as well as Foxconn.

[41] By Brandt et al., (2014, p. 79), besides lack of vision and lack of administrative structure to encourage development, China also faced with problems of lack of fiscal capacity, patronage economy, and interlocking elites.

4.4 Some Implications

There are several implications to derive from Examples 4A–4J. First, sector over sector, in raw silk, metallurgy, and so on, in prewar time, Japan has leapfrogged over China, who was the world leader in economic size and many aspects of technology prior to the industrial revolution.

Second, in the postwar time, Japan dealt with the United States and the entire world successfully in bicycle parts, zippers, mass-produced automobiles, memory chips, and core electronics components, in a manner almost exactly like how it dealt with China before the war.

Third, as mentioned in Sect. 3.5, when the success of Japan became a threat to the United States, the current world leader, the latter resorted to political pressure to negotiate for truce to end the first Cross-Pacific Trade War.

Fourth, Japan demonstrates what Solow's discussed about growth in the twenty-first century that the principal source of growth is the change of production technology based on innovation, which depends on entrepreneurship no less than scientific discoveries.

5 East Asian Facts from Korea and Taiwan

After the armistice of the Korean War, both Korea and Taiwan sought hard for export opportunities. With different social precondition, they took different routes, and both achieved certain success.

In Korea, President Park tried to govern the existing Korean chaebol families with loaning power from state-controlled banks to develop the economy together (Wan, 2006, p. 62–79). Large firms like Samsung, Hyundai, LG, and Daewoo rose during that period, from strength to strength. In the Asian Crisis of 1997–1998, Korean growth was seriously tested but got bailed out by the IMF and World Bank.[42] Of the major chaebols, only Daewoo sank.

In contrast, KMT, the ruling party till 2000 in Taiwan, followed the ideology of founder Sun Yat-sen, who was heavily influenced by Henry George, with a focus on land reform and capital "regulation." Hence, small and medium enterprises (SMEs) and public firms became the mainstays of the economy. By 1970, the representation of Taiwan at the UN was replaced by the PRC, ending its link with the Breton Woods Institutions of the IMF and the World Bank, which placed financial constraints to support active industrial policy. It is worth noting that, at that time, no state or private business in Taiwan could match any of Korea's major chaebols, such as Samsung.

[42] The total rescue funding Korea received for the 1997 Financial Crisis was US$58.35 billion, with $21 billion from IMF and $10 billion from World Bank. The rest came from Asian Development Bank ($4 billion) and 13 major developed countries ($23.35 billion) according to Lee (2011, p. 90).

5.1 Korea Succeeds in DRAM with Patient Capital

When both Korea and Taiwan upgraded their industrial structure toward electronics, Mody (1990) betted that with government support Korean electronics firms would triumph over those from Taiwan. One explanation is that internal increasing returns exist in advanced industries, where comparative advantage belongs to large economies with giant firms, likely supported by the government as *national champion firms*. Korean chaebols can "surmount the entry barriers through their ability to raise large amounts of capital efficiently" (Mody, 1990, p. 291–292), whereas Taiwanese firms are smaller and state help is less.

Kuo and Wang (2001) found that in products where the technology has less frequent changes, such as black and white TV, colored TV, and so on, Korean firms would amass funds and perfect product quality, then trounce their Taiwanese rivals with predictability. So Taiwanese firms would retreat to products with frequently changing fashions, like monitors, used by PCs and TVs, so their designs evolve, where Korean firms find it not worthwhile to devote their capital to.

Example 5A Korea's DRAM industry (strategic intent)

In the particular case of DRAM, Lee and Lim (2001) reported that there has been a given staged industrial trend, from 1 KB to 16 KB, and then 64 KB or up. To skip stages and resolve at once various related technical problems, the Korean government organized a consortium to mobilize resources of the entire industry by the mid-1980s. Consequently, Korea won a higher percentage of patents in the United States than before to dominate the industry against all competitors.

Remark In the DRAM market, the advance of the Korean firms was made possible by the acquiescence of Japan that its own challenge to the United States could not go on for geopolitical and economic reasons. For more details, see the remark of Example 4F above.

Remark Korea's Taiwanese counterpart fared quite differently. As the minimum threshold of a DRAM firm is 15–20% of the world market to generate enough profits to meet capital costs and R&D expenses, "no Taiwanese firm has achieved anything close to the volume of production considered necessary to sustain DRAM innovation" (Fuller et al., 2003, p. 182–183). In fact, three of the seven DRAM firms in Taiwan gave up before 2001,[43] and the other four had to rely on foreign licensing to survive. The main issue is the lack of patient capital for any firm in a small economy like Taiwan (Wan, 2006, p. 197).

[43] For example, in the early 2000s, TSMC instructed its subsidiary VIS to produce no more DRAMs, and turn to ASICs (application-specific integrated circuits), which are configured for all applications other than memory (e.g., DRAM) or microprocessor, whereas TSMC itself produces both ASICs and microprocessors for firms like Apple. See Tung (2001).

5.2 *TSMC Dominates in Foundry Market with Trust Created by Policy*

In another industry, it is Taiwan's TSMC, who created "trust" by policy, that has financially turned the table on Samsung, the top chaebol of Korea. Its market value has caught up and surpassed Samsung as well as Intel since 2020.[44] This success was explained in Tung (2001), and then a game-theoretic verification was offered in Tung and Wan (2019).

Example 5B TSMC (trust created by policy)

TSMC was launched in 1987. It operates as a pure-play contract producer at the industry frontier by serving primarily fabless clients who are the true innovators but cannot afford the expensive heavy equipment. It operates under the self-imposed constraint in its charter, that it would neither produce nor market any product under its own brand. This makes a major difference with most other semiconductor fabs, such as Samsung, who are integrated device manufacturers (IDMs), offering their spare capacity for hire.

As explained in Walker (2000), at a non-pure commercial fab, clients got worried that their ideas would be exploited without recourse. However, with a pure-play foundry model, should a client's idea be taken advantage of by the foundry, it can easily and quickly get legal remedy in court as a breach of promise. Worse, it would be the end of the lifelong personal reputation of the founder Morris Chang, which TSMC depends on.

To Chang (Patterson, 2007), lacking business from fabless chip designers was his great concern in the early period as its businesses from IDMs were transactions either of temporary nature or deals with thin profit; and local Taiwan customers were only interested in designing around foreign patents to save license fees. The Taiwanese authorities would like to have a well-known foreign investor to prevent patent suits that can be a major distraction (see below), but most foreign multinationals declined, and Gordon Moore regarded the foundry mode as a "bum idea." This played into the hands of the Dutch firm Philips, with 15,000 workers already in Taiwan. Philips was a tough negotiator, demanding the right to convert its share to control interest, but Chang managed to close the deal at reasonable terms (van Agtmael, 2007).

Started under the protective umbrella of the formidable collection of patents of Philips, TSMC had closed the experience gap with IBM and Intel in less than two decades and became ahead of the competition in certain areas, such as immersion technology (van Agtmael, 2007, p. 128). When Philips sold its last shares of TSMC in 2008, it had earned handsome returns. Its investment in TSMC was considered

[44] On August 11, 2021, the market value of TSMC was $603 billion, ranked number 9 in the world, ahead of Samsung ($459 billion, ranked #16) and Intel ($219 billion, ranked #47); as a comparison, the market value of these three firms were in reverse order at $64 billion, $107 billion, and $116 billion, respectively, on December 31, 2010 (https://companiesmarketcap.com/).

one of the most profitable single investments in chip industry history (Manners, 2008).

It turned out that the same foundry model that has worked to create the fabless chip designing sector in the 1990s (including Nvidia, a giant today) also works in later periods. First off, in the *downstream*, TSMC partnered intensely with Apple, the world's most valuable firm today, with mutual trust to outcompete Samsung, who has been in a long-running patent battle with Apple (Kastrenakes, 2018), in providing chips for smartphones and tablets since 2010.[45]

Moreover, in the *upstream*, TSMC invested and supported the research of the Dutch firm of ASML since the early 2010s jointly with Samsung and Intel to develop the EUV (extreme ultraviolet) lithography and elevate chip making to the next level. Again, by creating deep trust with ASML[46] since the early 2000s,[47] TSMC has become the most favored client of ASML till today.[48]

Remark From Example 5A and Example 5B, it is clear that, in circa-China East Asia, Japan is not alone, Korea did well in memory chips, where "patient capital" matters, and Taiwan also did well in foundry services by creating trust with clients. The contrast between Korea and Taiwan further suggests that, when outside financing is inadequate, as is often the case with a developing economy, policy-created trust serves as a substitute of patient capital for long-term growth.

6 How May East Asian Growth Records Benefit Indian Development?

Heretofore, in response to Basu's (2009, 2019) alert of India's slower growth behind China, we have noted that the same also happened between China and Japan during 1960–1990, which has partly reversed subsequently (see footnote 16). A natural question for India is what East Asian growth experiences would be useful? We shall go deeper in a number of aspects.

[45] Apple betted heavily on TSMC for making chips for iPhone and iPads without a backup plan, and TSMC betted on Apple by making a huge capital investment (TSMC, 2017, p. 23–24).

[46] ASML stated that reliability is one of the four pillars of ASML's partnership with TSMC (TSMC, 2017, p. 19, 22–23).

[47] Before the EUV technology, ASML produced the first immersion lithography device in the world in 2004, based on the technology of Dr. Burn Lin of TSMC. And the first device, TWINSCAN XT:1250i, was, of course, sent to TSMC (ASML, 2003).

[48] In 2020, TSMC bought and installed about half of the world's EUV machines from ASML over rivals Samsung and Intel (Cheng & Li, 2021b).

6.1 Getting the Basics Right

India is projected by the UN to surpass China as the world's most populous country around 2027. And with a "young" population relative to China, Taiwan, Korea, or Japan, India is supposed to enjoy a "demographic dividend" for the next three to four decades.

But India is relatively weak in human capital base, as reported in Sect. 3.6. And Sen (2015) has warned that "India is the only country trying to become a global economic power with an uneducated and unhealthy labour force."

For the potential dividend to translate into economic production, India obviously needs to invest more in domestic education and health, especially for the females,[49] so as to improve the quality and skill of its labor force, and to encourage more females to enter the labor market.

6.2 Getting the Institution Right

Yet differentials in human capital investment are only necessary conditions, not sufficient to make a full difference into economic performance. It takes suitable legal and institutional conditions to realize the advantages of population structure.

One example is from China. In the historical context, China was relatively late to realize Premier Zhou's wish to emulate the practice of KEPZ and make benefits until after 1978 (Chen, 2008). In contrast, Mauritius did in 1970, almost a decade earlier (Wellisz & Saw, 1993). This means, although the Chinese labor had potentially higher marketable skills than their Indian counterparts from better basic education, their advantage could not be brought to bear on the world market in the early days.

In fact, many Chinese labors then illegally migrated from Shenzhen to Hong Kong for a better living, until it brought Xi Zhongxun, Party Secretary of Guangdong, to visit Shenzhen in July 1978, to learn why people were leaving (Huang, 2014). Xi wrote, "The peasants are most pragmatic, if we cannot improve their lives, they will never stay. Our talk about the superiority of socialism was empty to them" (Bevan, 2021). He was determined to change the situation after a visit to the capitalist Australia in 1979. Later, with the support of Deng Xiaoping, he set up the Shenzhen SEZ. That success certainly contributed to why China outgrows India.

[49] To be specific, India's female labor force participation rate is very low at 30.41% in 2019 for those aged 15+. In contrast, it is 71.13% in China (though the labor force participation rate for males of India is quite similar to that of China, at 82.96% and 83.39%, respectively, from World Development Indicators). The narrowing of gender gap in labor force participation is not just an issue of human right, but also for practical reasons: to mobilize under-tapped labor force, and perhaps also to lower birth rate, as shown by evidence from KEPZ.

But again, investments in SEZ alone are symmetrically necessary but insufficient conditions for rapid growth or unleashing the innovative heritage.[50] India is home to the first Asian export zone at Kandla, opened one year before KEPZ, to substitute Karachi, which India lost in the Partition. Kandla suffered from the lack of water supply. Yet hundreds of other export zones were opened, and though such Indian investments were helpful, they have not brought as favorable growth a result as in Taiwan, Mauritius, or PRC. In fact, the improved state-invested infrastructure is often underutilized and appropriated for uses not necessarily the most effective in job creation. More reasonable institutional changes are needed.

6.3 Enhancing Market Orientation (The Wrong Emphasis of Brazil Relative to PRC)

As Solow (1957) emphasized, technical change is the main cause for growth and the result of repeating Schumpeterian contests (Solow, 2007). Therefore, the market mechanism has to work. And exporting is a critical test for the success of the innovative effort, as Sweden succeeded for a period with Volvo, but India did not achieve with Tata. As Worstall (2016) explained, by allowing freer trade, the quality of many local supplies of ordinary input, like solder, would rise; and as a country produces larger ranges of exportable inputs, the living standards would rise as well, affording better education for the mass in a virtuous circle.

Regarding the scale economy in production, there appears a sharp contrast between the two producing countries of iPhone, China and Brazil, to be elaborated below (Tung & Wan, 2019).

In Brazil, to pride itself as an iPhone producer, it succeeded to attract Apple and Foxconn with high tariff protection. But this ends up at a high unit cost, only for the consumption of a small local elite, with scale economy in neither production nor export, yet at high wages for union representatives to boast about.

In China, it turns out high output volume with a high profit for Apple and Foxconn to achieve both high export revenue and high labor employment, at low unit cost and a price that a substantial portion of locals can afford.

The debacle of Brazil is important here because India may be on a track similar to Brazil, planning to indigenize semiconductor production by attracting leading foreign firms, like TSMC or Intel, to set up fabs with heavy public subsidy (Culpan, 2021). Yet this plan runs the risk of ending up at a "Brazil-style solution" with high cost, high wage, low efficiency, low output, no trade gains from export, and little employment. That is, it may contribute little to the overall aim of India's development.

[50] The innovation heritage has benefited East Asians very much, like the *tatara* process in Japan, coming along with the peaceful teaching of Buddhism.

6.4 Self-discovery and Smart Planning Are Essential

As the title, rather than their model, of Hausmann and Rodrik (2003) implies, development is all about "self-discovery": in the presence of uncertainty about what the comparative advantage of a country is, there can be great social value to discovering costs of domestic activities to learn what a country can be good at producing.

Actually, this was a process practiced by Morris Chang, founder of TSMC, also a student of Samuelson at MIT back in 1986. Chang explained in his oral history (Patterson, 2007) how he founded his firm and raised the productivity of his workers.[51] By his business innovation of the pure-play foundry, he activated a worldwide fabless chip-design industry, which so many Indian software designers have enjoyed. His self-discovery process about Taiwan is focused on the potentially high skill that the Taiwanese workers later achieved.

That record began with a sound level of Taiwanese basic and technical education achieved way earlier before he set up TSMC. To be more specific, workers had already been competitive by their "time to market" skill as achieved by firms like Foxconn, another world-class giant from Taiwan, who helped their American clients to compete against Japan (Tung, 2015; Naughton, 1997).

In contrast, as shown by the example of GlobalFoundries, backed by Abu Dhabi oil wealth, deep pocket alone does not guarantee success in the foundry sector, especially since TSMC, Apple, and ASML have formed their mutually supportive industrial ecology, leaving little room for others.

In today's world, there are many high-tech industries to develop, such as AI, and chip foundry is certainly not the only direction for success (Culpan, 2021). With India as the homeland of present or past CEOs of many global giant firms, such as Microsoft, Alphabet, Nokia, and GlobalFoundries,[52] there should be sufficient sources of information for self-discovery of the right industry for successful high-tech development, which are naturally more valuable than the advice of outsiders.

6.5 Any Useful Lesson from East Asia?

As a way to conclude the chapter, we ask if there is any useful lesson from East Asia about the growth of India, in particular, and the developing world, in general.

[51] As Don Brooks, president of TSMC in 1991–1997, has observed that under the stock dividend program, the hard work of local engineers guaranteed the success of the foundry business (Walker, 2000).

[52] For example, Satya Nadella has served as Microsoft's CEO since 2014; Sundar Pichai is Alphabet's CEO since 2015; Rajeev Suri served as Nokia's CEO in 2014–2020; Sanjay Kumar Jha was the CEO of GlobalFoundries in 2014–2018, and Parag Agrawal has just become Twitter's CEO in 2021.

For India, a prerequisite to build up a competitive foundry industry, or any new high-tech industry, would be to invest in domestic education first, rather than to invest entirely in physical capital or infrastructure. And it also needs to provide an investment-friendly environment as well as a market-friendly mechanism. Most importantly, it needs to go through a self-discovery process to find out what it is good at, rather than imitating or copying the growth trajectory of other successful economies. The same principles seem to apply to all other developing countries.

A.1 Some Quantitative Exercise for Illustration

This chapter started from the development study view, motivated by remarks of Basu's remark on "growing as fast as China," a notion that fascinated the developing world. We soon found *ex ante* the mainstream theories of trade and growth did not predict the economic rise of PRC, presently the world's largest trader, which also might grow into the global leading economy in total GDP. As aforementioned, development economists are left alone in the policy forum, and they naturally focus the implications on their own homelands.

We then strived to review the Chinese trajectory *ex post*. Inspired by Basu's initiative, we tentatively offered an augmented experiment, gathering archival information from the sample of fast-growing also mutually interacting economies in East Asia, led by Japan and Korea, by record, and including China for information. The purpose is to see what one might offer out of this example, to India, the world's largest democracy that Basu started with, at its supposedly impending entry to the high-tech sector, for instance. This became Sect. 6.

Space limits made us to place *obiter dictum* as an epilogue here.

A.1.1 An Application on Innovation

Here, we take an analytic look into innovation, which is claimed by Schumpeter (1911) and Solow (2007) as the major source of economic growth. We shall attempt to formulate a theory that is not Eurocentric, then apply it to the multimillennia economic evolution of East Asia touched upon in this chapter, including China and circa-China, who interact with the West, who had embraced science for a few hundred years earlier, with the invention of the steam engine by Watt as an example. We will illustrate that the quantitative modeling can contribute to policy analysis, trade theory (such as production fragmentation), and growth theory (such as the learning phenomenon in endogenous growth theory), serving as organic components to a synthetic explanation.

By using the simplest possible models as components, we test the tentative theory against the Divergence-then-Convergence hypothesis of Brandt et al. (2014) of the

"Chinese economy" (see Example 4A), about the PRC, as well as the economies of Taiwan and the former British colony, Hong Kong.

A.1.2 Three Types of Innovation

There is more than one mode of innovation process. The first is the "American type," with science-based R&D that requires a sizeable fixed expenditure, but may lower the unit labor cost substantially.

The second is the "Japanese type" based upon small firms, which undertakes incremental evolution, combining the production and R&D activities side by side, according to the learning curve hypothesis, so that unit cost drops by the negative exponential law. With a limited scientific base (Uchida, 1990), it progresses in its own way.

There is also the "prewar China type," which operated just like the so-called "Japanese type" by and large until the high peak of the North Sung dynasty, as discovered by Joseph Needham (see the discussion of Brandt et al., 2014), but somehow the learning process stopped afterward. The dearth of data led to various hypotheses to explain the true cause of China's loss of learning. But from Examples 4B and 4J, Ming China had already witnessed the effect of the stop of learning, that is, the loss of the observed revealed comparative advantages to both Japan (swords) and Vietnam (fire arm) in weaponry, both of whom had received much military and civilian technology from China several centuries back. And then the Manchus, another neighbor society, conquered China in its internal division and established the Qing Dynasty.

Next for Qing Dynasty, Brandt et al. (2014), by using the available archive data on demography, concluded that for a population increase of 300% there was not any sign of the diminishing rate of returns in production. This led to their bold and convenient assumption that for Qing China the economics was time-invariant Ricardian: output/labor ratios for all industries were constant over scale, but also stationary over time, while the population within the border had tripled.

The fact that early Qing China could feed a population expanded by a magnitude of up to 300% within a much enlarged boundary with a relatively stagnant technology may be explained by the following: there was a vigorous warlike tribal ruling class with warlike international policies, which kept a huge mass of subject peoples at the subsistence level, leaving no energy for innovation.

Things only got worse for China afterward.

A.1.3 A Model of Competition of an Innovative Heterogeneous Oligopoly

Consider there are three types of firms with different characteristics:

Type A—Science-based entries, with a high fixed cost but low unit labor cost
Type B—Perfectly competitive, with exponential learning
Type C—Perfectly competitive, no learning

The unit material cost, m, is assumed to be constant and is the same for all types. The unit labor cost of A and C is constant, but $\overline{l_A} < \overline{l_C}$, and the unit labor cost of B, l_B, declines by learning. For simplicity, we assume that in the first instance the unit labor cost is the same for both B and C, $l_B(0) < \overline{l_C(0)}$. As for the fixed R&D cost, only type A pays for the expenditure. The unit total cost of each type is as follows:

$$t_A = m + \overline{l_A} + F/N,$$
$$t_B = m + l_B,$$
$$t_C = m + \overline{l_C}.$$

Note that F/N decreases when N gets larger. So, we have

Proposition *If F/N cuts the demand schedule DD between point X and point Y, as illustrated in* Fig. A1*, A wins; otherwise, B wins. C is clearly a loser.*

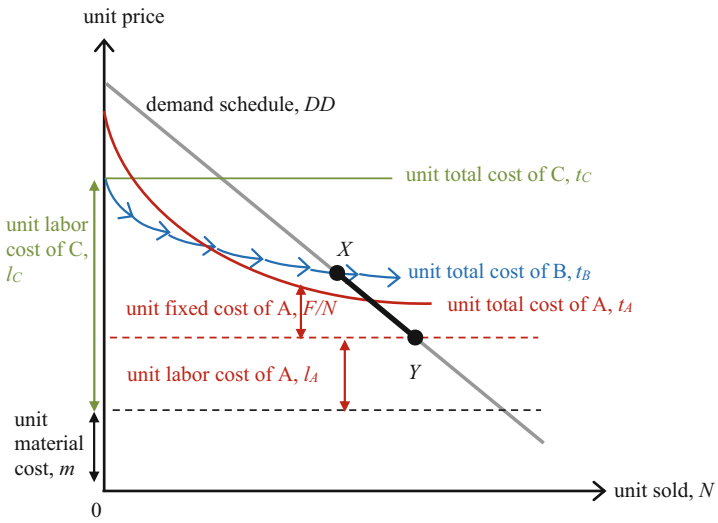


Fig. A.1 Which type of firms would prevail on the market?

A.1.4 Remark: The Learning Curve Explained

At this point, a brief detour is needed about the special hypothesis of learning-by-doing, initiated by Alchian (1963) and Arrow (1962), but criticized by Scott-Kemmis and Bell (2010). The Alchian–Arrow thesis postulates that output from given input rises by experience, which may be represented by the accumulated outputs over time, notably the production of airframe during WWII. Scott-Kemmis and Bell, drawing from records, claimed that it is just mythology as in reality there are instead discoveries of facts and redesigns of the process rather than the mere accumulation of production experience.

To us, the acid test is Example 4B of *Nihonto* (Japanese knife), under the desperate battlefield needs facing Mongolian invasion, and observation, redesign, and modification of various aspects of production are involved. As Solow commented about Schumpeter's theory on innovation, "the process can never be smooth." Desperate measures emerge from desperate circumstances.

Another empirical rule is the Moore's law in the miniaturization of microelectronic processors over time, which is known to "shift" over time as all empirical laws do. And there are classical remedial tools like the Chow test. With common sense, one is not likely to extrapolate the production statistics about the horse and buggy to automobiles, though both are means of transportation.

There may exist cases where some numerical index (such as cumulated output over time) may be used as a proxy for "experience" rather than using the entire descriptive history.[1] Thus, some quantitative formulation can be made, to be shared with interested readers, and some simulation exercises might be formulated to analyze and explain what goes on.

A.1.5 Three Types of Firms, Again

Today, the Schumpeterian competition has a far faster pace. One wave of innovative products replacing the other, setting the pace of offshore outsourcing for *cheap* workers overseas, or segmentation of production between designing and manufacturing.

[1] An example is when a patient seeks the venue for open-heart surgery in the United States. There are open-source data series, showing that the percentage of surgery failure declines with the length of time of both the surgeon at a hospital and the supporting team working together. The patient can make the choice, though the waiting period varies. So the data of using the cumulative number of operations for experience is an operational device helpful in planning and saving lives. If instead of publicly available indices one has to rely on archives of available histories, the outcome is most likely less satisfactory.

Therefore, time-to-market becomes an important advantage. This makes logistics a field of its own, laying at the same time the ground of Taiwan's Foxconn to become a million-employees giant, straddling the Taiwan Strait.

For firms operating in the market, three modes can be distinguished, and more studies can be done in the future.

1. Mass-producing science-based firms of the Western world. Their strategic intent is represented by what TSMC's Morris Chang had practiced at Texas Instrument, pricing ahead of the cost curve, or sacrificing early profits to gain market share and achieve manufacturing yields that would result in greater long-term profits (Myers, 2014). For a formal analysis, see Wan (1966).
2. Monopolistic competitive firms, with recognizable brand reputation, under the Japanese *Kaizen* system.
3. Pure price-taking mode, for traditional Chinese firms in perfect competition, but without much R&D.

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