Essays on Globalization, Skill Upgrading, and the Labor Market

Qiliang Chen

A dissertation
submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington

2023

Reading Committee:

Stephen Turnovsky, Chair

Jing Tao

Yuya Takahashi

Program Authorized to Offer Degree:
Economics

University of Washington

Abstract

Essays on Globalization, Skill Upgrading, and the Labor Market

Qiliang Chen

Chair of the Supervisory Committee:
Stephen Turnovsky
Department of Economics

This dissertation contributes to our understanding of the impact of global integration on skill upgrading and labor market outcomes. Across the three chapters of this dissertation, I investigate how foreign direct investment shapes skill upgrading decisions made by households, how trade liberalization affects firms' on-the-job training decisions, and how three dimensions of globalization (trade, FDI, and migration) exert an influence on the labor market.

The first chapter develops a dynamic stochastic general equilibrium model to address how foreign direct investment affects skill upgrading and wage inequality following households' endogenous labor training decisions. The model predicts that inward FDI in developing countries creates a positive productivity spillover effect on domestic firms and encourages more workers to invest in labor training to upgrade their skills. Lifting restrictions on FDI gives rise to higher wage inequality because multinational firms create more high-skill jobs and increase firm-level productivity. Compared to the special case with fixed high-skilled worker formation, the benchmark model with the skill upgrading channel produces smaller wage inequality over time.

The second chapter studies the short-term heterogeneous impacts of an Asian trade agreement, APTA, on skill upgrading performed by Chinese manufacturers. First, we develop a general equilibrium model of trade with heterogeneous firms, endogenous export decisions, and endogenous skill upgrading decisions to explain firm performance following trade liberalization. Second, we test the theoretical model by means of generalized difference-

in-differences estimations, which demonstrate that firms facing higher reductions in India's tariffs invest more rapidly in on-the-job training. The effect of trade openness on export participation is the largest for firms with mid-range productivity, whereas that on training spending is the smallest for the same group of firms, which calls for policy attention. Chapter two is a joint work with Chujian Shao[1] and Chen Zhuang[2].

In the third chapter, panel structural vector autoregression is utilized to study how global integration affects the labor market based on data from 141 countries over the period of 1991-2021. Three dimensions of globalization are considered, including trade, foreign direct investment, and international migration. The empirical results show that trade globalization has more significant effects on labor market outcomes compared to financial globalization (FDI) and interpersonal globalization (labor migration). Specifically, trade integration is associated with higher labor productivity, a lower unemployment rate, a higher labor force participation rate, and lower income and wealth gaps between the top 10% and the bottom 50% of the population. Overall, the impact of globalization on labor market outcomes is similar in high-income countries and the rest of the world.

---

[1]Email: cshao206@gmail.com

[2]Email: zogcee@gmail.com

TABLE OF CONTENTS

LIST OF FIGURES

Figure Number Page

LIST OF TABLES

ACKNOWLEDGMENTS

I would like to express my deepest gratitude and appreciation to all those who have supported me throughout this journey of completing my Ph.D. dissertation.

First and foremost, I am immensely grateful to my supervisor, Dr. Stephen Turnovsky, for his exceptional mentorship and invaluable insights. I am also deeply indebted to the members of my dissertation committee, Dr. Jing Tao, Dr. Yuya Takahashi, and Dr. Brian Flaherty, for their valuable feedback, constructive criticism, and expert guidance. Without their continuing encouragement, advice, and assistance, this attainment would not have been possible.

I would also like to extend my gratitude to Dr. Fabio Ghironi for his great support and inspiring teaching. I am thankful to Dr. Philip Brock, Dr. Yu-chin Chen, Dr. Yanqin Fan, Dr. Fahad Khalil, Dr. Quan Wen and all faculty of the UW Economics Department who taught me and held discussions with me. Their contributions have been indispensable to the completion of this dissertation.

My heartfelt thanks go to Dr. Chujian Shao and Dr. Chen Zhuang. Their stimulating discussions and collaborative efforts have furthered my research, and their companionship and encouragement have been a constant source of motivation. I also thank all my friends and fellow students for their kindness and support.

I am deeply appreciative of the generous funding provided by the Economics Department and the Statistics Department of the UW, which has enabled me to pursue my Ph.D. studies. I am very thankful to Dr. Caren Marzban and Dr. Alexander Giessing for trusting and hiring me as a teaching assistant. I am also very grateful to Dr. Haideh Salehi-Esfahani and Dr. Dennis O'Dea for their guidance while I worked as a teaching assistant for them. My special thanks go to Heidi Hannah, Simon Reeve-Parker, and Ellen Reynolds for their enormous administrative efforts. I want to also thank Chris Fendrich for kindly navigating me through payroll documents; his memory will always be with me.

Lastly I would like to express my gratitude to my parents and grandmother for their unwavering love, encouragement, and belief in my abilities. Their patience, understanding, and emotional support have been invaluable throughout this challenging process.

Thank you all for being part of this remarkable chapter of my life.

DEDICATION

to my family

Chapter 1

FOREIGN DIRECT INVESTMENT, SKILL UPGRADING, AND WAGE INEQUALITY

1.1 Introduction

According to the OECD statistics, global FDI flows were up to USD 972 billion in the first half of 2022 and increased by 9% compared to the first half of 2021 as shown in Figure 1.1. The United States is not only the leading FDI recipient but also the largest investor worldwide. Figure 1.2 indicates that the United States attracted the most FDI in the world in 2022, followed by China and Brazil, while China was the largest FDI recipient in certain periods of 2018, 2020 and 2021.[1] Compared to advanced economies, less developed regions experienced greater growth in FDI over the past few decades (Figure 1.3 and Figure 1.4). To be precise, Table 1.1 presents that net FDI inflows in low and middle income countries increased by 592% from 1990 to 2000, and edged down to 341% from 2000 to 2010, while those in high income countries dropped by 8.3% during the same period. In the past decade, most countries encountered a decline in FDI, but the reduction in high income countries was much larger. Therefore, a lot of studies attempt to investigate if FDI plays a role in stimulating economic growth, creating technological improvement, and enhancing workers' skill levels in less developed countries. An impressive amount of empirical literature finds that FDI leads to higher wages, productivity, and wage inequality, and some theoretical models of FDI analyze the effects of market size, productivity spillover, credit, and technology transfer on inequality. Moreover, the labor training channel has become a recent research focus, but most related research studies on-the-job training investment made by firms. Instead, this paper models households' training decisions. Trained workers can supply labor to perform skilled tasks for multinational firms if they are productive enough.

This paper develops a dynamic stochastic general equilibrium model featuring heterogeneous

[1] The top three investors worldwide in 2022 were the US, the Netherlands, and Australia.

workers and firms to investigate how inflows of foreign direct investment affect skill upgrading and wage inequality following households' endogenous labor training decisions in developing countries. Following Mandelman and Zlate (2022), the model features endogenous margins of labor training, and workers are heterogeneous in skill after training. The representative household decides how many raw labor units are converted into efficiency units of labor via skill upgrading and whether they provide skilled tasks to multinational firms. Workers need to pay an additional fixed cost of training to become eligible to execute tasks in multinational firms. The model also features an exogenous process for inward FDI for simplicity, i.e., the number of multinational firms. There are two sectors in the economy, namely, the final goods sector and the intermediate goods sector. The final output is a standard CES composite of one set of varieties produced by local firms and another set of varieties produced by multinational firms. In the intermediate goods sector, firms are heterogeneous in firm-level productivity, and they are subject to monopolistic competition. Local firms demand labor tasks executed by skilled workers and raw labor of untrained, low-skilled workers, while multinational firms only demand labor tasks provided by skilled workers with the highest productivity.

Important findings from the model are summarized below. Fewer restrictions on FDI entry[2] in the host economy boost output and consumption levels and encourage more workers to invest in labor training so they can transfer from the unskilled department to the skill-intensive department in the local firms or seek employment in the multinational firms. Inflows of FDI result in a higher skill premium for workers from either domestic or foreign firms, which reflects greater wage inequality. Additionally, high-skilled workers in FDI firms have a higher income share, while workers in the skill-intensive department of local firms witness a decrease in their income share. Surprisingly, low-skilled workers' income share increases following a reduction in the FDI entry cost. Even though wage inequality goes up, low-skilled workers still benefit from FDI to some extent because of higher firm

[2] According to OECD, there are four main types of restrictions on FDI: "foreign equity limitations, discriminatory screening or approval mechanisms, restrictions on the employment of foreigners as key personnel, and operational restrictions". The FDI Regulatory Restrictiveness Index is calculated to measure statutory restrictions on foreign direct investment. In this paper, types of restrictions are not distinguished for simplicity, and the reduction in FDI entry cost is equivalent to removing FDI restrictions.

productivity and aggregate income. These findings reflect how aggregate income allocation in the economy changes. We also find that FDI leads to a positive spillover effect on domestic firms by increasing firm-level productivity and creating more skilled jobs.

The household needs to pay a sunk cost to train new skilled workers. Skilled workers seeking employment in multinational firms are required to pay additional training costs each period. We discuss dynamic adjustments of key variables following reductions in the sunk cost of high-skilled worker formation and the per-period fixed cost of labor training. A decrease in the sunk entry cost boosts the number of new high-skilled workers and increases the stock of high-skilled workers in both local and multinational firms. Meanwhile, the labor productivity cutoff declines, so workers find it easier to meet the requirements of multinational firms in terms of their productivity. In this case, the average skill premium decreases and firm-level productivity increases with more high-skilled labor supply in the economy. Following a reduction in the fixed training cost, the stock of high-skilled workers, average skill premium, and average productivity of multinational firms are higher, while the corresponding effects on local firms are negative. These findings indicate that local firms lose competitiveness if workers face fewer barriers to being employed by multinational firms.

Finally, to highlight the roles of skill upgrading and FDI in the model, two alternative scenarios are analyzed. Shutting down the skill upgrading channel makes the number of high-skilled workers stay constant, which leads to a higher skill premium over time following a reduction in the fixed cost of FDI entry or an increase in aggregate productivity. Thus, the skill upgrading channel helps narrow wage differences. Assuming the number of multinational firms is greater than the value calibrated in the baseline model, wage inequality escalates. More FDI firms make the host country better off by raising aggregate output and consumption and increasing demand for skilled labor and skill premiums.

There are three related strains of research work. First, this paper builds upon previous literature on the impact of FDI on inequality. The influence of trade liberalization, labor migration, and FDI flows on job creation and destruction and income inequality has been much debated in the literature recently. Acemoglu (2003) finds that trade opening induces skill-biased change and causes a rise in inequality, and Mandelman and Zlate (2022) argue that low-skilled immigration encourages native workers to upgrade their skills and move into skilled occupations, resulting in a greater skill premium. In terms of FDI empirical studies, Hale and Xu (2015) summarize that FDI leads to an increase in income inequality in most studies, but several papers have opposite results.[3] Some theoretical work discusses what channels create higher inequality. For instance, Hijzen et al. (2013) find that wage effects because of foreign-owned firms are larger in developing countries and workers moving from domestic to foreign firms have the largest effect on wages. Driffield and Taylor (2000) conclude that inward FDI increases wage inequality by increasing demand for skilled workers and creating technology spillovers from foreign to domestic firms. One of the main objectives in this paper is to investigate if lifting restrictions on FDI in the host country increases skill premiums and redistributes incomes.[4]

Second, this paper is also related to a recent stream of theoretical literature that models labor training decisions. Head and Ries (2002) and Jung and Mercenier (2014) discuss the skill upgrading effects of offshoring production in the home country, and Sousa (2001), Dunning and Lundan (2008) and Liu and Qiu (2014) emphasize the importance of labor training provided by multinational firms. Koch and Smolka (2019) also find that foreign-acquired firms hire high-skilled workers and provide worker training to raise skills and innovation from the perspective of Spain. This paper focuses on how inflows of FDI affect households' labor training decision in the host country instead of on-the-job labor training provided by firms. The model setting in this paper relates to Mandelman and Zlate (2022), but also differs from it by incorporating an endogenous labor training decisions to provide skilled tasks for local or multinational firms.[5]

Third, this paper adds to the literature on the role of FDI in firm-level productivity and how it benefits host countries. Smarzynska Javorcik (2004) provides empirical evidence that

[3]For instance, Vargas Da Cruz et al. (2018) find that FDI in the emerging markets may create higher wages for unskilled workers relative to skilled workers.

[4]This paper doesn't discuss the driver of FDI flows or distinguish vertical and horizontal FDI. Matsumoto (2022) points out that reserve accumulation can attract foreign direct investment inflows. The share of vertical FDI is larger than commonly thought as discussed in Alfaro and Charlton (2009). Other research topics emphasize how FDI affects economic growth (Herzer (2012)) or regional inequality (Lessmann (2013)).

[5]Hakkala et al. (2014) distinguishes job tasks and labor skill, while this paper assumes that each skilled worker executes a certain task for firms.

FDI creates positive productivity spillover effects on domestic firms based on firm-level data from Lithuania. Moreover, Aitken Brian and Ann (1999) and Keller and Yeaple (2009) also study the FDI spillover effect on manufacturing firms in Venezuela and the US respectively. FDI firms have a financial advantage, so they face a lower productivity cutoff than local firms, even though they face a higher fixed production cost (Han et al. (2022)). A larger amount of literature examines the role of offshoring on firm-level productivity and skill upgrading in the home country with endogenous offshoring decisions. Theoretical studies such as Helpman et al. (2004), Yeaple (2009) and Zlate (2016) create models in which heterogeneous firms whose productivity exceeds a cutoff open an affiliate in foreign countries. Empirical studies including Carluccio et al. (2019) consider that only productive firms offshore skill-intensive or labor-intensive inputs, and provide evidence that reductions in fixed offshoring costs increase firm-level skill intensities. On the other hand, this paper proposes an exogenous process for FDI inflows featuring firm heterogeneity and finds that a decrease in the fixed cost of FDI entry improves firm-level productivity in the host economy.

The rest of the paper is organized as follows. Section 1.2 presents the benchmark model. Section 1.3 discusses model calibration. Section 1.4 explains the results. Section 1.5 concludes.

1.2 The Model

1.2.1 Household

Household members can work for either domestic or multinational firms. Workers are heterogeneous in their skills. Following Mandelman and Zlate (2022), the household faces an endogenous training decision since they can allocate low-skilled labor to the unskilled department of domestic firms or upgrade their skills to match the requirements of the skilled department. If they invest more in training, they will be able to provide skilled tasks to multinational firms.

A representative household is confronted with the subsequent lifetime utility maximization problem.

$$\max_{(C_t, L_t,, N_{e,t})} E_t \sum_{s=t}^{\infty} \beta^{s-t} \{ \frac{C_s^{1-\gamma}}{1-\gamma} - \frac{\chi}{1+\psi_l} L_s^{1+\psi_l} \}$$

Here, $\beta \in (0,1)$ represents the subjective discount factor, $\gamma > 0$ signifies the reciprocal of the inter-temporal elasticity of substitution, and $\psi_l \geq 0$ stands for the inverse of the Frisch elasticity of labor supply. L_t denotes the aggregate supply of raw labor provided by all workers. The budget constraint is

$$w_{u,t} L_t + \tilde{\pi}_t N_t + \Pi_t = C_t + f_{e,t} N_{e,t} \tag{1.1}$$

In each time period, the household generates income from unskilled wages by elastically providing raw labor $w_{u,t} L_t$, gains compensation by supplying skilled labor, $\tilde{\pi}_t N_t$ and receives profits Π_t from all firms. The household uses its income to purchase consumption goods C_t. There are $N_{e,t}$ new skilled workers joining the stock of existing skilled workers N_t. The household pays a sunk cost $f_{e,t}$ to train $N_{e,t}$ new skilled workers. The sunk training cost is expressed in units of raw labor: $f_{e,t} = w_{u,t} f_e$. New skilled workers participate in training at time $t-1$ and start to work at time t. With the time-to-build assumption and an exogenous skill-destruction shock δ, the quantity of skilled workers changes period by period according to the following equation:

$$N_t = (1-\delta)(N_{t-1} + N_{e,t-1}) \tag{1.2}$$

The raw labor supply L_t is derived as

$$w_{u,t} = \chi L_t^{\psi_l} C_t^{\gamma} \tag{1.3}$$

From the optimal choice of new skilled workers $N_{e,t}$ we derive the following equilibrium condition:

$$f_{e,t} = E_t \sum_{s=t+1}^{\infty} [\beta(1-\delta]^{s-t} \left(\frac{C_s}{C_t} \right)^{-\gamma} \tilde{\pi}_s \tag{1.4}$$

The skilled workers are heterogeneous in their degree of skill. This is demonstrated by their individualized productivity factor, denoted as a, which follows a collective distribution $G(a)$ spanning the interval $[1, \infty)$. Each worker realizes their productivity a after paying a sunk training cost $f_{e,t}$. Each skilled worker supplies a number of raw labor units $l_t(a)$

and produces labor tasks $n_t(a) = al_t(a)$, which can also be interpreted as the total number of efficiency units of labor provided by each skilled worker. A skilled worker with productivity $a > a_{m,t}$ executes a task for multinational firms with $n_{m,t}$ units of efficiency labor. Conversely, a skilled worker with productivity below $a_{m,t}$ executes a task for domestic firms with $n_{d,t}$ units of efficiency labor.

Skill Premiums and Tasks

The skill premium of workers employed in local firms is determined by the disparity between the income earned from a task $n_{d,t}(a)$ within the skill-intensive department of domestic firms and the income earned by raw labor in the unskilled department:

$$\pi_{d,t}(a) = w_{d,t}(a)n_{d,t}(a) - w_{u,t}l_{d,t}(a) \tag{1.5}$$

where domestic firms pay wage $w_{u,t}$ for raw labor and $w_{d,t}(a)$ for skilled workers. Home workers with higher skill levels provide tasks demanded by multinational firms, while there is an additional fixed training cost $f_{h,t}$. The skill premium for a skilled task delivered to multinational firms is

$$\pi_{m,t}(a) = w_{m,t}(a)n_{m,t}(a) - w_{u,t}l_{m,t}(a) - f_{h,t} \tag{1.6}$$

where $w_{m,t}(a)$ is the wage paid for the task demanded by multinational firms.

Workers choose to perform tasks for multinational firms if they receive a skill premium ($\pi_{m,t}$) greater than 0 after paying for a fixed training cost $f_{h,t}$ for skill upgrading. This fixed training cost is expressed in units of raw labor: $f_{h,t} = w_{u,t}f_h$. Equivalently, a worker with an idiosyncratic productivity level a above a threshold value $a_{m,t}$ benefits from providing tasks for multinational firms. If her benefit is offset by the skill upgrading cost $f_{h,t}$, the skill premium is equal to zero. On the other hand, a worker provides tasks for domestic firms only with productivity below $a_{m,t}$.

The number of skilled workers is $N_{d,t}$, while only a subset of $N_{m,t}$ skilled workers with $a > a_{m,t}$ provide tasks for multinational firms.

Labor tasks are imperfect substitutes in production. θ is the symmetric elasticity of substitution. The CES composite of tasks provided by skilled workers with productivity below $a_{m,t}$ is the aggregate skilled task demanded by domestic firms.

$$H_{d,t} = \left(\int_1^{a_{m,t}} n_t(a)^{\theta-1} dG(a) \right)^{\frac{1}{\theta-1}} \tag{1.7}$$

The aggregate high-skilled task demanded by multinational firms is a CES aggregate of tasks with productivity above the threshold $a > a_{m,t}$ provided by skilled workers with additional investment in training:

$$H_{m,t} = \left(\int_{a_{m,t}}^{\infty} n_t(a)^{\theta-1} dG(a) \right)^{\frac{1}{\theta-1}} \tag{1.8}$$

Average Labor Productivity, Wages and Skill Premiums

Similar to Melitz (2003), the labor productivity of skilled workers follows a Pareto distribution given by $F(a) = 1 - a^{-\lambda}$. The average productivity of the mass of $N_{d,t}$ skilled workers is

$$\tilde{a}_{d,t} = \frac{1}{F(a_{m,t})} \left(\int_1^{a_{m,t}} a^{\theta-1} dF(a) \right)^{\frac{1}{\theta-1}} = \phi a_{m,t} \left(\frac{a_{m,t}^{\lambda-(\theta-1)} - 1}{a_{m,t}^{\lambda} - 1} \right)^{\frac{1}{\theta-1}} \tag{1.9}$$

The average productivity of $N_{m,t}$ of skilled workers above the threshold $a_{m,t}$ is

$$\tilde{a}_{m,t} = \frac{1}{1 - F(a_{m,t})} \left(\int_{a_{m,t}}^{\infty} a^{\theta-1} dF(a) \right)^{\frac{1}{\theta-1}} = \phi a_{m,t} \tag{1.10}$$

where $\phi = \left(\frac{\lambda}{\lambda-(\theta-1)} \right)^{1/(\theta-1)}$ and $\lambda > \theta - 1$. The share of high-skilled workers executing tasks for multinational firms is

$$\frac{N_{m,t}}{N_t} = \left(\frac{1}{a_{m,t}} \right)^{\lambda} \tag{1.11}$$

Under monopolistic competition, skilled workers maximize their skill premium. The average wages of skilled workers working for local firms $\tilde{w}_{d,t}$ and multinational firms $\tilde{w}_{m,t}$ are respectively derived as

$$\tilde{w}_{d,t} = \frac{\theta}{\theta-1} \frac{w_{u,t}}{\tilde{a}_{d,t}} \qquad \tilde{w}_{m,t} = \frac{\theta}{\theta-1} \frac{w_{u,t}}{\tilde{a}_{m,t}} \tag{1.12}$$

The average skill premium for high-skilled tasks demanded by domestic firms is

$$\tilde{\pi}_{d,t} = \pi_t(\tilde{a}_{d,t}) = \frac{1}{\theta} (\tilde{w}_{d,t})^{1-\theta} (p_{h,t}^{d})^{\theta} H_{d,t} \tag{1.13}$$

The average skill premium for high-skilled tasks demanded by multinational firms is

$$\tilde{\pi}_{m,t} = \pi_t(\tilde{a}_{m,t}) = \frac{1}{\theta}(\tilde{w}_{m,t})^{1-\theta}(p^m_{h,t})^{\theta}H_{m,t} - f_{h,t} \tag{1.14}$$

Next, the average skill premium for total skilled workers is

$$N_t\tilde{\pi}_t = N_{d,t}\tilde{\pi}_{d,t} + N_{m,t}\tilde{\pi}_{m,t} \tag{1.15}$$

The price indexes of high-skilled task bundles for local and domestic prices are respectively

$$p^d_{h,t} = [N_{d,t}(\tilde{w}_{d,t})^{1-\theta}]^{1/(1-\theta)} \qquad p^m_{h,t} = [N_{m,t}(\tilde{w}_{m,t})^{1-\theta}]^{1/(1-\theta)} \tag{1.16}$$

1.2.2 Production

The production of final goods takes place under conditions of perfect competition. A representative producer of final goods blends intermediate goods manufactured by both domestic and multinational enterprises. In the intermediate goods sector, the mass of domestic firms is M_d and the mass of FDI firms is M_m. The mass is assumed to be exogenous in the model. Each firm pays a fixed entry cost in units of final goods to draw its firm productivity z. Additionally, each multinational firm also needs to pay an additional fixed entry cost to enter and produce in the host country, which reflects higher operational costs for multinational firms than local firms.

Final Goods Sector

Domestic firms ($\Omega_{d,t}$ being the mass) produce a set of varieties of goods, and multinational firms ($\Omega_{m,t}$) produce another set of varieties of goods. The aggregate production aggregates two types of inputs in Armington form:

$$Y_t = \left[\int_{\omega\in\Omega_{d,t}} y_{d,t}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega + \int_{\omega^*\in\Omega_{m,t}} y_{m,t}(\omega^*)^{\frac{\sigma-1}{\sigma}} d\omega^*\right]^{\frac{\sigma}{\sigma-1}} \tag{1.17}$$

where $\sigma > 1$ is the elasticity of substitution among the varieties. $y_{d,t}$ is the demand for a domestic variety ω, whereas $y_{m,t}(\omega^*)$ is the demand for a variety provided by a multinational firm ω^*. We have the following profit maximization problem for the final goods producer:

$$\max_{y_{d,t}(\omega), y_{m,t}(\omega^*)} P_tY_t - \int_{\omega\in\Omega_{d,t}} P_{d,t}(\omega)y_{d,t}(\omega)\mathrm{d}\omega - \int_{\omega^*\in\Omega_{m,t}} P_{m,t}(\omega^*)y_{m,t}(\omega^*)\mathrm{d}\omega^*$$

subject to Eq.(1.17). $P_{d,t}(\omega)$ and $P_{m,t}(\omega^*)$ are the prices of a domestic and a FDI variety ω, respectively. We hence derive the demand functions for varieties provided by domestic firms $y_{d,t}(\omega)$ and varieties provided by multinational firms $y_{m,t}(\omega)$, and the price function of aggregate output P_t.

$$y_{d,t}(\omega) = \left[\frac{P_{d,t}(\omega)}{P_t}\right]^{-\sigma} Y_t = \rho_{d,t}(\omega)^{-\sigma} Y_t \tag{1.18}$$

$$y_{m,t}(\omega^*) = \left[\frac{P_{m,t}(\omega^*)}{P_t}\right]^{-\sigma} Y_t = \rho_{m,t}(\omega^*)^{-\sigma} Y_t \tag{1.19}$$

$$P_t = \left[(P_{d,t})^{1-\sigma} + (P_{m,t})^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{1.20}$$

where $P_{d,t} = \left[\int_{\omega\in\Omega_{d,t}} M_d P_{d,t}(\omega)^{1-\sigma} d\omega\right]^{1/(1-\sigma)}$, $P_{m,t} = \left[\int_{\omega^*\in\Omega^*_{m,t}} M_m P_{m,t}(\omega^*)^{1-\sigma} d\omega^*\right]^{1/(1-\sigma)}$. We use $\rho_{d,t}(\omega) = \frac{P_{d,t}(\omega)}{P_t}$ and $\rho_{m,t}(\omega^*) = \frac{P_{m,t}(\omega^*)}{P_t}$ to denote the relative prices of domestic and FDI varieties, respectively.

Intermediate Goods Sector

Every firm incurs a fixed entry cost denoted as $f_{d,t}$ upon entering the market, and selects its productivity level z from the distribution $G(z)$. Each multinational firm not only needs to pay a fixed entry cost $f_{d,t}$ measured in units of final goods, but also incurs an additional fixed cost of FDI entry $f_{o,t}$ measured in units of final goods, prior to drawing its productivity z^*. Note that a firm's productivity z (z^*) will be used as the index for the firm. All firms are subject to the identical aggregate productivity factor Z_t.

Domestic Firms. There exists a mass M_d of domestic firms that are actively producing in the domestic market. Under monopolistic competition, firms take the demand functions for their varieties as given. Production is done with a Cobb-Douglas production function as follows:

$$y_{d,t}(z) = Z_t z h^{\eta}_{d,t}(z) l^{1-\eta}_{u,t}(z) \tag{1.21}$$

Production inputs include skilled tasks executed by skilled workers from the skill-intensive department and raw labor from the unskilled department. $h_{d,t}$ and $l_{d,t}(z)$ represent the demand for raw labor units and skilled tasks executed by a group of skilled workers from a domestic producer with productivity z. A domestic firm with productivity z chooses $h_{d,t}(z)$ and $l_{d,t}(z)$ to minimize production costs:

$$\min_{h_{d,t}(z),l_{u,t}(z)} p^d_{h,t}h_{d,t}(z) + w_{u,t}l_{u,t}(z)$$

subject to the technology constraint in Eq.(1.21). All variables are expressed in real terms. $w_{u,t} \equiv W_{u,t}/P_t$ is the real wage for supplying raw labor, and $p^d_{h,t} \equiv P^d_{h,t}/P_t$ is the real price index of skilled tasks demanded by domestic firms.

The first order conditions of $h_{d,t}(z)$ and $l_{u,t}(z)$ pin down

$$p^d_{h,t} = mc_{d,t}(z)\eta\frac{y_{d,t}(z)}{h_{d,t}(z)} \tag{1.22}$$

$$w_{u,t} = mc_{d,t}(z)(1-\eta)\frac{y_{d,t}(z)}{l_{u,t}(z)} \tag{1.23}$$

where $mc_{d,t}(z)$ is the real marginal cost of producing one unit of an intermediate good by domestic producers. The expression of $mc_{d,t}(z)$ is

$$mc_{d,t}(z) = \frac{1}{zZ_t}\left(\frac{p^d_{h,t}}{\eta}\right)^{\eta}\left(\frac{w_{u,t}}{1-\eta}\right)^{1-\eta} \tag{1.24}$$

The relative price index of an intermediate good produced by the domestic firm is $\rho_{d,t}(z) = \frac{\sigma}{\sigma-1}mc_{d,t}(z)$. The profit earned by a domestic firm with productivity z is $d_{d,t}(z) = \frac{1}{\sigma}\rho_{d,t}(z)^{1-\sigma}Y_t - f_{d,t}$.

Multinational Firms. There exists a mass M_m of multinational firms from the rest of the world entering the home country. Multinational firms only demand skilled tasks executed by the most productive workers. Thus, the production function of a multinational firm is expressed as

$$y_{m,t}(z^*) = Z_t z^* h_{m,t}(z^*) \tag{1.25}$$

We solve the profit maximization problem to get the relative price index $\rho_{m,t}(z^*)$ of an intermediate good produced by the multinational firm: $\rho_{m,t}(z^*) = \frac{\sigma}{\sigma-1}\frac{p^m_{h,t}}{z^*Z_t}$. The corresponding profit is $d_{m,t}(z^*) = \frac{1}{\sigma}\rho_{m,t}(z^*)^{1-\sigma}Y_t - f_{d,t} - f_{o,t}$.

Condition for Productivity Cutoffs

We substitute the demand functions and price equations to get

$$d_{d,t}(z) = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\frac{1}{zZ_t}\left(\frac{p^d_{h,t}}{\eta}\right)^{\eta}\left(\frac{w_{u,t}}{1-\eta}\right)^{1-\eta}\right)^{1-\sigma} Y_t - f_{d,t}$$

for domestic firms and

$$d_{m,t}(z^*) = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\frac{p^m_{h,t}}{z^* Z_t}\right)^{1-\sigma} Y_t - f_{d,t} - f_{o,t}$$

for multinational firms.

Firms will not produce unless their productivity levels are higher than a threshold. The zero cutoff profit conditions pin down their productivity thresholds. Denote z_d (z_m) as the productivity cutoff for domestic firms (multinational firms). Combining the two conditions, we derive the ratio of two productivity thresholds:

$$\frac{z_{d,t}}{z_{m,t}} = \left(\frac{f_{d,t}}{f_{d,t}+f_{o,t}}\right)^{\frac{1}{\sigma-1}} \frac{1}{p^m_{h,t}}\left(\frac{p^d_{h,t}}{\eta}\right)^{\eta}\left(\frac{w_{u,t}}{1-\eta}\right)^{1-\eta} \tag{1.26}$$

Condition for Average Firm-level Productivity

Following Ghironi and Melitz (2005), we posit that domestic and multinational firms' productivities follow respective Pareto probability distributions, i.e., $G(z) = 1-(z_{min}/z)^{\kappa}$ and $G^*(z) = 1-(z^*_{min}/z)^{\kappa^*}$. Therefore, the average productivity $\tilde{z}_d$ ($\tilde{z}_m$) for domestic firms (multinational firms) is:

$$\begin{aligned}
\tilde{z}_{d,t} =& \frac{1}{1-G(z_{d,t})}\left(\int_{z_d}^{\infty} z^{\sigma-1} dG(z)\right)^{\frac{1}{\sigma-1}} = \nu z_{d,t} \\
\tilde{z}_{m,t} =& \frac{1}{1-G^*(z_{m,t})}\left(\int_{z_m}^{\infty} z^{\sigma-1} dG^*(z)\right)^{\frac{1}{\sigma-1}} = \nu^* z_{m,t}
\end{aligned}$$

where parameters $\nu \equiv \left(\frac{\kappa}{\kappa-(\sigma-1)}\right)^{1/(\sigma-1)}$ and $\kappa > \sigma - 1$. The total firm profit is $\Pi_t = M_d\tilde{d}_{d,t} + M_m\tilde{d}_{m,t}$.

1.2.3 Aggregate Accounting

Final Goods Clearing Condition The resource constraint takes into account the household's consumption, the fixed costs of firm setup, and costs of FDI entry

$$Y_t = C_t + (M_d + M_m) f_{d,t} + M_m f_{o,t} \tag{1.27}$$

Labor Market Clearing Condition The total supply of raw labor is divided across the supply of raw labor in the unskilled department of local firms, the production of high-skilled tasks demanded by local and multinational firms, the sunk entry cost of new skilled workers, and the training cost of workers executing tasks for multinational firms.

$$L_t = N_{d,t}(\tilde{l}_{u,t} + \tilde{l}^d_{h,t}) + N_{m,t}\tilde{l}^m_{h,t} + N_{e,t} f_{e,t} + N_{m,t} f_{h,t} \tag{1.28}$$

1.3 Calibration

The model is calibrated to match the average of the 10 developing countries during the period of 2005–2022. We set the parameters based on the literature in a bid to be compatible with the characteristics of those developing countries (see Table 1.2 for details).

The discount factor β is set at 0.99, while the coefficient of relative risk aversion γ is assigned a value of 2. To be in line with the microeconomic estimates in Chetty et al. (2013), we set the Frisch elasticity $1/\psi_l$ equal to 0.75. The disutility from labor $\chi = 0.35$. As in Davis and Haltiwanger (1990), the quarterly job destruction rate δ is calibrated at 0.025. The elasticity of substitution between tasks is $\theta = 1.67$ following Mandelman and Zlate (2022).

To match the average inflows of FDI as a percentage of GDP 1.8%, the numbers of domestic and FDI firms are 1 and 0.2 respectively. Based on the FDI restriction index, the fixed entry cost of all firms is normalized at $f_d = 1$ and the fixed cost of FDI entry $f_o = 1.25$. Following Ghironi and Melitz (2005), we choose 3.8 as the elasticity of substitution between goods σ, and 3.4 as the parameter κ of the Pareto distribution for firm productivity. The share of high-skilled tasks employed by domestic firms η is set at 0.15 to match the overall educational achievement of the population aged 25 and older with a bachelor's degree or equivalent.

The remaining parameters in the model affect income shares among low- and high-skilled occupations. Empirically, average income shares held by the top 20%, the middle 40%, and the lowest 40% are 48%, 25%, and 17% respectively. The model-implied income shares of high-skilled workers in multinational firms and high-skilled and low-skilled workers in local firms help match these three targets. Thus, the Pareto distribution of idiosyncratic labor productivity λ is calibrated to 3.4. The sunk cost to train new skilled workers is normalized at $f_e = 1$ without loss of generality, and the additional per-period fixed training cost of skilled workers employed by foreign firms is set to $f_h = 1.4$ to target the average income share among the high skill workers in these countries.

1.4 Results

1.4.1 Impulse Responses

We look into the impulse response functions of key variables to innovations in aggregate productivity, the fixed cost of FDI entry, the sunk cost of high-skilled worker formation, and the fixed labor training cost in multinational firms.

Increase in Aggregate Productivity. Figure 1.5 illustrates the reactions to a temporary 1% increase in aggregate productivity Z in the host country. Higher aggregate productivity leads to higher output and encourages more labor training. The increase in the aggregate productivity triggers a decline in the labor productivity cutoff a_m, so the most skilled workers are able to switch from working for local firms to multinational firms. High-skilled workers are more willing to provide tasks for multinational firms when the market is more productive. There is a big drop in low-skill income share from the steady state, while skilled workers employed by either domestic or multinational firms benefit from higher income as a result of an increase in aggregate productivity. Moreover, the productivity cutoff of multinational firms negatively deviates from its steady state level, which indicates that foreign firms find it easier to operate in the host country.

Reduction in the Fixed Cost of FDI Entry. Fewer restrictions on FDI inflows in the host country is reflected by a decline in the fixed cost of FDI entry $f_{o,t}$. Lower FDI entry barriers increase the profitability of multinational firms, and thus a temporary 1%

decrease in the fixed cost of FDI entry creates more skilled jobs, and more workers choose to upgrade their skill levels, as shown in Figure 1.6. After acquiring higher skills, workers in local firms can transfer from the unskilled department to the skill-intensive department or seek employment in multinational firms. The entry of FDI firms boosts average firm productivity in the host country[6], since they increase competition and force domestic firms to increase their efficiency. Both types of firms expand skilled labor demand and increase wages for skilled workers. This reflects that the stocks of high-skilled workers employed by local and multinational firms increase, and income inequality in the economy rises as average skill premium in either local or multinational firms goes up. Part of the income share among high-skilled occupations is transferred from workers in domestic firms to the most productive workers in foreign firms with fewer restrictions on FDI entry. Moreover, low-skilled workers' income share goes up since low-skilled wages increase as well, even though the average skill premium becomes larger.

Reduction in the Sunk Cost of High-skilled Worker Formation. With a 1% reduction in the sunk cost of high-skilled worker formation, a larger number of workers invest in labor training to seek employment in multinational firms and the high-skilled department of local firms, according to the impulse response results displayed in Figure 1.7. Therefore, lower barriers to skilled worker formation increase the household's labor training incentives to upgrade their skills. More high-skilled labor supply reduces the skill premium in the host country. Interestingly, workers have a greater likelihood of working for foreign firms after skill upgrading as the labor productivity cutoff declines following a drop in the sunk cost. Income share reallocation towards high-skilled occupations in multinational firms occurs since a greater number of skilled workers execute tasks in multinational firms compared to local firms. Meanwhile, multinational firms become more productive after employing more high-skilled workers, and local firms' productivity also increases due to a positive spillover effect.

Reduction in the Fixed Labor Training Cost in Multinational Firms. Figure 1.8 pins down the impulse response functions following a temporary 1% decrease in the training

---

[6]FDI increases labor skill, allows transfer of technology and promotes R&D investment of enterprise.

cost of workers seeking employment in multinational firms. Lower training costs reduce the labor productivity cutoff, so more workers can upgrade their skills to meet the requirements of multinational firms. The reallocation of high-skilled labor towards multinational firms results in a higher skill premium and increases multinational firm productivity. On the other hand, local firms are worse off due to a lower stock of high-skilled workers and lower firm-level productivity. In terms of the effect on wage inequality, the average skill premium of workers in local firms decreases while the wage inequality of workers in multinational firms expands. This scenario illustrates that more skilled workers choose to work for multinational firms for higher wages when the training costs are lower.

1.4.2 Alternative Scenarios

In this section, we consider two alternative scenarios incorporating a larger stock of FDI firms and fixed formation of high-skilled workers in the model to discuss the dynamic effects of skill premium and firm productivity in the host economy.

A Larger Number of Multinational Firms. I study the function of FDI firms by studying the dynamic adjustment resulting from an increase in the stock of multinational firms M_m, which is raised by 50%. Figure 1.9 displays the impulse response functions in the baseline model and in the scenario with a larger stock of multinational firms following a positive aggregate productivity shock. A greater stock of multinational firms generates higher output and consumption levels, and thus the host country is better off by attracting more FDI. The steady-state deviation of average local firm productivity in this scenario and baseline shows that there are no obvious competition effects of multinational firms on local firms. In the short run, more multinational firms in the host country encourage more workers to upgrade their skills, leading to higher average total skill premium, but the effect is not significant after several periods of this shock. The dynamic adjustment of the average skill premium from both local and foreign firms demonstrates that FDI provides more skilled jobs and increases the skill premium as well.

Fixed High-skilled Worker Formation. The second alternative case is to shut down the high-skilled worker formation channel so the number of new high-skilled workers $N_{e,t}$ is fixed and matches the number of high-skilled workers hit by the skill-destruction shock each period.

Figure 1.10 shows that a positive aggregate productive shock increases wage inequality if there is no labor training and skill upgrading decisions. Intuitively, the host country becomes more attractive as a result of an increase in aggregate productivity. In addition, more workers begin to invest in training. The higher skilled labor supply thus reduces the skill premium. However, shutting down the skill upgrading channel leads to higher wage inequality and lowers average firm productivity.

A reduction in the fixed cost of FDI entry creates a higher skill premium in the scenario of fixed high-skilled worker formation, as shown in Figure 1.11. The effect of skill upgrading channel on multinational firm productivity is mild, while local firm productivity becomes lower than its steady state level following a reduction in the fixed cost of FDI entry. It creates more high-skilled labor demand. If existing low-skilled workers have no chance to pursue labor training and upgrade their skills, wage inequality becomes larger over time as high-skilled workers have relatively stronger bargaining power. In the meantime, there is no positive productivity spillover effect on domestic firms in this counterfactual case.

1.4.3 Sensitivity Analysis

The calibration of a model featuring heterogeneous workers and endogenous labor training is challenging since data sources and literature on some parameters are hard to obtain. Therefore, we verify the robustness of model results by means of re-calibrating key parameters. Following Mandelman and Zlate (2022), we calibrate the Pareto distribution of labor productivity λ at 2.3. The share of high-skilled tasks in local firms η is equal to 0.2 based on the educational attainment at the tertiary level. Meanwhile, we adjust the elasticity of substitution between tasks and the probability of skill destruction to match the average income share of skilled workers. We summarize the results of the sensitivity analysis in Table 1.3. We find that the benchmark calibration produces robust results following a permanent 50% reduction in the fixed cost of FDI entry.

1.5 Conclusion

I developed a DSGE model to study the impact of FDI inflows on skill premiums and firm-level productivity. This paper contributes to the FDI and skill upgrading literature, which typically abstracts from the household's training decision following FDI inflows.

Inward FDI triggers skill upgrading. In every period, a bunch of workers acquire skills to provide labor tasks in the skill-intensive department of local firms or seek employment in multinational firms if they are productive enough. Local firms increase high-skilled labor demand to become more skill intensive and improve their productivity. Therefore, multinational firms benefit the host economy by changing the skill structure and creating a positive productivity spillover effect on local firms. Also, fewer restrictions on FDI entry increase wage inequality, while the endogenous labor training and skill upgrading channel helps narrow down the wage gap to some extent.

Future work on this project may include relaxing the assumption of an exogenous number of multinational firms, so the macroeconomic dynamics of FDI firm entry decisions can be further analyzed.

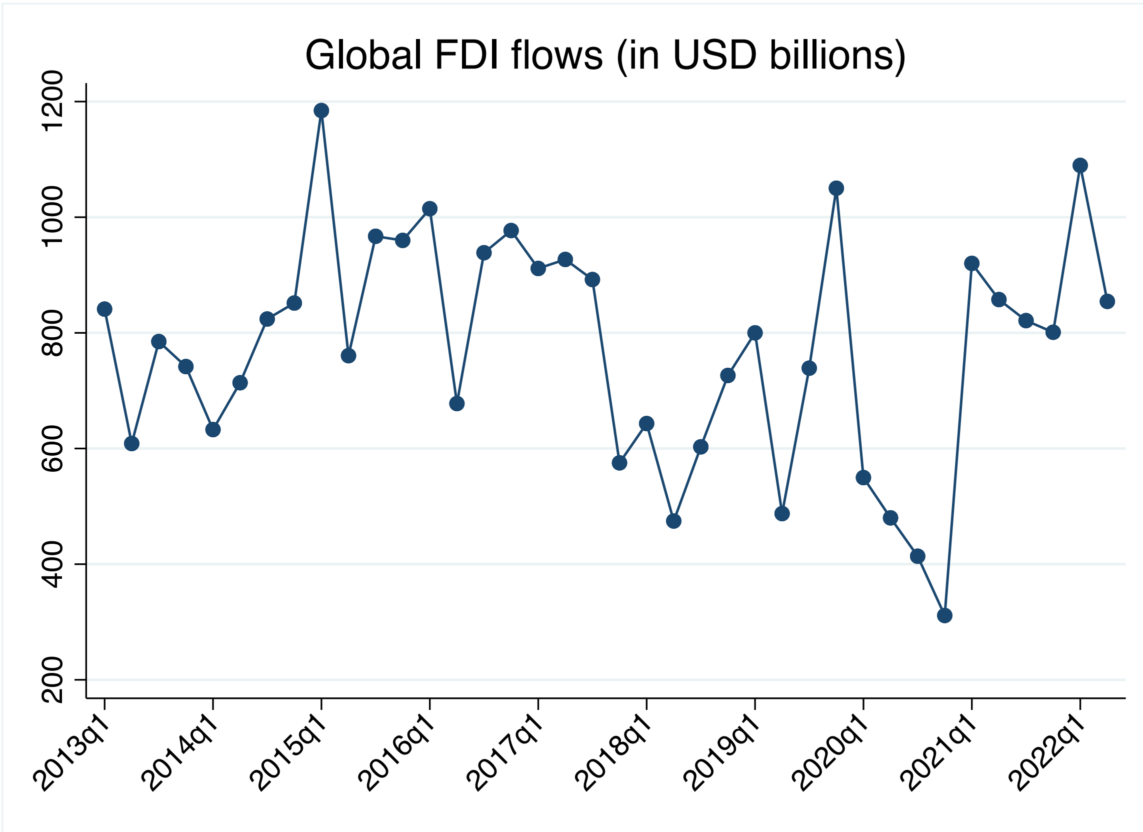

Figure 1.1: Total global FDI flows

Sources: OECD FDI database

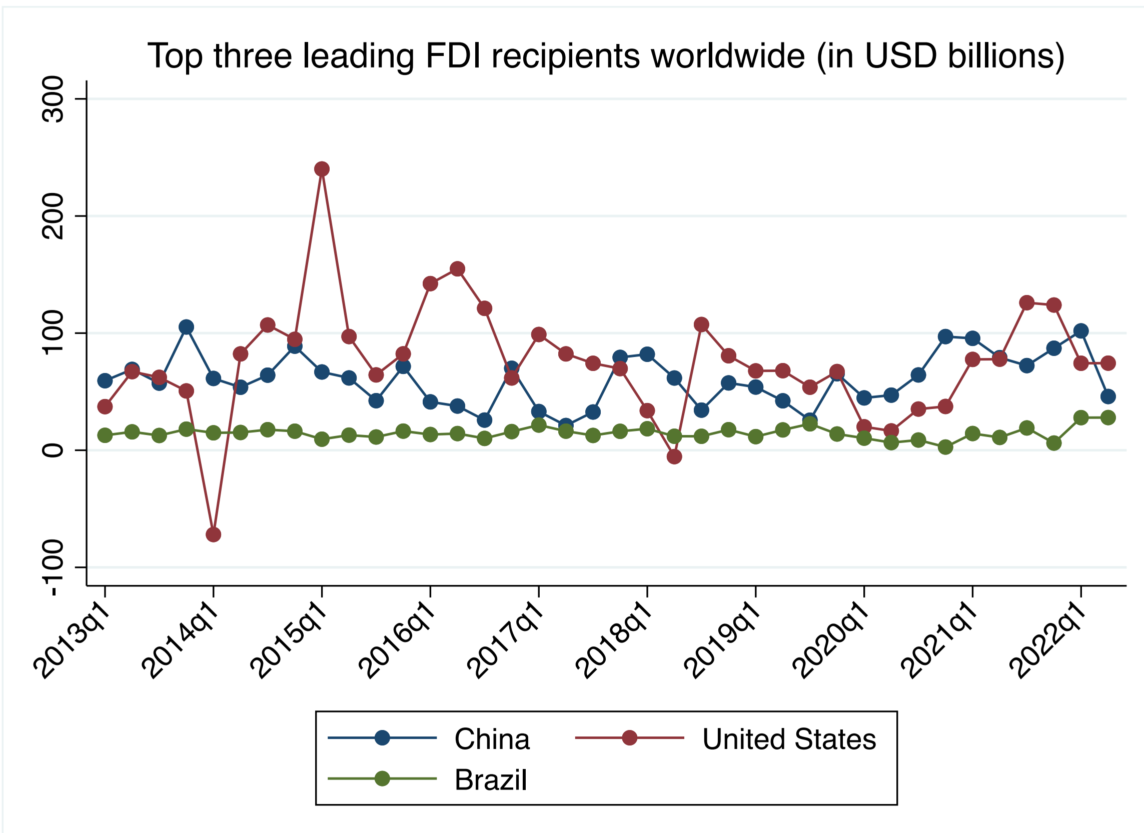

Figure 1.2: Three leading FDI recipients in 2022

Sources: OECD FDI database

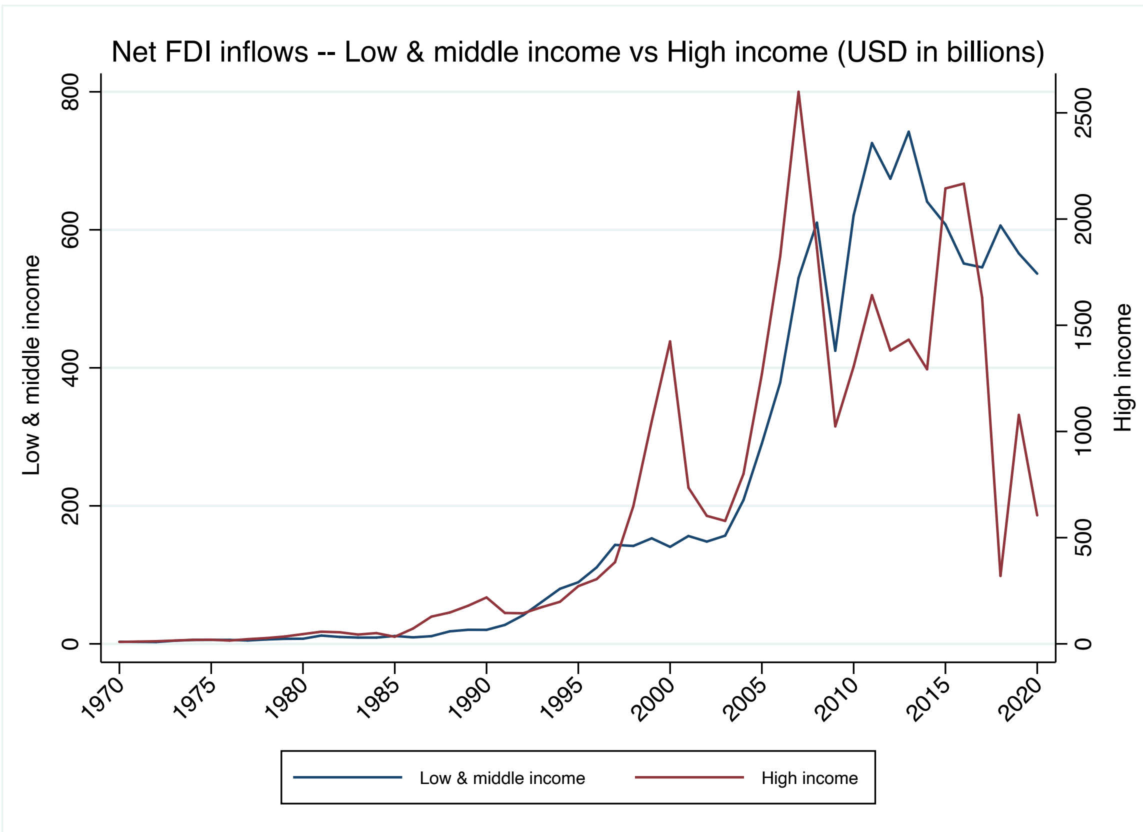

Figure 1.3: Average net FDI inflows – Low and middle income vs high income countries

Sources: International Monetary Fund, Balance of Payments database, supplemented by data from the United Nations Conference on Trade and Development and official national sources.

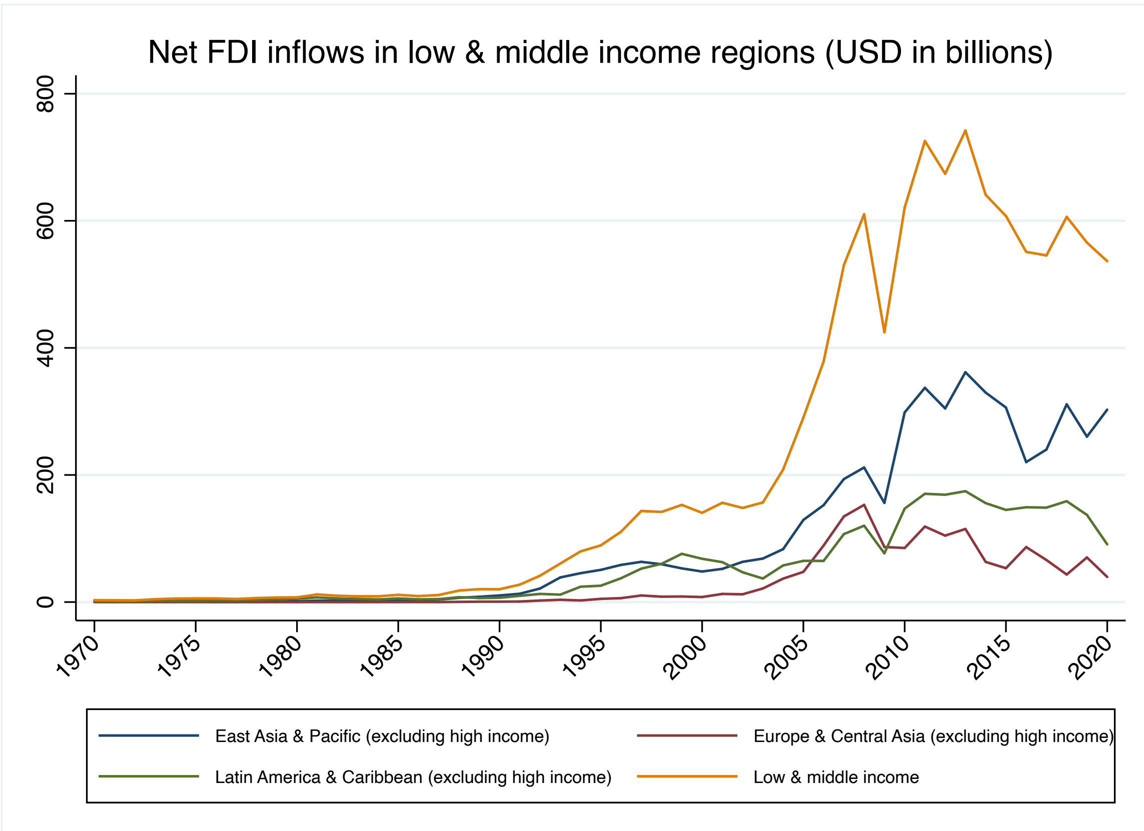

Figure 1.4: Net FDI inflows in low and middle income regions

Sources: International Monetary Fund, Balance of Payments database, supplemented by data from the United Nations Conference on Trade and Development and official national sources.

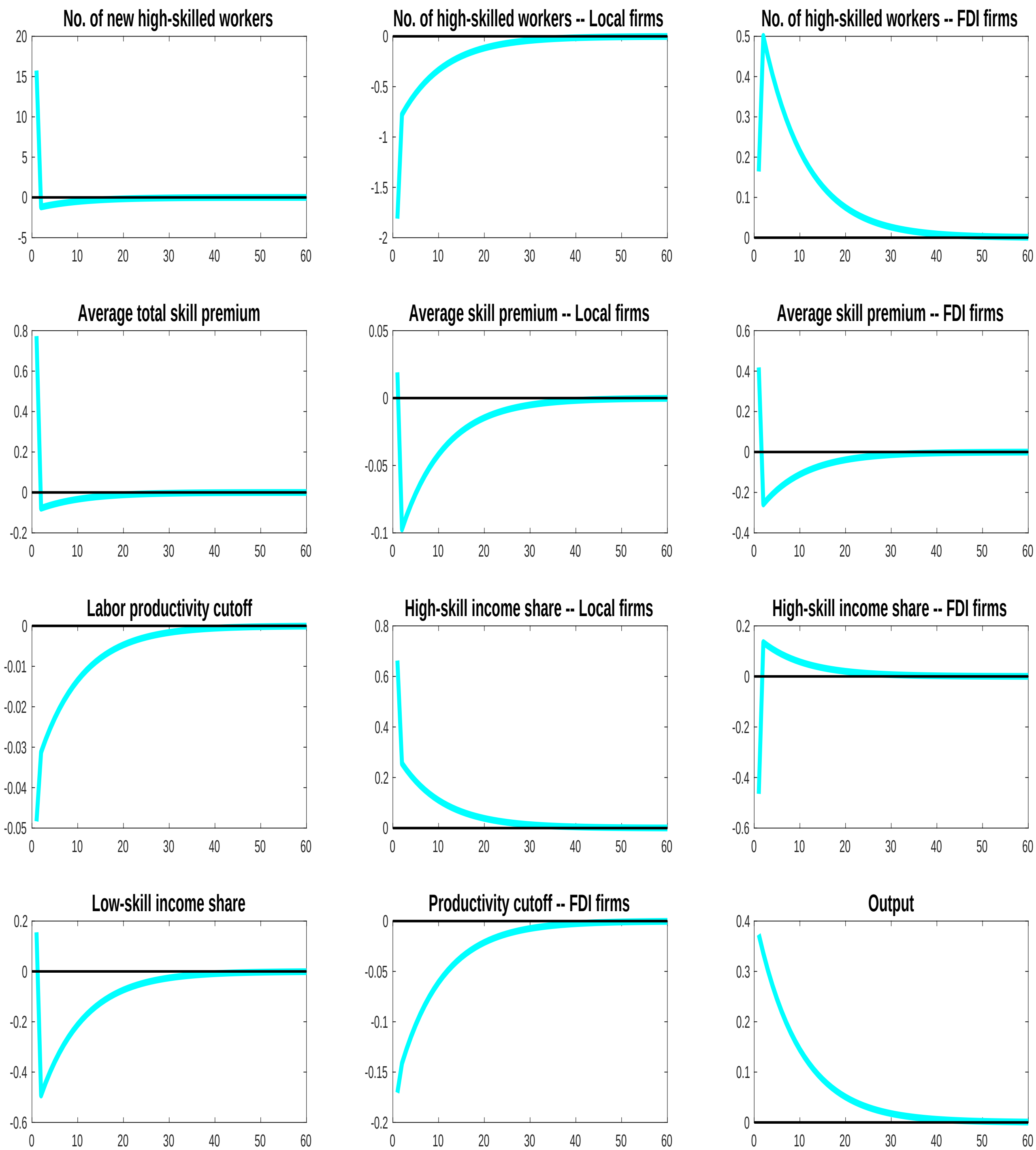

Figure 1.5: Transition dynamics for a 1% temporary increase in aggregate productivity

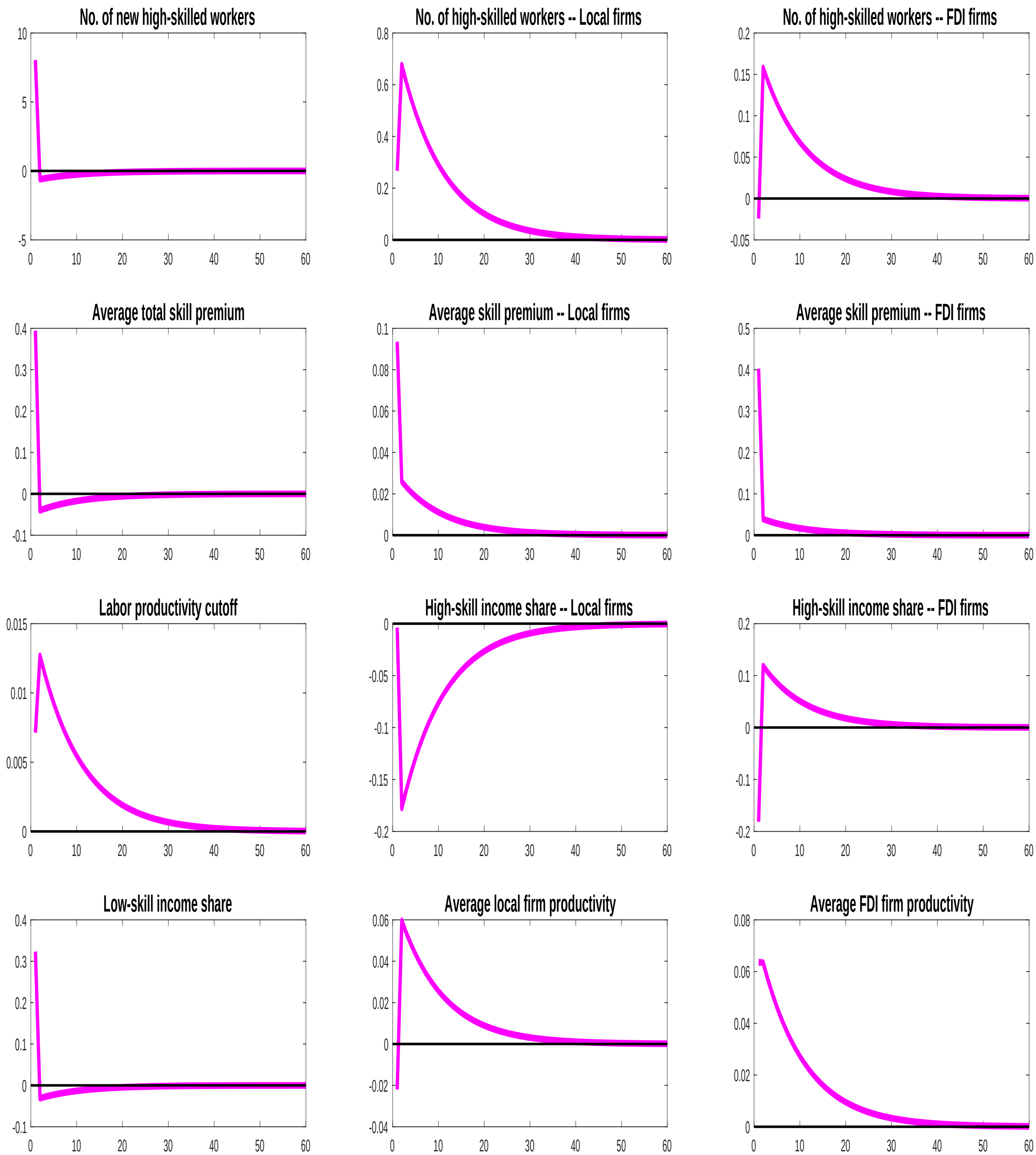

Figure 1.6: Transition dynamics for a 1% temporary decrease in the fixed cost of FDI entry

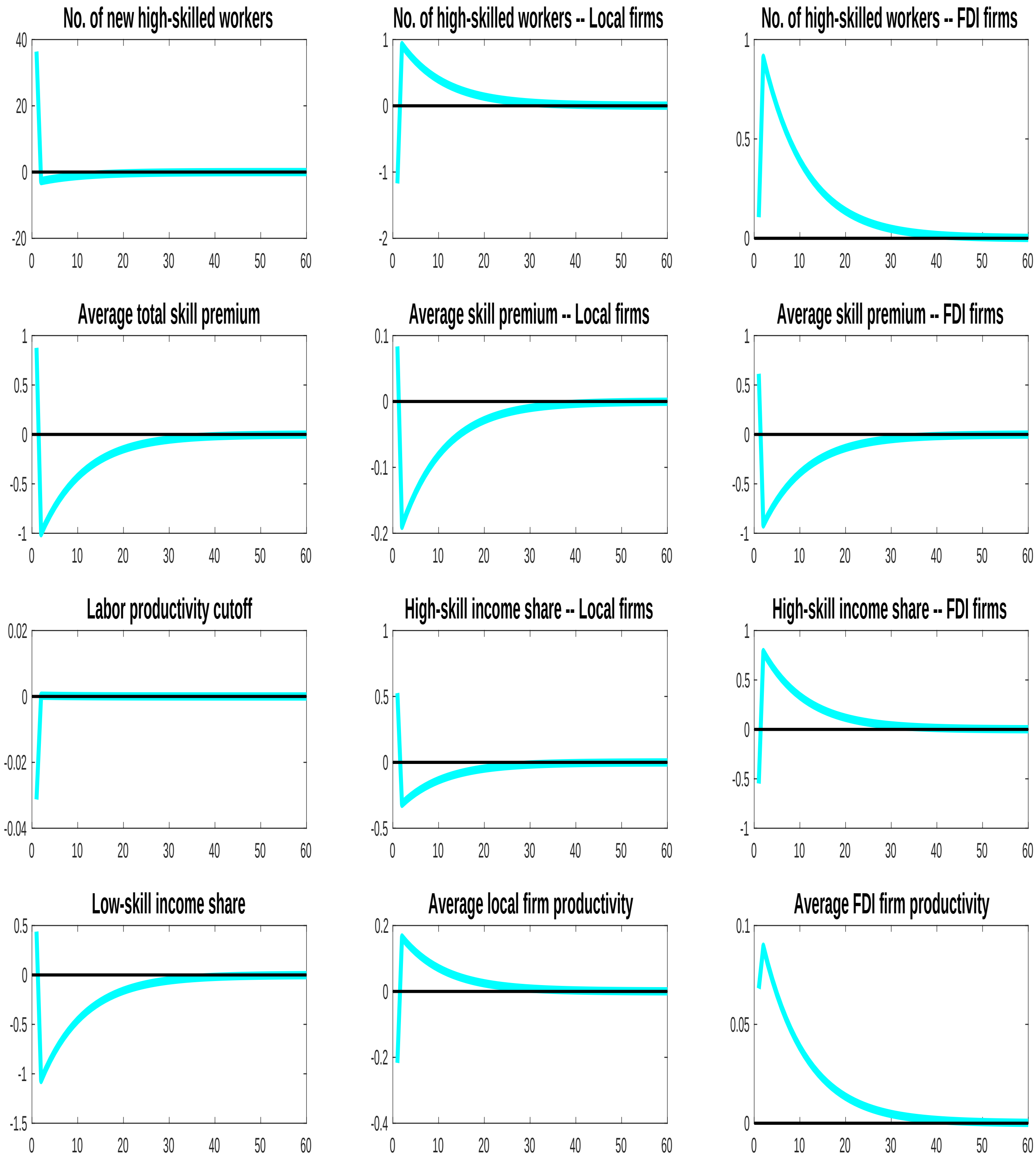

Figure 1.7: Transition dynamics for a 1% temporary decrease in the sunk entry cost of new high-skilled workers

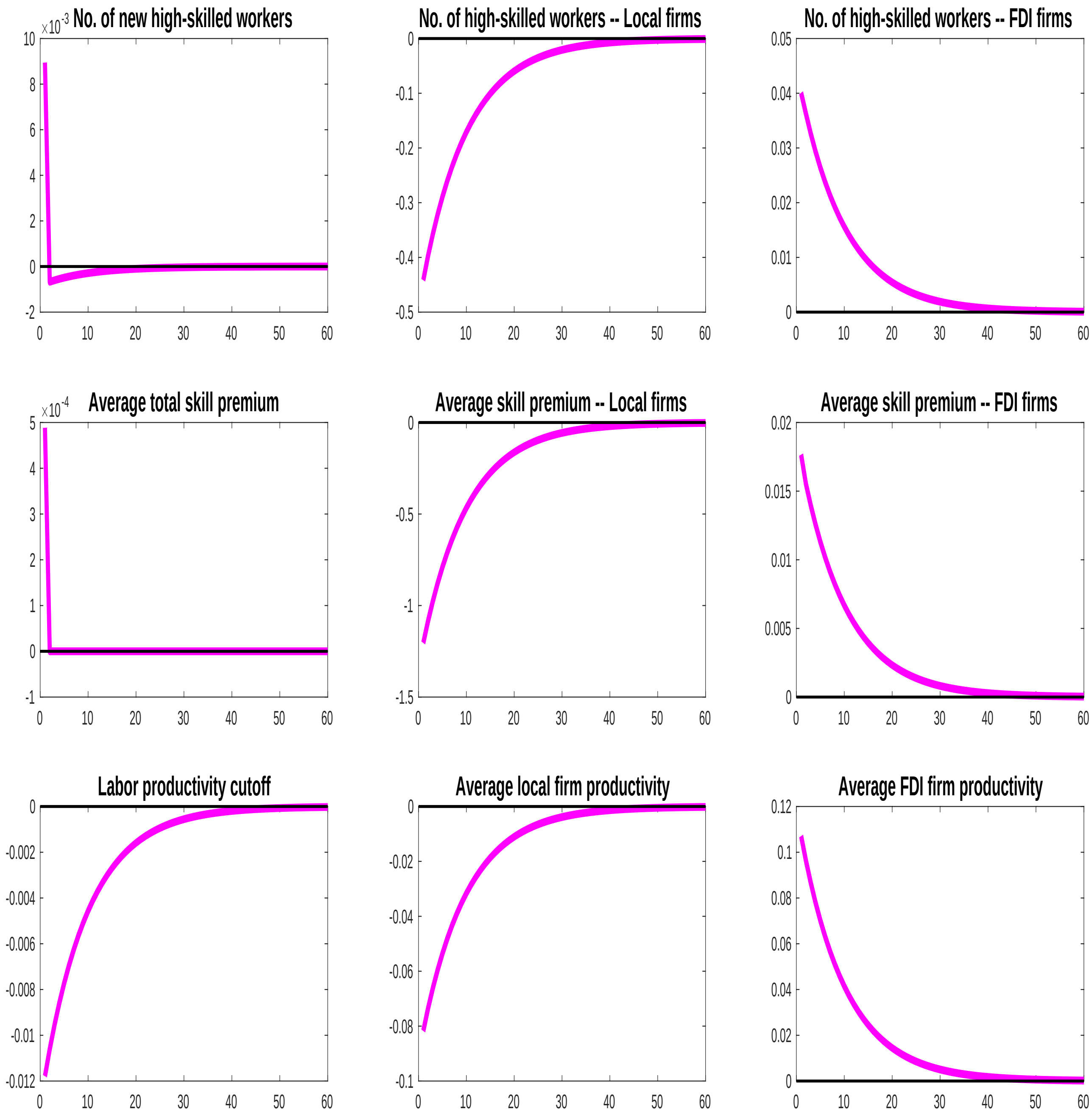

Figure 1.8: Transition dynamics for a 1% temporary decrease in the training cost of high-skilled workers employed by FDI firms

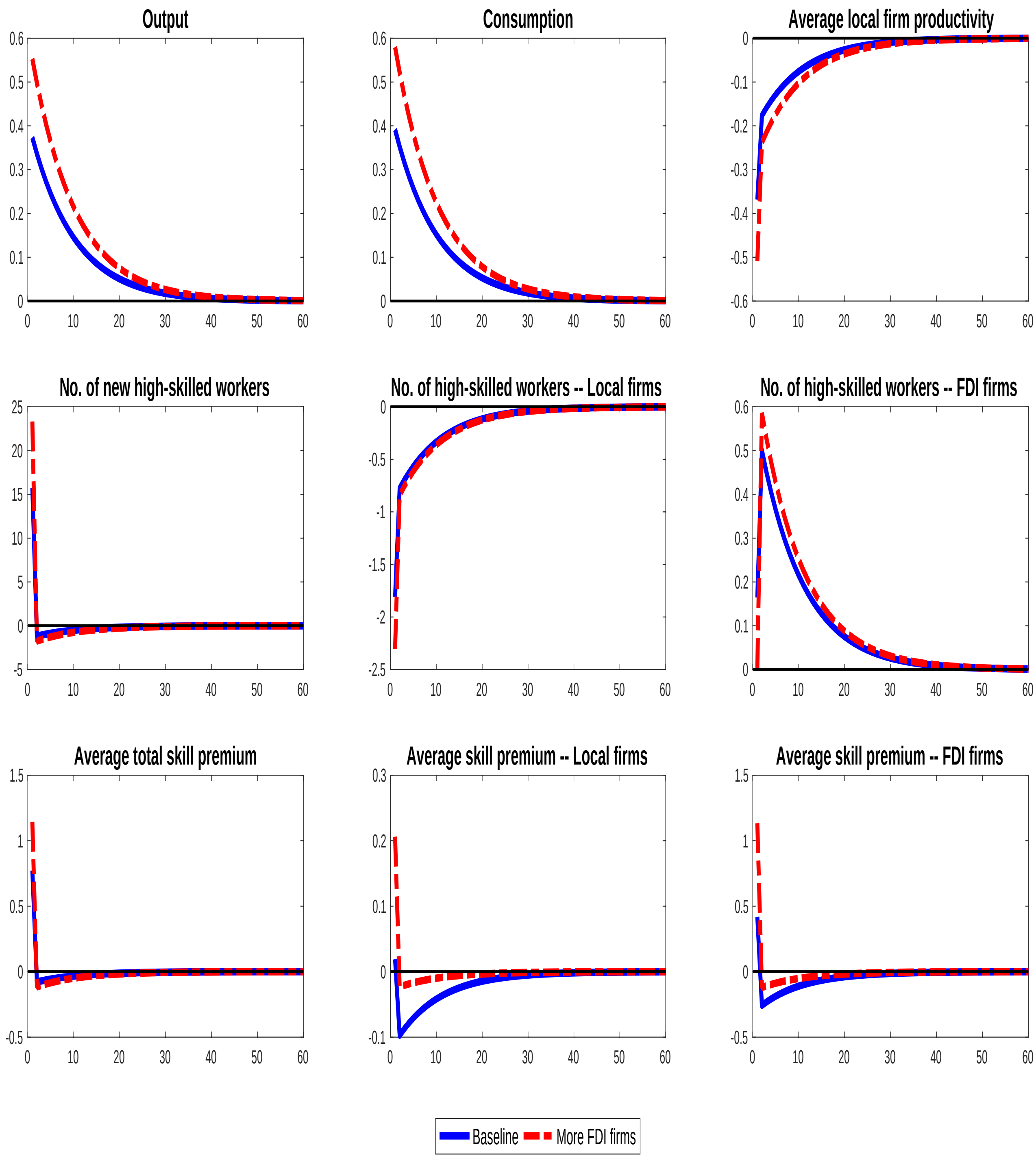

Figure 1.9: Transition dynamics for a 1% temporary increase in aggregate productivity, baseline model vs model with a greater number of multinational firms in the host economy

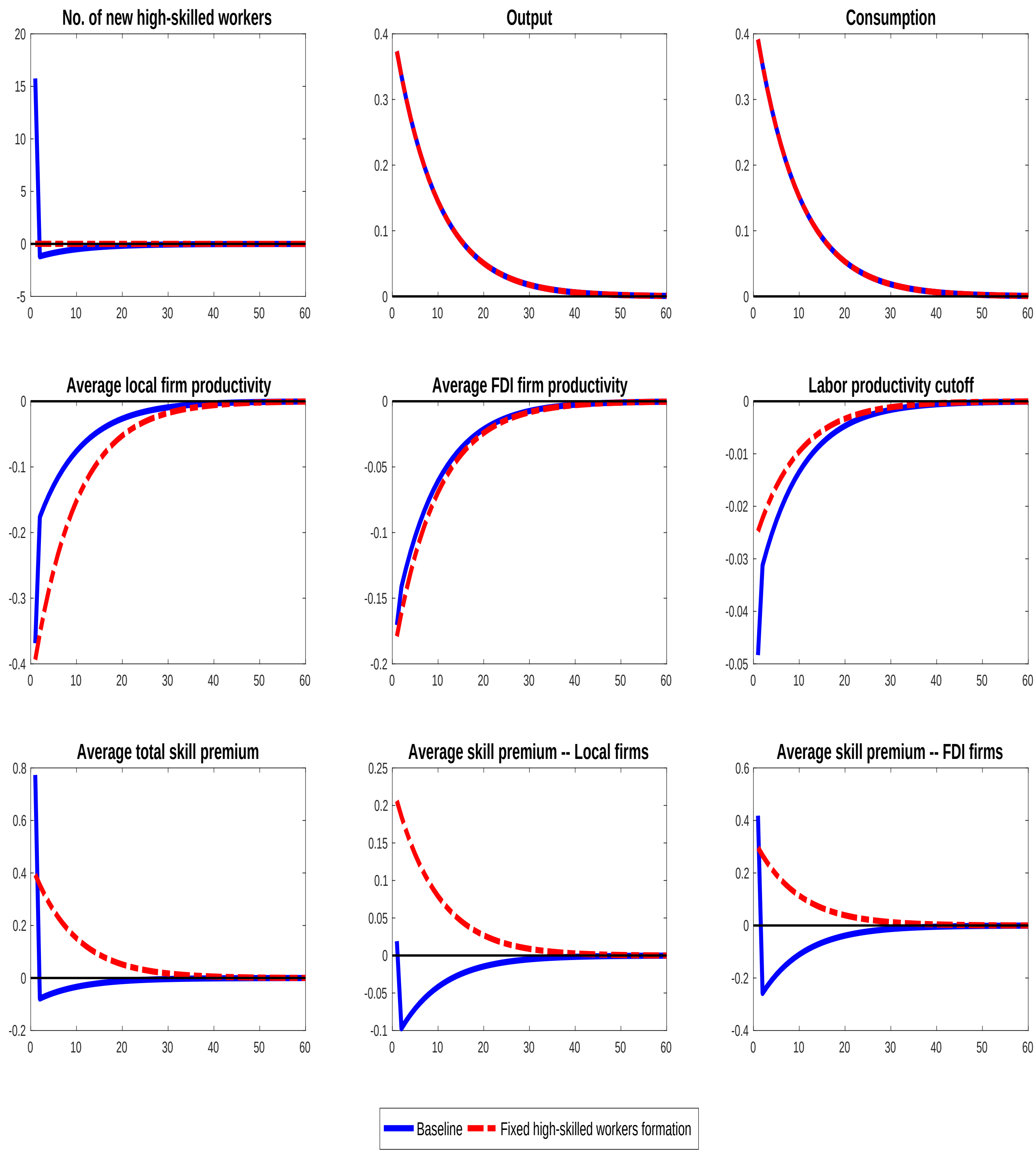

Figure 1.10: Transition dynamics for a 1% temporary increase in aggregate productivity, baseline model vs model with a fixed number of high-skilled workers

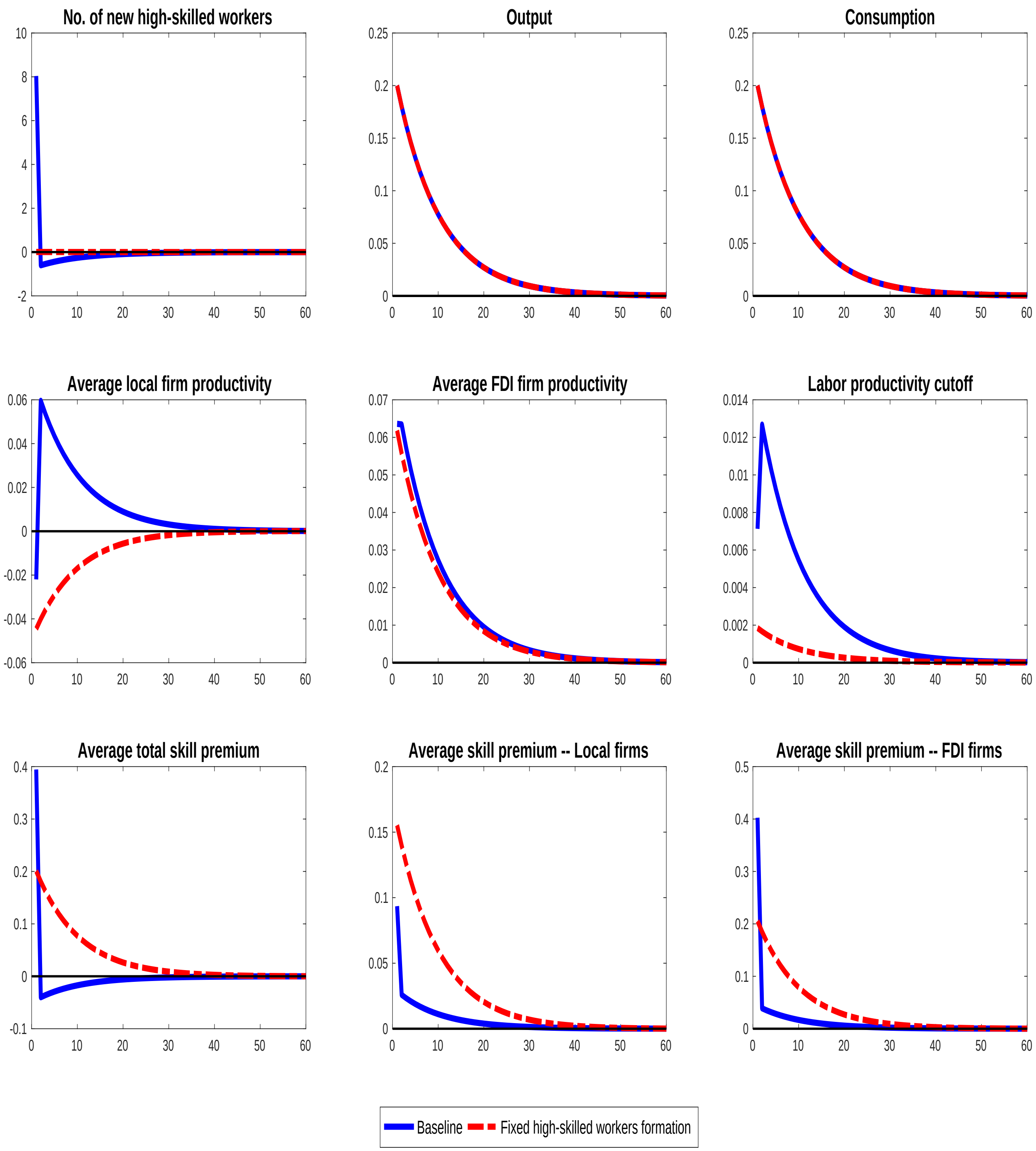

Figure 1.11: Transition dynamics for a 1% temporary decrease in the fixed cost of FDI entry, baseline model vs model with a fixed number of high-skilled workers

Table 1.1: % changes of net FDI inflows – low and middle income vs high income

	1970-1980	1980-1990	1990-2000	2000-2010	2010-2020
Low and middle income	140.9	172.1	592.0	341.88	-13.6
High income	394.4	376.4	551.2	-8.3	-53.6

Notes: This table presents the comparison of percentage changes in net FDI inflows between low & middle income countries and high income countries. All numbers are in percentage. Sources: International Monetary Fund, Balance of Payments database, supplemented by data from the United Nations Conference on Trade and Development and official national sources.

Table 1.2: Parameter calibration

Parameter	Value	Note
Discount factor	$\beta = 0.99$	Literature, 4 % interest rate
Relative risk aversion	$\gamma = 2$	Literature
The Frisch elasticity	$1/\psi_l = 0.75$	Chetty et al. (2013)
The disutility from labor	$\chi = 0.35$	Chetty et al. (2013)
Elasticity of substitution between tasks	$\theta = 1.67$	Mandelman and Zlate (2022)
Disutility from labor	$\chi = 0.35$	Labor supply equals to 1 in the steady state
The probability of skill destruction	$\delta = 0.025$	Davis and Haltiwanger (1990)
Pareto distribution of idiosyncratic labor productivity	$\lambda = 3.4$	Income share of top 60% workers, 73%
Sunk cost of new high-skilled workers	$f_e = 1$	Income share of top 60% workers, 73%
Fixed training cost of workers in multinational firms	$f_h = 1.4$	Income share of the most productive workers, 48%
The number of domestic firms	$M_d = 1$	The average inflows of FDI to GDP ratio, 1.8%
The number of multinational firms	$M_m = 0.2$	The average inflows of FDI to GDP ratio, 1.8%
Fixed entry cost of each firm	$f_d = 1$	FDI restrictiveness index
Fixed cost of FDI entry	$f_o = 1.25$	FDI restrictiveness index
Elasticity of substitution between goods	$\sigma = 3.8$	Ghironi and Melitz (2005)
Pareto distribution of firm-level productivity	$\kappa = 3.4$	Ghironi and Melitz (2005)
Share of high-skilled tasks employed by domestic firms	$\eta = 0.15$	Average educational attainment, bachelor's, 14.8%

Table 1.3: Fewer restrictions on FDI entry – % changes of non-stochastic steady state

	% $\Delta\tilde{\pi}_d$	% $\Delta\tilde{\pi}_m$	% ΔN_d	% ΔN_m	% $\Delta\tilde{z}_d$	% $\Delta\tilde{z}_m$
Baseline	1.8	4.0	8.2	10.7	42.1	67.4
$\delta = 0.03$	2.0	4.3	8.6	11.7	40.5	67.7
$\lambda = 2.3$	1.8	4.0	8.2	10.9	42.2	67.7
$\theta = 1.54$	2.1	4.1	8.1	10.5	43.3	68.9
$\eta = 0.20$	1.8	4.0	8.1	10.7	42.4	68.6

Notes: We consider a permanent 50% reduction in the fixed cost of FDI entry to see the percentage changes in steady state of skill premiums, the number of high-skilled workers and average firm-level productivity with alternative parameterization.

Chapter 2

HETEROGENEOUS IMPACTS OF TRADE LIBERALIZATION ON SKILL UPGRADING: EVIDENCE FROM APTA

2.1 Introduction

China's performance in terms of economic growth is remarkable, and one of the significant contributors is trade openness. After joining the World Trade Organization (WTO) in 2001, China engaged further in international trade and attracted more foreign direct investments (FDI). It greatly benefits from trade integration by acting as a leading exporter, inducing capital inflows, and promoting economic growth. Besides the WTO accession, regional trade liberalization such as the Asian Pacific Trade Agreement (APTA) and the Regional Comprehensive Economic Partnership (RCEP) also foster economic development in China. In the meantime, human capital accumulation has improved sharply in China in the past twenty years. For instance, its tertiary school enrollment rate has increased from 7.69% in 2000 to 53.77% in 2018 according to the World Bank. Workers upgrade their skill levels through education or on-the-job training. Our firm level data show a pattern: Chinese new exporters have greater incentives to provide labor training than non-exporters. This indicates that there is a relationship between exports and human capital investment, but it is not enough to explain whether expanded export opportunities encourage firms to invest more in human capital for innovation or vice versa. In this paper, we intend to study the effect of trade liberalization (APTA) on the export and skill upgrading decisions of Chinese manufacturers theoretically and empirically.

The heterogeneous-firm trade model in Melitz (2003) and Bernard et al. (2003) emphasizes that trade integration reallocates market shares towards exporters that are larger, more productive, and more skill- and capital-intensive compared to non-exporters. In our model, following the literature, firms that exhibit higher productivity discover it economically advantageous to cover the fixed expenses associated with entering the global export market, and those with even higher productivity choose to invest in human capital with fixed skill-upgrading costs because firms receiving larger sales are able to provide labor training, which is also consistent with our data pattern. A reduction in trade costs increases export sales, encourages more new entrants in the export market, and induces more firms to invest in human capital and produce skill-intensive products.

Figure 2.1 (green solid line) reflects that a reduction in India's tariff leads to a boost in exports to the Indian market by Chinese firms. India's average applied effective tariff declined by about 15 percentage points from 2004 to 2007, but the change in the average tariff in the rest of the world (Figure 2.1's red dashed line) was nearly zero during the same period. Based on this fact, we extend our model to distinguish between export destinations—the "main" trading countries with lower and stable trade barriers (the rest of the world) and the less preferential trading partners such as India, which impose relatively higher (but declining) tariffs—and then study the effects of trade liberalization on firms' export participation and investment in on-the-job training in the home country (China). Regional trade liberalization policies are expected to boost regional trade and investment, facilitate technology and skill upgrading, and stimulate economic growth. We assess the model's validity within the framework of a regional trade liberalization event, specifically the APTA agreement. This involves gauging the impact of India's tariff reduction on firm entry into the export market and labor training provided by firms between 2004 and 2007.

We start our empirical analysis by exploring data patterns. In the first check, we examine whether the sorting arrangement anticipated by Bustos (2011b)'s model aligns with the actual distinctions observed between entities engaged in exporting and those that are not. The model suggests that disparities in productivity lead to the division of firms into four distinct groups: the least productive firms exit the market (not in the data), the low productivity group employs low-skilled workers and serves the domestic market only, the middle group exports but still produces unskilled goods with demand for low-skilled workers, and the most productive firms not only export but also produce skilled goods as a result of upgrading labor skill levels. Indeed, the data confirm that exporters provided more labor training than non-exporters in 2004. Moreover, new exporters increased investment in human capital faster than continuing exporters throughout the period of liberalization

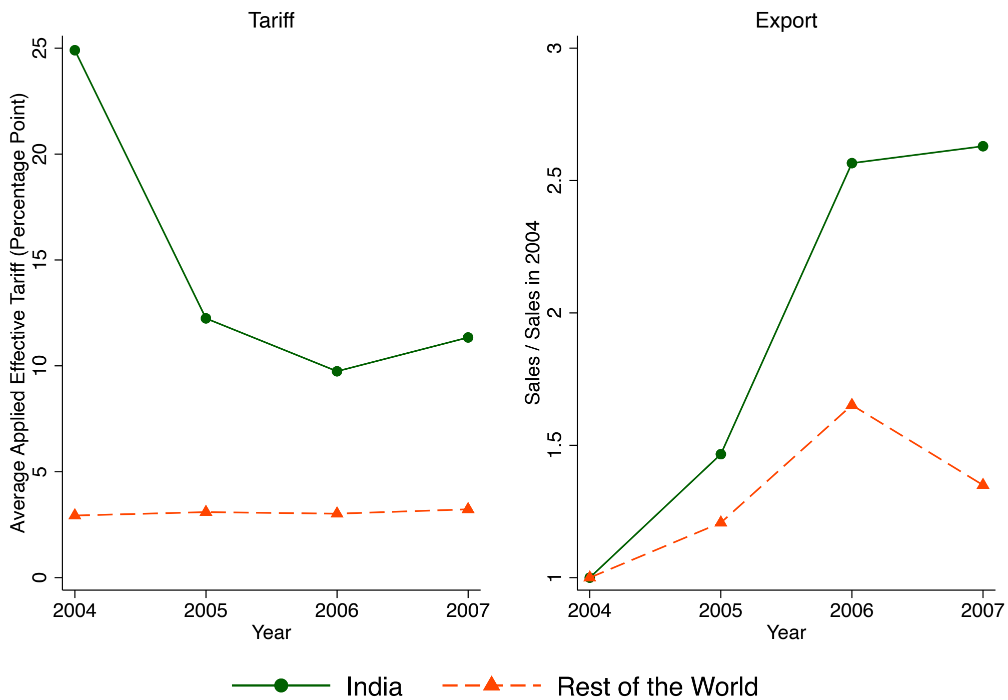

Figure 2.1: Trends of tariffs and china's export sales (2004–2007)

Notes: The left panel shows the average applied effective tariff China faces when exporting goods to India and the rest of the world; the average for the rest of the world is weighted by the export sales from China to each country. The right panel depicts China's total export sales in each year relative to 2004.

spanning from 2004 to 2007. It is plausible that new exporters produce more skill-intensive products in order to become more competitive in the foreign market.

In the second data check, we explore whether the pattern of categorization anticipated by the model aligns with the observed disparities among exporters to main trading partners and exporters to less preferential trading partners. In our model, the least productive firms exit the market; the lower-middle group exports unskilled goods to main trading countries; the upper-middle group exports unskilled goods to less preferential trading partners; the high productivity group upgrades labor skills, and only exports skilled goods to main trading countries; the most productive firms are able to both provide labor training and export skilled goods to less preferential trading countries. The model assumes that some firms find it more profitable to export skilled goods to the main countries than unskilled goods to other countries that impose higher trade barriers. This assumption comes directly from the data pattern, as we notice that switching exporters from India to the rest of the world increased training spending per worker faster during 2004–2007. The data pattern also shows that exporters to less preferential trading countries such as India invest more in on-the-job training than those exporting to main countries (the rest of the world) in 2004, except for those who switch destination countries in 2007. In particular, both new and switching exporters to India increase labor training slightly more than continuing, exiting, and never exporters during the regional trade liberalization period.

The aforementioned data patterns indicate a correlation between engaging in exports and enhancing skills. However, they do not address the inquiry of whether trade liberalization prompts firms to invest in human capital and produce skill-intensive goods instead of unskilled goods. Hence, we attempt to establish a cause-and-effect relationship by directly connecting export activities and skill upgrading to the decrease in tariffs on imports from China into India. This constitutes a direct assessment of the model, wherein the choices of firms to enter export markets and offer labor training are endogenous. In the meantime, we compare two export destinations imposing different trade costs, and analyze whether exporters switch to another export market following trade liberalization.

First, following Bustos (2011b)'s model setting, we find that the productivity cutoffs for entering the export market and upgrading labor skills fall more when tariffs fall. Firms find it easier and more profitable to participate in foreign markets and provide labor training following trade integration. Subsequently, we calculate the shift in the likelihood of a firm entering the export market based on the change in India's tariff rates. The mean tariff reduction of 15 percentage points raises the likelihood of market entry by 1.55 to 1.88 percentage points between 2004 and 2007. Furthermore, we gauge the alteration in labor training expenditure in relation to changes in tariffs. The average tariff reduction elevates labor training spending by 0.11 to 0.13 logarithmic points over the same time span. The above empirical results are from a sample of Chinese manufacturers.

Next, the advanced setting in Section 2.2 predicts that the reduction in tariffs of less preferential trading partners (country o) increases the probability of entering the export markets of both main trading partners (country m) and less preferential trading partners (country o). Meanwhile, lower trade costs induce more spending on labor training provided by exporters to country o, but discourage skill upgrading by exporters to country m as predicted by the model. The estimation for Chinese manufacturers shows that the lowering of India's tariffs stimulates an increased influx of exports into the Indian market and increases spending on labor training provided by new exporters to India. Consistent with model prediction, new exporters have a larger likelihood of entering the Indian market, and new exporters to India induce more investment in on-the-job training following the reduction in India's tariffs.

This paper adds to the body of theoretical literature that examines the mechanism by which trade openness affects firms' investment training. The theoretical model in this paper builds on Melitz (2003) and Bustos (2011b).[1] The heterogeneous-firm model offers new insights into the causes and consequences of international trade.[2] There are model specifications that study trade-induced economic outcomes.[3] In the context of human capital

[1] Bustos (2011a) points out that firms upgrading skills also upgrade technology, and analyze skill upgrading in the context of the employment share of skilled workers. In this paper, firms make decisions on labor training spending for skill upgrading.

[2] Recent literature also incorporates firm dynamics in models of international trade. Burstein and Melitz (2013) demonstrate that the responses of "trade volumes, innovation, and aggregate output depend on the assumption for firm dynamics, endogenous innovation, and the expected time path of trade liberalization".

[3] For instance, Helpman et al. (2004) stress the role of "within-sector firm productivity differences" in understanding international trade and FDI featuring heterogeneous firms.

adjustment, however, Falvey et al. (2010) build a traditional two-sector Heckscher-Ohlin trade model with skilled and unskilled labor to address when and if unskilled workers "opt for skill upgrading in response to trade liberalization in a skill-abundant country"; Van Long et al. (2007) construct a model centered around the accumulation of firm-specific human capital and focus on workers' choices to acquire skills that are firm-specific after trade liberalization. The major differences between our paper and theirs are that 1) we apply the "new" trade theory (heterogeneous-firm model) and 2) we focus on the decisions of firms. In terms of studies on China's economy, some papers associate China's economic growth with its human capital accumulation. China has been sustaining the fastest growth for a long period of time after it started economic reform and became engaged in the global economy. Li et al. (2017) point out that human capital is also an important source and prospect for future economic growth in China, as increased per capita income is correlated with elevated levels of human capital. This paper is concerned with the impact of a regional trade liberalization policy, APTA, on export participation, as well as labor training decisions by Chinese manufacturing firms. Firms' investment in on-the-job training is an important way for skill enhancement, human capital adjustment, and product quality improvement in China.

The empirical analysis presented here pertains to the fields of trade liberalization and manufacturing firms' performance. A wide range of studies have investigated the impacts of trade integration on export market entry, technology adaptation, skill upgrading, productivity, wage inequality, and other economic outcomes. For instance, Bustos (2011b) empirically analyzes the impact of free trade on export participation and technology upgrading of Argentinian firms. Bas (2012) extends the previous work by also considering skill upgrading with plant-level data from Chile's manufacturing sector. However, the heterogeneity of the trade effect on skill upgrading by export destinations exists. For example, Yamashita (2008) finds that fragmentation of trade with high-income countries exhibits a skill-downgrading impact, contrasting with the phenomenon of skill upgrading among firms in East Asian countries, based on a panel dataset of 52 Japanese manufacturing industries. Some empirical studies about trade adjustment and human capital development in less developed countries include (Edmonds et al., 2010),[4] and (Bazzi et al., 2016).[5] Wang (2007) uses data from manufacturing industries in 25 developing countries to study the role of human capital in trade-related technology spillovers. Regarding trade liberalization in China, Brandt et al. (2017) focus on how the WTO accession influences the markups and productivity of Chinese manufacturing firms. Our research is closely related to Bustos (2011b). The departure of this paper from the literature is that we introduce two different export markets to discuss firms' export decisions in response to the reduction in one destination's tariffs, and examine how a regional trade liberalization (APTA) affects investment in on-the-job training of Chinese manufacturers.[6]

The remaining sections of the paper are structured as follows. Section 2.2 demonstrates the model where we distinguish two distinct export markets. Section 2.3 describes trade policies and data sets. Section 2.4 provides an empirical framework to examine the impacts of trade liberalization on export participation and skill upgrading, and test the predictions of the model; in particular, Section 2.4.5 makes a discussion about Chinese manufacturers. Section 2.5 concludes the whole paper.

2.2 The Model

Our model is extended from Melitz (2003) and Bustos (2011b) to examine the influence of trade liberalization on firms' human capital investment decisions. There are two identical countries, and each country has two sectors, the skill-intensive sector s and the unskilled sector u. We consider a monopolistically competitive setup with heterogeneous firm productivity, endogenous skill upgrading decisions and endogenous export participation. The least productive firms have to exit the market due to negative profits. Some firms within the intermediate range of productivity can export to a foreign country even though they are not productive enough to invest in labor training. The most productive firms are able to export and invest

[4]They examine the impact of India's 1991 trade reform on schooling and child labor.

[5]The authors investigate how location-specific human capital and the transferability of skills influence productivity in Indonesia.

[6]In the context of labor training, Liu and Lu (2016) and Huang and Zhuang (2021) apply a large panel dataset of manufacturing firms in China to investigate the effects of on-the-job training on firm productivity and wages.

in labor training. They employ high-skilled labor and produce skill-intensive products.

2.2.1 Preferences

In each country, there are two sectors, indexed by $i \in (s, u)$, the skill-intensive sector s and the unskilled sector u. The preferences of a representative consumer in the home country are given by the following CES function, which combines skilled and unskilled goods:

$$\max_{y_{s,t}(\omega), y_{u,t}(\omega)} \left[\left(\int_{\omega \in \Omega_u} y_{u,t}(\omega)^{\frac{\theta-1}{\theta}} d\omega \right)^{\frac{\theta}{\theta-1}\frac{\rho-1}{\rho}} + \left(\int_{\omega \in \Omega_s} y_{s,t}(\omega)^{\frac{\theta-1}{\theta}} d\omega \right)^{\frac{\theta}{\theta-1}\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

subject to

$$\int_{\omega \in \Omega_u} p_{u,t}(\omega) y_{u,t}(\omega) d\omega + \int_{\omega \in \Omega_s} p_{s,t}(\omega) y_{s,t}(\omega) d\omega = E$$

where Ω_i is the mass of varieties available in sector i coming from home and foreign countries, E is the aggregate level of spending, $y_i(\omega)$ and $p_i(\omega)$ are the consumption of good ω and the price of this good respectively, θ is the elasticity of substitution within sector varieties and ρ is the elasticity of substitution between sector varieties.

These preferences generate demand functions in sector u and s, and they are

$$y_u(\omega) = \left(\frac{p_u(\omega)}{P_u} \right)^{-\theta} \frac{P}{P_u} Y = \rho_u(\omega)^{-\theta} \rho_1^{\theta-\rho} Y$$
$$y_s(\omega) = \left(\frac{p_s(\omega)}{P_s} \right)^{-\theta} \frac{P}{P_s} Y = \rho_s(\omega)^{-\theta} \rho_2^{\theta-\rho} Y$$

where the relative prices are defined as $\frac{p_u(\omega)}{P} = \rho_u(\omega)$, $\frac{p_s(\omega)}{P} = \rho_s(\omega)$, $\frac{P_u}{P} = \rho_1$, $\frac{P_s}{P} = \rho_2$ and aggregate consumption good defined as $Y \equiv U$ (utility) and $PY = E$.

The aggregate price index is denoted as $P = \left[P_u^{1-\rho} + P_s^{1-\rho} \right]^{\frac{1}{1-\rho}}$, where $P_u = \left(\int_{\omega \in \Omega} p_u(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}}$ and $P_s = \left(\int_{\omega \in \Omega} p_s(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}}$ are the prices of unskilled and skilled goods respectively.

2.2.2 Firm Entry

Firms under monopolistic competition display diversity in their levels of productivity z, and pay a sunk entry cost f_e in units of aggregate consumption good. Following Ghironi and Melitz (2005), the firm entrant draws its productivity z with a Pareto distribution $G(z) = 1 - z^{-\kappa}$ after entering the market. Then, firms can make decisions for exporting and human capital investment. Human capital investment in this paper refers to how much training spending firms are able to provide workers with for skill upgrading.

2.2.3 Production

We assume that the foreign country can be either a main trading partner of the home country, denoted as country m, or a less preferential trading partner of the home country, denoted as country o. The home country and its main trading partner are assumed to impose the most-favored-nation (MFN) tariff, which is the lowest possible tariff a country can assess from another country. The less preferential trading partner imposes larger tariffs. In this section, two export productivity cutoffs are considered to distinguish if the firm can export to only the main country m or both countries o and m. In section 2.4.5, we regard India as a representative country o because empirically India imposed higher tariffs on Chinese products compared to the rest of the world during our study period 2004–2007.

There are two types of iceberg trade costs, $\tau_m < \tau_o$, and fixed export costs, $f_{mx} < f_{ox}$, since trade barriers are lower if the home firms export to country m. Four pricing rules of export are $\rho_s^{mx}(z) = \tau_m \rho_s^d(z)$, $\rho_s^{ox}(z) = \tau_o \rho_s^d(z)$, $\rho_u^{mx}(z) = \tau_m \rho_u^d(z)$ and $\rho_u^{ox}(z) = \tau_o \rho_u^d(z)$. [7]

Profits if producing unskilled goods and only serving the domestic market:

$$\pi_u^d(z) = \frac{r_u^d(z)}{\theta} - f_u$$

Profits if producing unskilled goods and exporting to country m:

$$\pi_u^{mx}(z) = (1 + \tau_m^{1-\theta})\frac{r_u^d(z)}{\theta} - f_u - f_{mx}$$

Profits if producing unskilled goods and exporting to country o:

$$\pi_u^{ox}(z) = (1 + \tau_o^{1-\theta})\frac{r_u^d(z)}{\theta}\gamma_u^{\theta-1} - f_u - f_{ox}$$

Profits if producing skill-intensive goods and exporting to country m:

$$\pi_s^{mx}(z) = \lambda_m^{\theta-1}(1 + \tau_m^{1-\theta})\frac{r_u^d(z)}{\theta}\left(\frac{\rho_2}{\rho_1}\right)^{\theta-\rho} - \phi_m f_u - f_{mx}$$

[7] The four pricing rules of exporting are $\rho_u^d(z) = \frac{\theta}{\theta-1}\frac{w_l}{z}$, $\rho_s^d(z) = \frac{\theta}{\theta-1}\frac{w_h^{\beta} w_l^{1-\beta}}{\gamma z}$, $\rho_s^x(z) = \tau\rho_s^d(z)$, $\rho_u^x(z) = \tau\rho_u^d(z)$. Hence, $\rho_s^d(z) = \rho_u^d(z)/\lambda$ where $\lambda \equiv \gamma\left(\frac{w_l}{w_h}\right)^{\beta}$.

Profits if producing skill-intensive goods and exporting to country o:

$$\pi_s^{ox}(z) = \lambda_o^{\theta-1}(1+\tau_o^{1-\theta})\frac{r_u^d(z)}{\theta}\left(\frac{\rho_2}{\rho_1}\right)^{\theta-\rho} - \phi_o f_u - f_{ox}$$

where $f_{ox} > f_{mx}$, $f_{os} > f_{ms} > f_u$, $\alpha > \beta$, $\gamma_o > \gamma_m > \gamma_u > 1$ and $\phi_o > \phi_m > 1$. Firm revenues $r_u^d(z) = \left(\frac{\theta}{\theta-1}\frac{w_l}{z}\right)^{1-\theta}\rho_1^{\theta-\rho}Y$. Let $\lambda_m \equiv \gamma_m\left(\frac{w_l}{w_h}\right)^{\beta}$ and $\lambda_o \equiv \gamma_o\left(\frac{w_l}{w_h}\right)^{\beta}$.

Firms with productivity above z_{mx} export to country m (the main trading partner) while they can export to country o if their productivity is above z_{ox}. Thus, these two export productivity cutoffs are

$$z_{mx} = \{z|\pi_u^d(z) = \pi_u^{mx}(z)\} \qquad\qquad z_{ox} = \{z|\pi_u^{mx}(z) = \pi_u^{ox}(z)\}$$

The productivity cutoff of producing skill-intensive goods (skill upgrading) is also different from the one in Bustos (2011b)'s model. The highly productive firms find it profitable to provide labor training when trading with country m, and the most productive firms are able to export to country o and invest in human capital; thus the two productivity cutoffs of skill upgrading are

$$z_{ms} = \{z|\pi_u^{ox}(z) = \pi_s^{mx}(z)\} \qquad\qquad z_{os} = \{z|\pi_s^{mx}(z) = \pi_s^{ox}(z)\}$$

In equilibrium, firms are categorized into six distinct groups. The least productive entities ($z < z_e^{'}$) eventually leave the market, the low productivity firms ($z_e^{'} < z < z_{mx}$) employ low-skilled labor and serve only the home country, the lower-middle productivity firms ($z_{mx} < z < z_{ox}$) employ low-skilled labor and export to country m; the upper-middle productivity firms ($z_{ox} < z < z_{ms}$) export unskilled goods to country o; the high productivity firms ($z_{ms} < z < z_{os}$) export to country m but is able to employ skilled labor, the most productive firms ($z > z_{os}$) can export to country o and provide labor training.

$$z_{mx} = z_e^{'}\tau_m\left(\frac{f_{mx}}{f_u}\right)^{\frac{1}{\theta-1}} \tag{2.1}$$

$$z_{ox} = z_e^{'}\left(\frac{f_{ox} - f_{mx}}{((1+\tau_o^{1-\theta})\gamma_u^{\theta-1} - \tau_m^{1-\theta} - 1)f_u}\right)^{\frac{1}{\theta-1}} \tag{2.2}$$

$$z_{ms} = z_e^{'}\left[\frac{(\phi_m - 1)f_u + f_{mx} - f_{ox}}{((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - (1+\tau_o^{1-\theta})\gamma_u)f_u}\right]^{\frac{1}{\theta-1}} \tag{2.3}$$

$$z_{os} = z_e^{'}\left[\frac{f_{ox} - f_{mx} + (\phi_o - \phi_m)f_u}{(\lambda_o^{\theta-1}(1+\tau_o^{1-\theta}) - \lambda_m^{\theta-1}(1+\tau_m^{1-\theta}))(\rho_2/\rho_1)^{\theta-\rho}f_u}\right]^{\frac{1}{\theta-1}} \tag{2.4}$$

2.2.4 Equilibrium

Labor Market

The aggregate demand for low-skilled workers in both the unskilled and skill intensive sectors is

$$\begin{aligned} L^{'} &= L_u^{'} + L_s^{'} \\ &= \int_{z_e^{'}}^{z_{mx}} l_u^d(z)dz + \int_{z_{mx}}^{z_{ox}} l_u^{mx}(z)dz + \int_{z_{ox}}^{z_{ms}} l_u^{ox}(z)dz + \int_{z_{ms}}^{z_{os}} l_s^{mx}(z)dz + \int_{z_{os}}^{\infty} l_s^{ox}(z)dz \end{aligned}$$

while the aggregate demand for high-skilled workers in the skill-intensive sector is

$$H^{'} = \int_{z_{ox}}^{z_{ms}} h_s^{mx}(z)dz + \int_{z_{os}}^{\infty} h_s^{ox}(z)dz$$

Free Entry

The numbers of firms exporting unskilled or skilled goods to country m and country o can be derived as: $n_{mx} = \left(\frac{z_{mx}}{z_e^{'}}\right)^{-\kappa}$, $n_{ox} = \left(\frac{z_{ox}}{z_e^{'}}\right)^{-\kappa}$, $n_{ms} = \left(\frac{z_{ms}}{z_e^{'}}\right)^{-\kappa}$ and $n_{os} = \left(\frac{z_{os}}{z_e^{'}}\right)^{-\kappa}$. The average profit is $\tilde{\pi} = \tilde{\pi}_u^d + n_{mx}\tilde{\pi}_u^{mx} + n_{ox}\tilde{\pi}_u^{ox} + n_{ms}\tilde{\pi}_s^{mx} + n_{os}\tilde{\pi}_s^{ox}$, and it can be described in this way:

$$\begin{aligned} \tilde{\pi}^{'} = \frac{\tilde{r}^{'}}{\theta} - f_u - n_{mx}f_{mx} - n_{ox}(f_{ox} - f_{mx}) - n_{ms}((\phi_m - 1)f_u + f_{mx} - f_{ox}) \\ - n_{os}((\phi_o - \phi_m)f_u + f_{ox} - f_{mx}) \end{aligned}$$

Similar to Bustos (2011b)'s model, we can derive the average revenues $\tilde{r}^{'}$ expressed as the productivity cutoffs:

$$\begin{aligned} \tilde{r} = \theta f_u \left(\frac{\tilde{z}_e^{'}}{z_e^{'}}\right)^{\theta-1} + n_{mx}\theta f_{mx}\left(\frac{\tilde{z}_{mx}}{z_{mx}}\right)^{\theta-1} + n_{ox}\theta(f_{ox} - f_{mx})\left(\frac{\tilde{z}_{ox}}{z_{ox}}\right)^{\theta-1} \\ + n_{ms}\theta(f_u(\phi_m - 1) + f_{mx} - f_{ox})\left(\frac{\tilde{z}_{ms}}{z_{ms}}\right)^{\theta-1} + n_{os}\theta(f_{ox} - f_{mx} + (\phi_o - \phi_m)f_u)\left(\frac{\tilde{z}_{os}}{z_{os}}\right)^{\theta-1} \end{aligned}$$

After substituting $\tilde{r}^{'}$ into the free entry condition, we obtain

$$z_e^{'} = \left(\frac{\theta - 1}{\kappa - (\theta - 1)}\frac{1}{\delta f_e}\Psi\right)^{1/\kappa} \tag{2.5}$$

where $\Psi^{\kappa} = f_u + n_{mx}f_{mx} + n_{ox}(f_{ox} - f_{mx}) + n_{ms}(f_u(\phi_m - 1) + f_{mx} - f_{ox}) + n_{os}(f_{ox} - f_{mx} + (\phi_o - \phi_m)f_u)$.

2.2.5 Trade Liberalization

The trade liberation effect based on Bustos (2011b)'s setting is presented in Appendix B.2.3. Two additional propositions of the reduction in iceberg trade costs in our new model are discussed below.

Proposition 1. A reduction in iceberg trade costs of country m (τ_m):

a. increases the average profit, $\frac{\partial \tilde{\pi}'}{\tau_m} < 0$

b. increases the productivity cutoff of exiting the market, $\frac{\partial z_e'}{\tau_m} < 0$

c. reduces the productivity cutoff of exporting to country m, $\frac{\partial z_{mx}}{\tau_m} > 0$

d. reduces the skill-upgrading cutoff of exporters to country m, $\frac{\partial z_{ms}}{\tau_m} > 0$

Proof: Please see Appendix B.2.5. Part d is established only when certain conditions are met.

Proposition 2. A reduction in iceberg trade costs of country o (τ_o):

a. increases the average profit, $\frac{\partial \tilde{\pi}'}{\tau_o} < 0$

b. increases the productivity cutoff of exiting the market, $\frac{\partial z_e'}{\tau_o} < 0$

c. reduces the productivity cutoff of exporting to country m, $\frac{\partial z_{mx}}{\tau_o} > 0$

d. reduces the productivity cutoff of exporting to country o, $\frac{\partial z_{ox}}{\tau_o} > 0$

e. increases the skill-upgrading productivity cutoff of exporters to country m, $\frac{\partial z_{ms}}{\tau_o} < 0$

f. reduces the skill-upgrading productivity cutoff of exporters to country o, $\frac{\partial z_{os}}{\tau_o} > 0$

Proof: Please see Appendix B.2.5. Parts c and d are established only when certain conditions are met.

2.3 Trade Policies and Data

2.3.1 Post-WTO Accession Trade Liberalization in China

Trade liberalization policies undertaken in China after WTO accession are described in this session. First, China joined the WTO in 2001 and continued trade liberalization from 2001-2005. For instance, China committed to eliminating tariffs on all tariff lines, leading to a decrease in the average applied most-favored nation (MFN) rate from 15.6% in 2001 to 9.7% in 2005. This reduction was more pronounced in the manufactured goods category, where the rate decreased from 14.3% to 8.9%, and in agricultural products, where the rate went down from 23.2% to 14.6% over the same time frame (Bin, 2015). This indicates that China made a great achievement of import liberalization. Meanwhile, China's industrial goods conquered global markets after it joined the WTO in 2001. China doubled its share of trade in manufactured goods from 7.9% in 2000 to 17.7% in 2012 (Hilpert, 2014). According to UNCTADStat, its share of global export goods was 3.9% in 2000, and went up to 14.7% in 2020. FDI in China was less restricted after WTO accession, so China became the most important global investment destination. According to the World Bank, the net inflows of FDI in China started at 42.1 billion dollars in 2000 and reached a peak level of 290.9 billion dollars in 2013. Furthermore, China overtook the US as the world's leading destination for FDI in 2020.

Next, we describe an important regional trade liberalization. Formerly known as the Bangkok Agreement, APTA (Asia-Pacific Trade Agreement) was established through its signing in 1975. Bangladesh, China, India, Lao PDR, Mongolia, the Republic of Korea, and Sri Lanka are the current parties. APTA promotes intra-regional trade and contributes to economic development of the seven developing countries through trade and investment liberalization. China acceded to APTA in 2001 and endorsed a preferential trade arrangement among developing Asian countries. In 2005, the first Ministerial Council was held in Beijing, China, and the third round of negotiation results was implemented in 2006. Trade and tariff data from World Integrated Trade Solution (WITS) between 2004 and 2007 (see Figure 2.1) shows that India became the most preferential trading partner of China. This paper emphasizes the impact of APTA on exports and human capital investment of Chinese manufacturing firms theoretically and empirically. India is selected as a representative country because it imposed much higher tariffs than the rest of the world in 2004 and also reduced trade barriers with China more significantly from 2004 to 2007. More trade agreements among APTA members were made after 2007,[8] which will not be our focus.

2.3.2 Firm-Level Data

We resort to two data sources to construct a balanced panel of manufacturing firms in China. First of all, we obtain data from the Chinese Industrial Enterprises Database (CIED). The China National Bureau of Statistics (CNBS) primarily compiled the dataset based on annual or quarterly reports submitted to local bureaus of statistics. This comprehensive database includes both non-state-owned and "large-scale"[9] state-owned industrial enterprises. Notably, about 90% of these entities are manufacturing firms, which serves as the specific focus of this study. Although the database covers the period from 1998 to 2013, pertinent information regarding on-the-job training expenditure (TS), our principal metric for assessing skill enhancement in the empirical analysis, is only accessible for the years 2004 to 2007, which is exactly the regional trade liberalization period we emphasize. This database has been worked on by Hsieh and Klenow (2009), Song et al. (2011), Brandt et al. (2017), as well as Huang and Zhuang (2021), who provide more details about this database. From CIED, we also learn about each firm's total sales (which include both domestic and export sales) and number of employees, other than TS.

Second, we collect dis-aggregated information from the China Customs Database (CCD). It provides data on exports by firm, 8-digit HS product, and destination country. We merge the information from CCD to the CIED according to the firms' names, postal codes, or

[8] In November 2020, a new Asia-Pacific trade agreement was established. This agreement, known as the Regional Comprehensive Economic Partnership (RCEP), is a comprehensive Free Trade Agreement (FTA) uniting 15 countries in the Asia-Pacific region. Its signatories consist of the ten member states of the Association of Southeast Asian Nations (ASEAN), as well as Japan, Korea, China, Australia, and New Zealand. The signing of the RCEP aims to facilitate regional or even world trade and investment. RCEP connects about 30% of the world's population and output, makes Asian economies more efficient, improves technology, and solidifies global value chains. China continues to benefit from trade openness.

[9] The criterion for a "large-scale" enterprise's primary business income was initially set at over 5 million RMB, and it was subsequently raised to 20 million RMB in 2011.

telephone numbers, following Ruiqin et al. (2019).[10] We then aggregate export data at the 4-digit CIC industry level for each firm-destination country pair (some firms operate in multiple industries domestically and/or globally).

Next, we select the firms in the sectors that are covered by India's consolidated list of concessions to APTA member countries from the first 3 rounds of negotiations and in the 4-digit CIC industries with information on India's tariffs. We ended up with a balanced panel of 110,632 manufacturing firms (operating in 131,460 4-digit CIC industries) in each year from 2004 to 2007. The sample is reflective of firms that possess establishments employing more than 10 individuals that can potentially be affected by APTA.

By merging the CIED and CCD data, we can calculate the total sales per employee for each firm, which will be one of our firm-level controls. Moreover, domestic sales can be calculated by subtracting export sales from total sales. One special feature of the data is that we know each firm's export sales to each destination country, including India—we can therefore learn about whether a firm exports to India or not.

Table B.1 located in in Appendix B.3 provides summary statistics categorized by export status for the primary variables of interest corresponding to the base year of 2004..

2.3.3 Industry-Level Data

We introduce controls for 4-digit CIC industry attributes that could exhibit a correlation with fluctuations in tariffs. We collect information on the average capital and skill intensity within industries in the United States during the 1980s from the National Bureau of Economic Research (NBER) productivity database (detailed further in Appendix B.3). Additionally, we incorporate the import demand elasticity and export supply elasticity as computed by Broda and Weinstein (2006) and Broda et al. (2008).

2.4 Empirics

In this section, we put the theoretical forecasts outlined in Section 2.2 to the test. To begin, we verify if the model-projected sorting pattern of firms into exporting and training aligns

[10] The numbers of merged manufacturing enterprises are 52,046 in 2004, 51,026 in 2005, 60,345 in 2006, and 61,749 in 2007. These correspond to 38.1%, 37.7%, 27.8%, and 28.9% of the enterprises in CCD.

with the actual traits exhibited by exporters targeting diverse nations and non-exporters within the same four-digit CIC industry. Subsequently, we examine the core conjectures of our model. Specifically, we investigate whether a decrease in export tariffs stimulates firm participation in the export market and triggers skill upgrading. We focus on the regional trade liberalization (APTA) effect, as we select the sectors covered by India's consolidated list of concessions from the first 3 rounds of negotiations to APTA member countries.

2.4.1 Within-Industry Patterns in the Data

Following Bustos (2011b)'s model setting, inherent differences in productivity result in the categorization of firms into four distinct groups: the least productive firms leave the market (not depicted in the data), firms with low productivity manufacture unskilled goods exclusively for the domestic market, entities within the intermediate range continue producing unskilled goods for both domestic and export markets, and the most productive firms engage in both exports and offer labor training for the production of skilled goods. Within this context, a decrease in trade costs τ amplifies export profits, leading to a greater influx of enterprises within the intermediate productivity range to participate in the export market and enhance the skill levels of their workers. Figure 2.2 portrays the results of trade liberalization on firms situated within various segments of the productivity distribution, demonstrating changes in productivity thresholds from 2004 to 2007. Precisely speaking, firms with intermediate productivity find it easier to start exporting and the more productive firms also have greater incentives to provide labor training.

In the model, we distinguish the trade effects of two export destinations, countries m and o. Country m refers to a main trading partner of the home country, while country o is a less preferential trading partner since it imposes a higher tariff ($\tau_o > \tau_m$). This paper refers to India as a representative country o. In this scenario, firms are classified into six distinct groups. The least productive firms opt to leave the market. Low productivity firms exclusively manufacture unskilled goods for the domestic market. Lower-middle firms continue producing unskilled goods while also exporting to country m. Upper-middle firms export unskilled goods to country o. High productivity firms are capable of offering labor

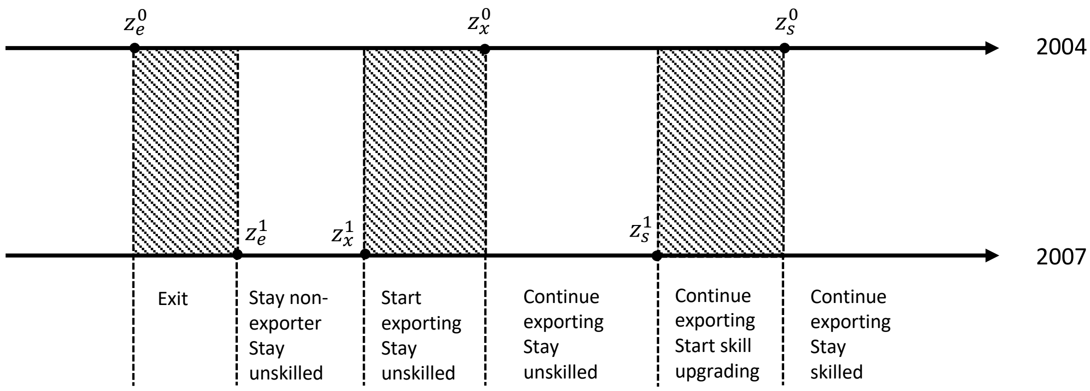

Figure 2.2: Effect of lowering variable trade costs: Bustos (2011b)'s setting

training and exporting skilled goods to country m. The most productive firms can export skilled goods to country o. Figure 2.3 also displays the impact of trade liberalization on firms located within each segment of the productivity distribution. In particular, as shown by the shaded areas, firms switching export markets from country m to o could continue producing unskilled goods, start skill downgrading, or begin skill upgrading.[11]

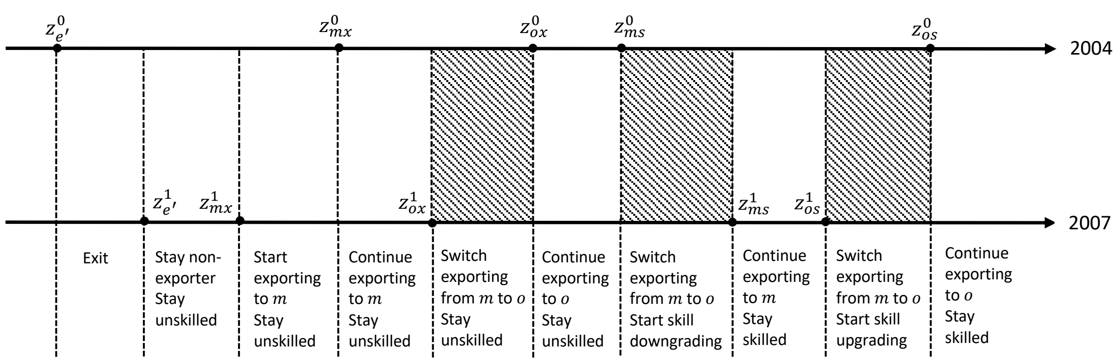

Figure 2.3: Effect of lowering variable trade costs: Advanced setting

To validate whether the sorting patterns illustrated in Figures 2.2 and 2.3, as well as

[11]The model does not reflect trade-induced switching from country o to m. There should be an exogenous shock that leads to this switching.

the parameter constraints necessary for the model, align with the empirical data, we follow Bustos (2011b) to divide firms into four groups: continuing exporters, new exporters, exiting exporters, and firms serving the domestic market only (never exporters), and compute the differences in characteristics, including sales, employment, and training spending per worker, for firms operating within the same four-digit CIC industry.

First, Table 2.1 indicates that, based on the basic model, all types of exporters have higher sales, employment, and training spending per worker than never exporters in 2004 on average, which mirrors the fact that (potential) exporters are larger, more productive, and more skill-intensive. Second, although sales and employment of new exporters are relatively lower than incumbent exporters in 2004, their per capita training spending is higher than continuing exporters on average, preparing them to enter the skill-intensive sector and employ more high-skilled workers. Third, the increase in training spending per worker for continuing exporters is almost zero from 2004 to 2007 (trade liberalization period), but exiting exporters that later serve the domestic market only reduce labor training.[12] On the contrary, new exporters have the largest average increases in sales, employment, and training spending per worker compared to never exporters. These results indicate that new exporters benefit more from trade liberalization and have greater incentives for human capital investment. It is intuitive that new exporters might demand more high-skilled workers in order to become more competitive in the foreign market.

In terms of our model, we distinguish two export markets, country m and o. Exporters to India have higher sales, employment, and training spending per worker in 2004 than those exporting to non-Indian countries (except for those who switch destinations) as shown in Table 2.1, which is consistent with the model setting that firms exporting to India are more productive, conditional on skill level. Moreover, firms switching from non-India to Indian markets in 2004 have slightly higher training spending per worker than those doing the converse, which shows that more of them started to produce high-skilled products earlier. From 2004 to 2007, there is a larger decline in India's tariffs and a greater increase in

[12]Based on the number of industry-level observations and the number of distinct firms, we can see that only continuing exporters operate in multiple industries, while exiting and new exporters both operated in a single industry.

Table 2.1: Differences between different types of exporters and non-exporters in APTA sectors

	Levels in 2004			Changes 2004–2007			Size	
Firm characteristic	Sales	Employment	Training per worker	Sales	Employment	Training per worker	Observations	Firms
Bustos (2011b)'s model								
New exporters	0.596***	0.505***	0.412***	0.176***	0.146***	0.129***	3,957	3,957
	(0.020)	(0.017)	(0.041)	(0.014)	(0.010)	(0.048)		
Continuing exporters	1.240***	1.027***	0.150***	-0.095***	0.058***	0.011	40,873	20,045
	(0.009)	(0.008)	(0.017)	(0.006)	(0.004)	(0.019)		
Exiting exporters	1.086***	0.852***	0.438***	-0.130***	-0.035***	-0.087*	3,919	3,919
	(0.021)	(0.018)	(0.040)	(0.015)	(0.010)	(0.046)		
Our model								
New exporters to non-Indian	0.532***	0.462***	0.329***	0.152***	0.132***	0.129**	3,203	3,203
countries (m)	(0.021)	(0.018)	(0.045)	(0.015)	(0.011)	(0.052)		
New exporters to India (o)	0.876***	0.691***	0.769***	0.278***	0.205***	0.128	754	754
	(0.049)	(0.042)	(0.091)	(0.027)	(0.021)	(0.111)		
Continuing exporters to m	1.160***	0.997***	0.047***	-0.113***	0.046***	-0.001	34,448	17,227
	(0.010)	(0.008)	(0.018)	(0.006)	(0.004)	(0.020)		
Continuing exporters to o	1.751***	1.234***	0.813***	-0.024*	0.102***	0.015	2,200	1,831
	(0.032)	(0.026)	(0.058)	(0.014)	(0.011)	(0.063)		
Switching exporters from m to o	1.562***	1.131***	0.594***	0.061***	0.163***	0.080	2,971	2,379
	(0.029)	(0.024)	(0.049)	(0.012)	(0.010)	(0.054)		
Switching exporters from o to m	1.545***	1.157***	0.435***	-0.165***	0.014	0.140*	1,254	1,082
	(0.042)	(0.034)	(0.071)	(0.020)	(0.016)	(0.078)		
Exiting exporters to m	0.997***	0.794***	0.338***	-0.140***	-0.044***	-0.080	3,348	3,348
	(0.022)	(0.019)	(0.043)	(0.016)	(0.011)	(0.049)		
Exiting exporters to o	1.618***	1.194***	1.032***	-0.072**	0.015	-0.129	571	571
	(0.053)	(0.045)	(0.104)	(0.031)	(0.023)	(0.124)		
Observations	131,460	131,460	131,460	131,460	131,460	131,460		
Firms	110,632	110,632	110,632	110,632	110,632	110,632		

Notes: (1) Robust standard errors are in parentheses. (2) Exporter premia are estimated from a regression of the form $\ln Y_{ij} = \alpha_1 \text{Type } 1_{ij} + \alpha_2 \text{Type } 2_{ij} + ... + I_j + \varepsilon_{ij}$ where i indexes firms, and j indexes four-digit CIC industries; the reference category relative to which differences are estimated is non-exporters; I are industry dummies, and Y is the firm characteristic for which the differences are estimated. (3) ***, **, * denote significance levels at 1%, 5%, and 10%, respectively. (4) Some continuing and switching exporters operated in multiple industries.

exports to India compared to those of other countries (Figure 2.1). Therefore, new exporters targeting Indian markets have even larger average increases in sales and employment than those targeting non-Indian markets. However, interestingly, new exporters targeting India have a slightly less significant average increase in training spending per worker than those targeting non-Indian nations. That is likely due to the fact that they have already spent more in training their workers in 2004 before changes in trade costs τ_o, or there could be sector heterogeneity. Moreover, continuing exporters targeting non-Indian markets had even lower average increases in sales and employment than those targeting India, although their increases in average per capita training spending were almost the same. Additionally, there are firms switching export destinations during the same period. Table 2.1 shows that the trade liberalization period coincides with a slightly higher increase in training pending per worker among firms which switch export markets from country o to m, which supports our model assumption that some firms could find it more profitable to export skilled goods to country m than to export unskilled goods to country o which imposes higher (but declining) trade barriers. For firms which switch destinations from m to o, the increase in per capita training is not so significant. This result is actually also in line with the model in some way, as two shading areas in Figure 2.3 imply that these firms either start skill downgrading or continue producing unskilled goods. Thus, the average effect of labor training could be ambiguous.

The pattern presented in Table 2.1 indicates a correspondence between participation in the export market and the enhancement of skill levels, and the performance of exporters targeting the Indian market differs from other firms. However, we are unable to determine whether improved export opportunities stimulate investments in human capital, or if it's the other way around, or if both are influenced by a third underlying factor. The subsequent empirical analysis aims to establish a causal relationship by directly connecting exporting and skill upgrading to the decrease in India's tariffs for imports originating from China.

2.4.2 The Impact of the APTA: Identification Strategy

After China joined APTA in 2001, a reduction in India's tariffs for imports from China across four-digit CIC industries leads to changes in Chinese firms' entry the export market and skill upgrading. There are two features of the source of identification that make it exogenous with respect to these two outcomes of interest. First, the tariff reductions were constantly adjusted and negotiated among APTA members between 2004 and 2007. In our data, the average tariff facing manufacturing firms in the sectors covered by APTA decreases from about 28.59 percentage points in 2004 to 13.43 percentage points in 2007. These tariff reductions are not likely to be determined by any individual firm in a specific country. Second, the 2004 simple average effectively applied (AHS) import tariff of India for China was close to those of the rest of the world.[13] It's improbable that India's import tariffs are designed to specifically target industry characteristics unique to China. The share of India's imports from China was 6.11% in 2004, but rose to 11.24% in 2007, since India's average tariff declined by more than a half during the same period.

The reverse causality problem may not be a concern, but India's initial tariff structure is surely not random. India's trade policy exhibits a correlation with certain industry characteristics, making their omission a potential source of bias. As a countermeasure, we compute all equations in first differences to eliminate constant industry traits. However, it's possible that India's tariffs might encapsulate some unaccounted industry-level variables that change over time, especially if industries with distinct initial characteristics follow different trends. To delve deeper into this matter, we include in the first-differenced equations sector dummies to control for unobserved sector trends and also include four-digit CIC level controls for industry characteristics such as import demand elasticity, export supply elasticity, and capital and skill intensity.

We employ India's tariffs as a gauge to quantify the impact of heightened export prospects on both export engagement and skill enhancement. Yet, these effects could potentially correlate with alterations in China's tariff policies. Consequently, we incorporate controls

[13] According to WITS, the simple average AHS tariffs of India for China and the world are 28.78 and 28.57 percentage points respectively in 2004. In terms of the simple average MFN tariff, the 2004 tariff rates of India are 28.78 percentage points for China and 29.51 percentage points for the world.

for changes in China's tariffs concerning the world from 2004 to 2007, alongside changes in China's tariffs concerning India. [14]

In Bustos (2011b)' model, the decrease in India's tariffs encourages firms situated within the intermediate range of productivity to engage in export activities and enhance their skill levels, while it appears to have limited effects on the least and most productive groups. Our model also predicts that firms in the middle or upper-middle range have a higher likelihood of exporting, switching export destinations, and starting skill downgrading or upgrading following trade integration. To examine these varied impacts associated with different firm productivity, we utilize firm size in relation to the 2004 four-digit CIC industry average as a surrogate for initial productivity, categorizing firms into quartiles based on this measure. In the next section, we discuss the empirical results of the decline in India's tariffs in each quartile of the firm size distribution. We emphasize the decisions related to entering the export market and skill upgrading, and subsequently compare these findings with our theoretical predictions.

2.4.3 Export Market Entry Decisions

In this section, we intend to identify the signs of the partial derivatives of interest in the model of the export market entry choices described by equations B.6, as well as 2.1 and 2.2. To do so, we calculate a linearized rendition of the entry models and evaluate the economic importance of the estimated coefficients. We outline the procedure for estimating the average impact of a decrease in India's tariffs on entry into the export market for all firms. Next, we distinguish the export markets, comparing non-Indian countries with India.

Consistent with Bustos (2011b)'s model, we empirically analyze the export entry decisions using an index model:

$$EX^k_{ijst} = \begin{cases} 1 & \text{if } \beta^k_{\tau^{ex}} \tau^{ex}_{jt} + \alpha^k_{st} + \mu^k_i + \epsilon^k_{ijst} > 0 \\ 0 & \text{otherwise} \end{cases} \tag{2.6}$$

where i indexes firms; j indexes four-digit CIC industries; s indexes sectors; t indexes years

[14] Both final goods and intermediate inputs tariffs are controlled.

from 2004 to 2007; τ_{jt}^{ex} are India's tariffs that vary across four-digit CIC industries and time; α_{st}^{k} are sector dummies that capture time-varying sector features; μ_{i}^{k} are firm fixed effects capturing unobserved constant heterogeneity including firm heterogeneity z defined in the model and other characteristics affecting productivity cutoffs; EX_{ijst}^{k} is a dummy that captures firms' export decisions to any partner or India. When $k = 0$, firms can either be exporters or non-exporters; EX_{ijst}^{0} is assigned a value of 1 if a firm engages in exporting to any country during year t, and 0 if it does not. If $k = 1$, the firm is an exporter; $EX_{ijst}^{1} = 1$ when the firm exports to India (and potentially other countries at the same time), and $EX_{ijst}^{1} = 0$ if the firm exports only to non-Indian countries.

First-Differenced Specification

We take first differences to eliminate time-invariant plant and sector heterogeneity, and obtain

$$\Delta EX_{ijst}^{0} = \beta_{\tau^{ex}}^{0} \Delta \tau_{jt}^{ex} + \Delta \alpha_{st}^{0} + \Delta \epsilon_{ijst}^{0} \tag{2.7}$$

In the meantime, we include controls for alterations in China's import tariffs concerning both outputs and inputs in relation to the global context and India ($\Delta \tau_{jt}^{im}$). Additionally, we account for firm attributes in the base year (2004), including factors like workforce size and sales per worker (z_{ij2004}), along with four-digit industry traits such as import demand and export supply elasticities, as well as skill and capital intensity in the US (c_j).[15] Hence, we have the following equation:

$$\Delta EX_{ijst}^{0} = \beta_{\tau^{ex}}^{0} \Delta \tau_{jt}^{ex} + \beta_{\tau^{im}}^{0} \Delta \tau_{jt}^{im} + \beta_{z}^{0} Z_{ij2004} + \beta_{c}^{0} c_j + \Delta \alpha_{st}^{0} + \Delta \epsilon_{ijst}^{0} \tag{2.8}$$

The estimation of equation (2.7) is presented in column 1 of Table 2.2, and the regression coefficients including other controls (equation 2.8) are shown in columns 2 to 8. From panel A of Table 2.2, we find that a reduction in India's tariffs increases the likelihood of entering export for the full sample. For instance, columns 5 and 8 indicate that the probability for firms to enter the export market increases by 1.55 percentage points when the average reduction in India's tariffs is around 15 percentage points from 2004 to 2007. This empirical

[15] We calculate elasticities sand intensity following Broda and Weinstein (2006) and Broda et al. (2008).

Table 2.2: Entry in the export markets stratified by sector group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Full sample. Dependent variable: year-over-year change in export status								
ΔIndia's tariffs	-0.124***	-0.125***	-0.120***	-0.104***	-0.103**	-0.112***	-0.104***	-0.103***
	(0.032)	(0.031)	(0.034)	(0.038)	(0.040)	(0.031)	(0.032)	(0.033)
ΔChina's tariffs w.r.t. world								
Outputs			yes	yes	yes			
Inputs				yes	yes			
ΔChina's tariffs w.r.t. India								
Outputs						yes	yes	yes
Inputs							yes	yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Firm-level controls		yes	yes	yes	yes	yes	yes	yes
Industry controls					yes			yes
Observations	91,869	91,869	91,869	91,869	91,869	91,869	91,869	91,869
R^2	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Panel B: Full sample. Dependent variable: export status in the current year								
ΔIndia's tariffs	-0.147***	-0.147***	-0.143***	-0.127***	-0.116***	-0.135***	-0.128***	-0.116***
	(0.036)	(0.036)	(0.038)	(0.042)	(0.043)	(0.036)	(0.036)	(0.036)
Export status in the	0.933***	0.932***	0.932***	0.932***	0.931***	0.932***	0.932***	0.931***
previous year	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
R^2	0.884	0.884	0.884	0.884	0.884	0.884	0.884	0.884
Panel C: Sample of baseline non-exporters. Dependent variable: export status in the current year								
ΔIndia's tariffs	-0.128***	-0.126***	-0.122***	-0.121***	-0.090**	-0.127***	-0.120***	-0.092***
	(0.038)	(0.039)	(0.039)	(0.043)	(0.035)	(0.039)	(0.038)	(0.031)
Export status in the	0.729***	0.726***	0.726***	0.726***	0.725***	0.726***	0.726***	0.725***
previous year	(0.021)	(0.021)	(0.021)	(0.021)	(0.020)	(0.021)	(0.021)	(0.020)
Observations	60,273	60,273	60,273	60,273	60,273	60,273	60,273	60,273
R^2	0.317	0.318	0.318	0.318	0.319	0.318	0.318	0.319

Notes: (1) Standard errors are clustered at the 4-digit CIC industry level. (2) Δ denotes the year-over-year change in a variable during the period 2004–2007. (3) Firm-level controls include the number of employees and sales per worker, all measured in the initial year (2004). (4) Industry controls include import demand elasticity, export supply elasticity, skill intensity, and capital intensity in the United States. (5) In panel C, remaining controls are the same as in the corresponding column in panel A. (6) In panel B, controls and number of observations are the same as in the corresponding column in panel A. (7) ***, **, * denote significance levels at 1%, 5%, and 10%, respectively. (8) Data include 14 manufacturing sectors as follows: "wood processing and wood, bamboo, rattan, palm and grass products" (No. 32), "coatings, inks, pigments and similar products" (No. 42), "daily chemical products" (No. 45), "rubber products" (No. 48), "plastic products" (No. 49), "brick, stone and other building materials" (No. 52), "boilers and prime movers" (No. 64), "metal processing machines" (No. 65), "mining, metallurgy, and special equipment for construction" (No. 69), "special machines for agriculture, forestry, animal husbandry and fishery" (No. 71), "ship and floating devices" (No. 75), "household electric and non-electric appliances" (No. 80), "instrumentation" (No. 88), and "cultural and office machines" (No. 89).

result is consistent with the model prediction that a reduction in trade costs increases firm profit and encourages export participation.

Lagged-Dependent Variable

To check for robustness, we implement two more exercises. First, current export decisions might be influenced by lagged export status because of sunk export costs. Therefore, we control the export status in the previous year and estimate the equation in levels with the following regression:

$$EX^0_{ijst} = \beta^0_{\tau^{ex}} \Delta\tau^{ex}_{jt} + \gamma^0 EX^0_{ijs,t-1} + \alpha^0_{st} + \epsilon^0_{ijst} \qquad (2.9)$$

The second check is to create a sample of baseline non-exporters and estimate the equation (2.9) that is restricted to non-exporters in 2004. This estimation highlights the effects of changing tariffs on initial non-exporters as we notice that trade liberalization between 2004 and 2007 has a greater positive impact on sales, employment, and labor training for new exporters in Table 2.1. The estimates in panels C and D of Table 2.2 are very close to the coefficients of changes in India's tariffs in panel A. This implies that our estimated results of the export entry decisions are fairly robust.

Export Decision by Quartile of the Firm Size Distribution

Following Bustos (2011b)'s model setting, we predict that reduced trade costs encourage the participation of firms with intermediate levels of productivity in the export market. This is because a decrease in trade costs leads to a lowering of the export productivity threshold z_x. As Figure 2.2 depicts, the export productivity cutoff in 2007 (z^1_x) is much lower than the initial cutoff (z^0_x). Firms with productivity in the range $z^1_x < z < z^0_x$ become exporters following trade liberalization. The less productive firms still stay out of the market or serve the domestic market only, and the most productive firms continue exporting. Empirically, we calculate the influence of the adjustment in India's tariffs on each quartile within the initial firm size distribution:

$$\Delta EX^0_{ijst} = \sum_{n=1}^{4} \beta^0_{\tau^{ex},n} (\Delta\tau^{ex}_{jt} \times Q_{ij,n}) + \sum_{n=1}^{4} \delta^0_n Q_{ij,n} + \beta^0_{\tau^{im}} \Delta\tau^{im}_{jt} + \Delta\alpha^0_{st} + \Delta\epsilon^0_{ijst} \qquad (2.10)$$

where n signifies each of the four quartiles within the distribution of firm sizes, while $Q_{ij,n}$ are binary variables that assume a value of 1 when firm i falls into quartile n. Columns 1 to 9 of Table 2.3 demonstrate that the impact of the decrease in India's tariffs on firms' entry into the export market holds significance within the last three quartiles of the firm size distribution, while firms in the fourth quartile ($\beta_{\tau^{ex},4} = -0.17$) actually receive larger influences from changes in tariffs than those in the second ($\beta_{\tau^{ex},2} = -0.11$) and third quartiles ($\beta_{\tau^{ex},3} = -0.13$). Columns 4 to 6 provide estimations of the aforementioned equation in levels, while accounting for lagged export status. The point estimates of $\beta_{\tau^{ex},n}$ are slightly higher, yet the pattern remains consistent. Additionally, the estimated results of the sample of non-exporters in 2004 are smaller than those of the full sample, and the impacts of trade costs on the third and fourth quartiles are more significant compared to the first and second quartiles. In particular, the point estimates of $\beta_{\tau^{ex},3}$ in Columns 4 and 7 suggest that the average reduction in India's tariffs (15 percentage points) leads to an increase in the probability of engaging in the export market by 2.13 percentage points across all firms, and by 1.64 percentage points for the subset of firms that were non-exporters in 2004.

All coefficients ($\beta_{\tau^{ex},n}$) are negative, although some firms in the first quartile are not always statistically significant. This suggests that some firms in the first quartile are less likely to be induced to export with a reduction in India's tariffs, which is consistent with the model prediction. Nevertheless, firm size distribution might not necessarily serve as a reliable gauge of firm productivity, and it's plausible that export productivity thresholds could exhibit variations across different industries, which explains the significance of the fourth quartile.

Overall, most firms in the first quartile are still below the productivity threshold of exports after liberalization, while firms in the middle range (second and third quartiles) of the size distribution are more likely to be induced to enter the export market. However, the empirical findings show that firms in the fourth quartile have the largest incentive to enter the export market as the absolute value of $\beta_{\tau^{ex},4}$ is the biggest in each column. This result is not in line with the model prediction that the most productive firms would always export regardless of tariffs. Besides the initial firm size not being a perfect measure, some relevant policies in China could help explain this finding. Large-scale enterprises were encouraged to participate in the export market in the Eleventh Five-Year Plan of China in 2006. In particular, Chapter 11 of the Plan includes goals to revitalize manufacturing of major technical equipment, strengthen the shipbuilding industry and improve the performance of the automotive industry. Therefore, this policy could explain why more firms in the fourth quartiles entered the export market during the episode of trade-integration.

2.4.4 Skill Upgrading Decisions

In this section, we focus on the skill upgrading decisions made by firms. The decision to provide labor training is described in equations (B.7), (2.3) and (2.4). Following the estimation of equation (2.8), in addition to India's tariffs, we control for China's import tariffs regarding outputs and inputs, four-digit CIC industry characteristics, sector dummies, and plant fixed effects; thus, the level of investment in on-the-job training can be expressed as:

$$\log TS_{ijst} = \beta_{\tau^{ex}} \tau_{jt}^{ex} + \beta_{\tau^{im}} \tau_{jt}^{im} + \alpha_{st} + \mu_i + \epsilon_{ijst} \tag{2.11}$$

where TS denotes a firm's spending on labor training; τ_{jt}^{im} are China's import tariffs, which also affect firm revenues and skill upgrading decisions.

First-Differenced Estimation

Similarly, we estimate equation (2.11) in first differences to eliminate constant plant and sector heterogeneity:

$$\Delta \log TS_{ijst} = \beta_{\tau^{ex}} \Delta\tau_{jt}^{ex} + \beta_{\tau^{im}} \Delta\tau_{jt}^{im} + \Delta\alpha_{st} + \Delta\epsilon_{ijst} \tag{2.12}$$

Panel A of Table 2.4 indicates that trade liberalization between 2004 and 2007 induces more investment in on-the-job training by manufacturing firms. In particular, columns 5 and 8 of panel A with additional controls shows that the 15 percentage point decline in India's tariffs increases labor training provided by firms by about 0.11 to 0.13 log points. When trade costs become lower, productive firms earn greater revenues, so they have higher incentives to increase human capital investment and produce more skill-intensive products.

In terms of the sample of non-exporters in 2004, the estimation in panel B of Table 2.4 implies that skill upgrading in response to a reduction in India's tariff is still positive but

Table 2.3: Entry in the export market by quantile of the firm size distribution

Dependent variable	Full sample						Baseline non-exporters		
	Change in status			Status in the current year			Status in the current year		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔIndia's tariffs									
× first size quartile	-0.070*	-0.054	-0.050	-0.079**	-0.064	-0.060	-0.060*	-0.059	-0.060*
	(0.036)	(0.042)	(0.036)	(0.039)	(0.046)	(0.040)	(0.036)	(0.040)	(0.036)
× second size quartile	-0.113***	-0.095**	-0.095**	-0.124***	-0.107**	-0.107**	-0.084**	-0.082**	-0.083**
	(0.035)	(0.041)	(0.037)	(0.039)	(0.047)	(0.042)	(0.038)	(0.041)	(0.038)
× third size quartile	-0.126***	-0.107***	-0.107***	-0.142***	-0.124***	-0.124***	-0.109***	-0.107***	-0.107***
	(0.033)	(0.041)	(0.034)	(0.037)	(0.044)	(0.038)	(0.034)	(0.039)	(0.035)
× fourth size quartile	-0.169***	-0.150***	-0.149***	-0.194***	-0.176***	-0.175***	-0.162***	-0.160***	-0.160***
	(0.040)	(0.048)	(0.038)	(0.041)	(0.048)	(0.039)	(0.041)	(0.047)	(0.041)
ΔChina's tariffs w.r.t. world		yes			yes			yes	
ΔChina's tariffs w.r.t. India			yes			yes			yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes	
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	
Firm-level controls	yes	yes	yes	yes	yes	yes	yes	yes	
Industry controls		yes	yes		yes	yes		yes	yes
Observations	91,869	91,869	91,869	91,869	91,869	91,869	60,273	60,273	60,273
R^2	0.004	0.004	0.005	0.884	0.884	0.884	0.320	0.320	0.320

Notes: (1) Standard errors are clustered at the 4-digit CIC industry level. (2) Δ denotes the year-over-year change in a variable during the period 2004–2007. (3) Firm-level controls encompass dummy variables representing the second, third, and fourth quartiles of the firm-size distribution in the base year (2004). (4) Industry controls encompass import demand elasticity, export supply elasticity, skill intensity, and capital intensity in the United States. (5) Controls for variations in China's tariffs concerning both the world and India comprise both output and input tariffs. (6) ***, **, * denote significance levels at 1%, 5%, and 10%, respectively. (7) Data include 14 manufacturing sectors mentioned in Table 2.2.

Table 2.4: Investment in on-the-job training stratified by sector group and initial export status

Dependent variable: year-over-year change in log(training spending)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Full sample.								
ΔIndia's tariffs	-0.854***	-0.854***	-0.903***	-0.796**	-0.753*	-0.859***	-0.883***	-0.842***
	(0.304)	(0.304)	(0.325)	(0.397)	(0.409)	(0.316)	(0.311)	(0.320)
ΔChina's tariffs w.r.t. world								
Outputs			yes	yes	yes			
Inputs				yes	yes			
ΔChina's tariffs w.r.t. India								
Outputs						yes	yes	yes
Inputs							yes	yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Firm-level controls		yes	yes	yes	yes	yes	yes	yes
Industry controls					yes			yes
Observations	91,869	91,869	91,869	91,869	91,869	91,869	91,869	91,869
R^2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Panel B: Sample of baseline non-exporters.								
ΔIndia's tariffs	-0.810**	-0.804**	-0.818**	-0.778*	-0.683	-0.820**	-0.908***	-0.824**
	(0.324)	(0.324)	(0.344)	(0.443)	(0.441)	(0.339)	(0.325)	(0.320)
Observations	60,273	60,273	60,273	60,273	60,273	60,273	60,273	60,273
R^2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Panel C: Sample of baseline exporters.								
ΔIndia's tariffs	-0.917	-0.915	-1.018	-0.931	-1.096	-0.878	-0.889	-1.050
	(0.788)	(0.785)	(0.851)	(0.869)	(0.900)	(0.805)	(0.805)	(0.833)
Observations	31,596	31,596	31,596	31,596	31,596	31,596	31,596	31,596
R^2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Notes: (1) Standard errors are clustered at the 4-digit CIC industry level. (2) Δ denotes the year-over-year change in a variable during the period 2004–2007. (3) Firm-level controls involve number of employees and sales per worker, all measured in the base year (2004). (4) Industry controls invlove import demand elasticity, export supply elasticity, skill intensity, and capital intensity in the United States. (5) In panels B, C, and D, the remaining controls are consistent with those utilized in the corresponding column of panel A. (6) ***, **, * denote significance levels at 1%, 5%, and 10%, respectively. (7) Data include 14 manufacturing sectors mentioned in Table 2.2.

less significant. The estimated coefficients for the sample of exporters in 2004 are also insignificant as presented in panel C. One possible explanation is that some continuing exporters switch to the Indian market due to an increase in skill upgrading productivity cutoff in non-Indian countries and no longer produce high-skill products, and some exiting exporters no longer demand high-skill workers when serving the domestic market only.[16]

Skill Upgrading Decisions by Quartile of the Firm Size Distribution

Following Bustos (2011b)'s model setting, we find that lower trade costs encourage firms operating in the range $z_s^1 < z < z_s^0$ to provide more labor training, since a reduction in trade costs decreases the skill upgrading productivity cutoff z_s. As shown in Figure 2.2, these firms are situated within the intermediate range of the productivity distribution, and they invest more in human capital following trade liberalization. The least and the most productive firms wouldn't change their decisions about labor skill upgrading in response to trade openness. Empirically, we calculate the influence of the adjustment in India's tariffs on each quartile within the initial firm size distribution:

$$\Delta \log TS_{ijst} = \sum_{n=1}^{4} \beta_{\tau^{ex},n}(\Delta\tau_{jt}^{ex} \times Q_{ij,n}) + \sum_{n=1}^{4} \delta_n Q_{ij,n} + \beta_{\tau^{im}} \Delta\tau_{jt}^{im} + \Delta\alpha_{st} + \Delta\epsilon_{ijst} \quad (2.13)$$

In this context, n signifies each of the four quartiles within the distribution of firm sizes, while $Q_{ij,n}$ are binary variables that assume a value of 1 when firm i falls into quartile n. Columns 1–3 of Table 2.5 show that the effect of the decrease in India's tariffs on investment in on-the-job training is significant in the first three quartiles of the firm size distribution for the full sample. Trade liberalization has a relatively larger impact on the skill upgrading decisions of firms in the second quartile. For instance, the 15 percentage point reduction in India's tariffs from 2004 to 2007 increases spending on training of firms in the second quartile by 0.18 log points, while firms in the first and third quartiles increase labor training by only about 0.14 log points. As the model predicts, firms with productivity in the middle range are sensitive to changes in trade costs, so the reduction in tariffs positively affects skill upgrading decisions of firms in the second and third quartiles.

[16]Although not shown in Table 2.2, the effect of trade liberalization on entry in the export market is less statistically significant (although larger) in the sample of baseline exporters.

One question is: why do firms in the low or lower-middle range of the size distribution choose to increase human capital investment after liberalization? Bustos (2011b)'s model cannot match this empirical result. One possible reason is that Chinese local governments protect some smaller domestic firms and state-owned enterprises. The less productive firms could receive subsidies from governments or benefit from new regulations, so that they can follow their high productive competitors to provide more labor training and employ more high-skilled workers during the liberalization period, especially among those who are encouraged to "go out" (a famous slogan from the Chinese government during that period).

In terms of the sample of initial non-exporters and the sample of initial exporters in 2004, the trade-integration effect on labor training by firms in the first quartile is very similar to the findings in panels B and C of Table 2.4. Regardless of the initial export status, the effect of the reduction in tariffs on the fourth quartile more open to debate. This aligns with the model's prediction that the most productive firms ($z > z_s$) still find it profitable to provide labor training even when India's tariffs are lower.

From the findings in Table 2.3 and Table 2.5, trade liberalization induces a significant increase in both the probability of export participation and spending on labor training by firms in the second and third quartiles, which is consistent with the prediction of Bustos (2011b)'s model. In the next section, we attempt to extend our empirical analysis to focus more on our model, and make some further discussions, including sector characteristics and specific policies or regulations in China, to understand those empirical results.

2.4.5 Advanced setting

Recall that the data pattern shows that India's tariffs are much higher than those of other countries, but the reduction in India's tariffs is much more drastic between 2004 and 2007. Thus, we build a model that distinguishes two different export destinations, countries m and o in order to highlight the effect of trade liberalization on exporters to the Indian market or other foreign markets. Next, we estimate two similar first-differenced models as in subsections 2.4.3 and 2.4.4, but analyze the export destination decisions of new exporters and the skill upgrading decisions of new exporters to the Indian market.

Table 2.5: Investment in on-the-job training by quartile of the firm size distribution and initial export status

Dependent variable: year-over-year change in log(training spending)	Full sample			Baseline non-exporters			Baseline exporters		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ΔIndia's tariffs									
× first size quartile	-0.977***	-0.913**	-0.992***	-1.065***	-0.999**	-1.117***	-0.860	-0.895	-0.845
	(0.338)	(0.416)	(0.344)	(0.330)	(0.419)	(0.330)	(0.904)	(0.981)	(0.919)
× second size quartile	-1.222***	-1.153**	-1.246***	-1.045**	-0.972*	-1.117***	-1.838**	-1.857*	-1.824**
	(0.380)	(0.478)	(0.386)	(0.403)	(0.523)	(0.407)	(0.877)	(0.959)	(0.897)
× third size quartile	-0.924***	-0.854**	-0.953***	-0.650*	-0.573	-0.740**	-1.537*	-1.560*	-1.511*
	(0.332)	(0.427)	(0.335)	(0.352)	(0.469)	(0.351)	(0.846)	(0.938)	(0.875)
× fourth size quartile	-0.168	-0.099	-0.195	0.048	0.124	-0.051	-0.420	-0.432	-0.388
	(0.343)	(0.420)	(0.354)	(0.338)	(0.423)	(0.353)	(0.866)	(0.952)	(0.884)
ΔChina's tariffs w.r.t. world		yes			yes			yes	
ΔChina's tariffs w.r.t. India			yes			yes			yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes	
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	
Firm-level controls	yes	yes	yes	yes	yes	yes	yes	yes	
Industry controls		yes	yes		yes	yes		yes	yes
Observations	91,869	91,869	91,869	60,273	60,273	60,273	31,596	31,596	31,596
R^2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Notes: (1) Standard errors are clustered at the 4-digit CIC industry level. (2) Δ denotes the year-over-year change in a variable during the period 2004–2007. (3) Firm-level controls comprise dummies for the second, third, and fourth quartile of the firm-size distribution in the initial year (2004). (4) Industry controls comprise import demand elasticity, export supply elasticity, skill intensity, and capital intensity in the United States. (5) Controls for shifts in China's tariffs concerning the world and India cover both output and input tariffs. (6) ***, **, * denote significance levels at 1%, 5%, and 10%, respectively. (7) Data include 14 manufacturing sectors mentioned in Table 2.2.

Rewriting equation (2.6) when $k = 1$ yields:

$$EX^1_{ijst} = \begin{cases} 1 & \text{if exporting to India} \\ 0 & \text{if exporting to non-Indian countries} \end{cases}$$

Figure 2.3 shows that more continuing exporters switch to India and new exporters are more likely to enter the Indian market after India's tariffs are reduced. Meanwhile, within-industry patterns in the data (Table 2.1) shows that new exporters have the largest increase in sales and training per worker from 2004 to 2007. Hence, to estimate the equation (2.14), we select the sample of firms which do not export in 2004 but become exporters in 2007.

$$\Delta EX^1_{ijst} = \sum_{n=1}^{4} \beta^1_{\tau^{ex},n} (\Delta \tau^{ex}_{jt} \times Q_{ij,n}) + \sum_{n=1}^{4} \delta^1_n Q_{ij,n} + \beta^1_{\tau^{im}} \Delta \tau^{im}_{jt} + \Delta \alpha^1_{st} + \Delta \epsilon^1_{ijst} \quad (2.14)$$

Columns 1–3 of Table 2.6 present the estimated results of equation (2.14). Coefficients in each quartile of size distribution are statistically significant. In particular, the decrease of 15 percentage points in India's tariffs results in a noteworthy 24.23 percentage point rise in the likelihood of entering the Indian market for new exporters in the high productivity group (fourth quartile). Furthermore, the empirical results of exporting to India in Table 2.6 are consistent with the model prediction, as there are three shaded areas located in different ranges of productivity levels in Figure 2.3, representing that firms in each range of productivity levels could find it more profitable to export to India.

Next, recall that some firms switch export destinations from country m to o and start to produce unskilled or skilled goods after trade liberalization (Figure 2.3). To investigate the skill upgrading decisions made by new exporters to India, we estimate equation (2.13) again with the sample of non-exporters in 2004 and exporters to India in 2007.

In column 5 of Table 2.6, trade liberalization is shown to have significantly positive effects on skill upgrading of new exporters targeting India in the last three quartiles. Although firm size may not be a perfect measure of productivity, this reflects that new exporters targeting India with a size above the medium level actually start to increase investment in on-the-job training when trade costs are lower. The absolute value of the coefficient of the fourth quartile is the largest likely due to the fact that the most productive new exporters to India are more capable of increasing labor training. Column 5 of Table 2.6 presents that

Table 2.6: Entry in the India export market and investment in on-the-job training

Dependent variable	New exporters Change in status of exporting to India			New exporters to India log(training spending)		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔIndia's tariffs						
× first size quartile	-1.721***	-1.723***	-1.888***	-8.054	-15.082*	-3.714
	(0.484)	(0.562)	(0.522)	(6.791)	(8.015)	(5.745)
× second size quartile	-1.533***	-1.555***	-1.676***	-13.208*	-20.970**	-10.031
	(0.486)	(0.555)	(0.512)	(7.591)	(8.530)	(6.596)
× third size quartile	-1.450***	-1.471**	-1.522***	-11.187	-18.683**	-7.860
	(0.485)	(0.565)	(0.502)	(7.409)	(8.943)	(5.681)
× fourth size quartile	-1.600***	-1.615***	-1.654***	-15.153	-23.569**	-12.200*
	(0.533)	(0.603)	(0.549)	(9.079)	(10.006)	(7.083)
ΔChina's tariffs w.r.t. world		yes			yes	
ΔChina's tariffs w.r.t. India			yes			yes
Sector FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Firm-level controls	yes	yes	yes	yes	yes	yes
Industry controls		yes	yes		yes	yes
Observations	2,475	2,475	2,475	489	489	489
R^2	0.025	0.026	0.028	0.035	0.061	0.054

Notes: (1) Standard errors are clustered at the 4-digit CIC industry level. (2) Δ denotes the year-over-year change in a variable during the period 2004–2007. (3) Firm-level controls consist of dummies for the second, third, and fourth quartile of the firm-size distribution in the base year of 2004. (4) Industry controls consist of import demand elasticity, export supply elasticity, skill intensity, and capital intensity in the United States. (5) ***, **, * denote significance levels at 1%, 5%, and 10%, respectively. (6) New exporters and new exporters to India are defined in Table 2.1. (7) Data include 14 manufacturing sectors mentioned in Table 2.2.

a 15 percentage point reduction in trade costs from 2004 to 2007 leads to a 3.54 log point increase in labor training provided by the new exporters to India in the fourth quartile. The absolute value of the coefficient of second quartile is smaller, but still larger than that of the third quartile. These results are in line with the pattern in Figure 2.3 as some firms in the middle range of productivity levels continue to produce unskilled products or reduce spending on labor training.

2.4.6 Mechanism

Empirically, the decline in tariffs encourages a higher number of firms to participate in the export market and leads to heightened investment in labor training within the second and third quartiles of the firm size distribution, as demonstrated by the preceding tables. This observation underscores the substantial advantages that firms within the intermediate range of the productivity distribution derive from trade liberalization. The model mechanism implies that firms gain higher revenues when trade costs are lower, so they find it more profitable to export and have greater incentives for skill upgrading, mirroring the reduction in productivity cutoffs of export and skill upgrading. In this section, we provide evidence of how trade integration between China and India affects China's export sales to India and domestic sales.

Table 2.7: Export sales to India and domestic sales of new exporters to India

Dependent variable	Change in log(export sales to India)			Change in log(domestic sales)		
	(1)	(2)	(3)	(4)	(5)	(6)
ΔIndia's tariffs	-40.851***	-41.207***	-43.108**			0.016
	(13.352)	(13.727)	(17.650)			(1.577)
ΔChina's tariffs w.r.t. India						
Output		yes		0.302	0.521	0.518
				(0.862)	(1.995)	(1.984)
Input		yes			-1.515	-1.517
					(14.819)	(14.862)
ΔChina's tariffs w.r.t. world			yes			
Sector FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Firm-level controls	yes	yes	yes	yes	yes	yes
Industry controls		yes	yes		yes	yes
Observations	489	489	489	489	489	489
R^2	0.141	0.154	0.153	0.063	0.071	0.071

Notes: (1) Standard errors are clustered at the 4-digit CIC industry level. (2) Δ denotes the year-over-year change in a variable during the period 2004–2007. (3) Firm-level controls encompass number of employees and sales per worker, all measured in the initial year (2004). (4) Industry controls encompass import demand elasticity, export supply elasticity, skill intensity, and capital intensity in the United States. (5) ***, **, * denote significance levels at 1%, 5%, and 10%, respectively. (6) New exporters to India are defined in Table 2.1. (7) Data include 14 manufacturing sectors mentioned in Table 2.2.

Export Sales to India

We select a sample of firms which do not export in 2004 but become new exporters to India in 2007. We find that the decrease in India's tariffs increases China's export sales to India, as reported by columns 1–3 of Table 2.7 following the previous estimation method. Upon accounting for the changes in China's import tariffs concerning India, the 15 percentage point reduction in India's tariffs results in a growth of approximately 6.18 logarithmic points in export sales to India. This exercise produces consistent results, and mainly reflects changes in export sales by new exporters to India. The coefficients are large in magnitude because we analyze the export sales at the firm level instead of the industry level. The firm level data can help emphasize how a small group of firms respond to changes in trade costs.

Domestic Sales

Our theoretical model also shows that the reduction in trade costs leads to a decline in domestic sales and causes more low productivity firms to exit the market. However, trade costs are symmetric for two countries in the model, which cannot be easily matched to the data. In fact, India's tariffs differ from China's tariffs. The empirical evidence under columns 4–6 of Table 2.7 indicates that the decline in China's tariffs with respect to India could result in lower domestic sales with point estimates ranging from 0.30–0.52. However, these results are not significant. This phenomenon is likely attributed to the fact that China as a developing country has a rapid growth rate as well as a large population. For instance, annual GDP growth rate in China increased from 10% in 2004 to 14% in 2007.[17] Chinese firms increase export sales a lot following trade openness and can also maintain a great amount of domestic sales even if there are more imported varieties.

2.4.7 Discussion

In this section, we attempt to understand why firms in certain sectors would enter the export markets and invest more in on-the-job training following trade liberalization, while others would not. Bustos (2011b)'s model can only explain some empirical findings, while others can result from special sector characteristics or policies targeting certain industries. Due to sector heterogeneity in productivity and policy, trade liberalization has positive impacts on firms' decisions about export entry and skill upgrading in only some sectors, including

[17] Data source: World Bank national accounts data, and OECD National Accounts data files.

manufacturers of "ship and floating devices".

First, some large-scale manufacturing companies in China such as pharmaceutical, home appliances, and electronics manufacturers, have their own universities for labor training, so their labor training procedures are canonical and their training decision might not be sensitive to changes in trade costs. Second, industry characteristics and certain policies could determine whether some industries have a comparative advantage or sustainable competition in the foreign market. We pick the shipbuilding industry included in our sample and the textile industry not included in our sample to understand their different responses to regional trade liberalization.

Textile Industry. According to an investigation report from the CNBS[18], the labor-intensive textile industry used to have a strong advantage in terms of labor costs, but it is now offset by low labor productivity. Compared with China's main competitors in Asia, its labor costs gradually lose their advantage. In 2002, the average wage level in China's textile industry reached 1.12 times that of India. Moreover, the production technology of spinning machinery is relatively mature, while the production technology of weaving and sewing machinery is relatively backward. Due to low productivity levels and less advanced technologies, some firms in the textile industry are less competitive in the export market and determine it to be unprofitable to participate in exports or increase labor training even if trade costs are very low. This explains why they are not sensitive to changes in tariffs. Instead, they could have a higher investment in on-the-job training when tariffs are high and when they could receive protection or subsidies from the government.

Shipbuilding Industry. China engages in foreign trade further after joining the WTO and APTA in 2001. In particular, China's total volume of imports and exports increased by 23.2% and the export of mechanical and electrical products and high-tech products increased by 32.0% and 31.8% respectively, from 2004 to 2005.[19] Meanwhile, the Eleventh Five-Year-Plan was announced in 2006, which encourages large-scale enterprises such as shipbuilding or auto-car firms to enter the export market. In 2020, China was still the world's largest shipbuilding

[18] The first China Industrial Security Forum was held in 2006. It reported on the domestic environment of China's textile industry from 1997 to 2005.

[19] These data were reported at the Fourth Session of China's Tenth National Congress in 2006.

market, accounting for 43.08% of total shipbuilding volume in the world. Shipbuilding industry is one of our sectors in the empirical studies. Shipbuilding firms are more productive and likely to fall in the second or the third quartiles of the firm size distribution. They should be sensitive to changes in trade costs. Besides, they actually receive support in the export market after the government implements the Eleventh Five-Year-Plan. Thus, the reduction in tariffs still has significantly positive impacts on their export entry decisions.

2.5 Conclusion

This chapter builds a general equilibrium model of trade and applies general difference-in-differences estimation to examine how a regional trade liberalization policy affects export decisions and investment in on-the-job training of Chinese manufacturers from 2004 to 2007.

The model predictions and empirical results based on Bustos (2011b)'s setting show that a decrease in trade costs reduces the export productivity cutoff and increases profits for exporters, resulting in more export participation and more spending on labor training. Furthermore, the most substantial positive influence of trade liberalization is observed on firms positioned within the intermediate range of productivity levels. On the contrary, the effects of trade liberalization on firms' skill upgrading decisions are more heterogeneous in the setting of two export destinations, as the model and the empirical evidence demonstrate.

Chapter 3

THE EFFECTS OF GLOBALIZATION ON THE LABOR MARKET: A PANEL VAR ANALYSIS

3.1 Introduction

The world becomes more interconnected than ever with the growing interdependence of economies, populations, information, cultures, and politics. KOF Swiss Economic Institute defines a set of globalization indexes to comprise the economic, social, and political aspects of globalization.[1] The economic globalization index is a measure of trade and financial global integration.[2] The social globalization index, on the other hand, incorporates the dimensions of interpersonal, informational, and cultural globalization,[3] and the political globalization index includes the measurement of embassies, UN peace keeping missions, and international NGOs. As shown in Figure 3.1, Economic globalization gained momentum during the 1990s, while the social globalization index has been growing faster since the late 2000s, which reflects that the interconnection of populations, information, and cultures is becoming more significant. Overall, the force of globalization experienced the largest acceleration during the 1990s and 2000s, while it slowed down recently with lower trade growth and heightened political tensions. Additionally, Table 3.1 shows that high income countries had a greater globalization index compared to other countries. The indexes of lower middle and low income countries were far below the world level, but they experienced the fastest growth in globalization between 1980 and 2020 with a percentage change in the globalization index of up to 40%. In particular, China roughly doubled its globalization index during this period, although the level of global integration was much higher in developed

---

[1]It is called the KOF Globalization Index.

[2]Trade globalization index considers the weight of trade values, trade partner diversity, tariff rates, and trade agreements. Foreign direct investment, portfolio investment, international debt, and income payment are the four important components of the financial globalization index.

[3]Migration, international tourism, international students, and income transfer are the main elements of interpersonal globalization.

economies. Overall, emerging markets play an increasingly important role in globalization. One of our experiments attempts to compare the effects of globalization on high income countries with those on the rest of the world regarding labor market outcomes.

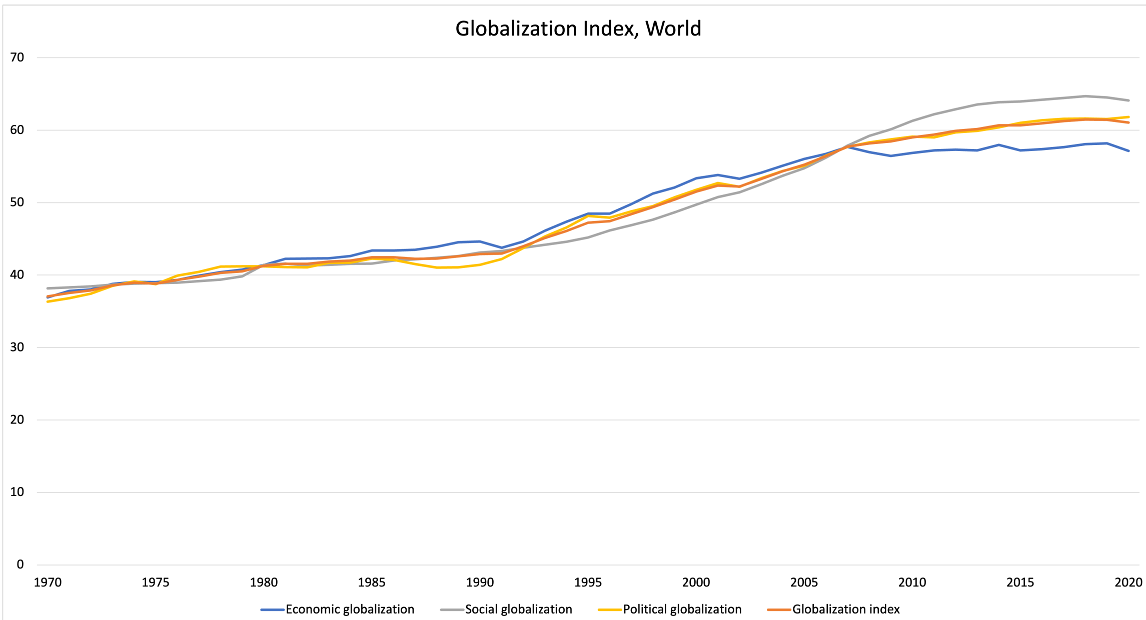

Figure 3.1: The KOF Globalization Index

Sources: KOF Swiss Economic Institute, Gygli et al. (2019) and Dreher (2006)

In most previous studies, increased globalization is only associated with higher trade integration. Few papers take different dimensions of globalization into account. To obtain new insights into global interconnection, this paper considers its three aspects, namely, trade, financial, and interpersonal integration. A lot of papers study how globalization contributes to economic growth,[4] while this paper discusses labor market outcomes. The focus of this paper revolves around the utilization of panel structural vector autoregression (SVAR) models to investigate the macroeconomic consequences of globalization on several key labor market indicators, including labor productivity, unemployment rate, labor force participation

[4] Grossman and Helpman (2015) point out that globalization contributes to economic growth through several channels: international knowledge spillovers, scale and competition effects, innovation, and technological diffusion.

Table 3.1: Globalization index by selected country, 1980-2020

	2020	2010	2000	1990	1980	% Change between 1980 and 2020
Switzerland	91	89	87	77	74	18.7
Netherlands	90	89	86	78	78	13.3
United Kingdom	89	89	85	77	77	13.5
Canada	84	82	81	69	67	20.2
Singapore	83	84	78	70	63	24.1
United States	81	80	77	70	63	22.2
Malaysia	81	79	71	58	53	34.6
China	65	62	52	36	26	60
World	61	59	52	43	41	32.8
High income	73	72	65	56	56	23.3
Upper middle income	61	59	51	42	40	34.4
Lower middle income	54	51	44	35	33	38.9
Low income	45	43	34	29	27	40

Sources: KOF Swiss Economic Institute, Gygli et al. (2019) and Dreher (2006) rate, and income inequality. In addition, we examine if globalization contributes to increased education and innovation by analyzing variations in government spending on education and the number of researchers in R&D in the economy. The last exercise is to identify if globalization has contrasting results between high income countries and middle and low income countries by way of sub-sample analysis.

To study how globalization affects the labor market, we only take economic and social dimensions into account, as quality data sets on the political dimension are difficult to obtain. Therefore, the three globalization measurements employed are trade, foreign direct investment, and labor migration across countries. Changes in tariff rates or trade values are the main indicators of trade globalization, and inflows of foreign direct investment are selected as the measurement of financial globalization. Net migration is the key variable of the social dimension, as many previous studies point out that immigration has certain effects on the unemployment rate and income distribution. Furthermore, we also evaluate the interplay among the three dimensions of globalization (exports, immigration, and FDI) and study their responses to labor productivity and investment shocks.

Following the literature, the identification strategy is concerned with imposing sign restrictions on macroeconomic variables. We assume some shocks cause strictly positive or negative impacts on endogenous variables within several periods. In the sensitivity analysis, we use the weighted average of applied tariff rates instead of export values. In this case, the identification assumption is that changes in tariff rates are due to new policies or agreements, so shocks to other endogenous variables have no contemporaneous effects on countries' tariff rates. This assumption can be achieved by imposing zero short-run restrictions.

The key findings are listed below. First, only trade has strong and persistent action on the unemployment rate and labor force participation rate. Trade globalization is associated with a lower unemployment rate and a higher labor force participation rate. Financial and interpersonal globalization have nearly zero impact on these two variables. Second, more exports increase labor productivity, but more foreign labor inflows affect labor productivity inversely because the number of low-skilled immigrants in most countries is still much higher than the number of high-skilled ones. Third, we use two terms, the Gini index and income shares, to represent income inequality. Neither business cycle fluctuations (labor productivity and investment shocks) nor globalization indicators (trade, FDI, and labor migration shocks) have significant effects on the Gini index. In terms of changes in income shares, positive labor productivity, investment, and trade shocks increase income shares held by the top 10% and the bottom 50% groups, while the changes in the income share held by the bottom 50% is larger. Hence, the income gap between the richest 10% and the poorest 50% narrows following trade integration.[5] Fourth, both trade and FDI integration reduce the wealth gap between the top 10% and the bottom 50%. Fifth, either an increase in labor productivity or investment in the economy creates persistent and positive effects on trade, FDI, and labor migration, which enhance economic and interpersonal globalization. Sixth, FDI and labor migration fluctuations are interconnected to some degree based on the results of variance decomposition of those two terms. Lastly, the impact of globalization on labor market outcomes is very similar for high-income countries and middle- and low-income countries in sub-sample analysis.

The paper adds to the literature on globalization and the labor market. To study how global integration influences the labor market, most papers address the macroeconomic effects of one aspect of globalization only. With respect to trade openness, a lot of research focuses on emerging markets.[6] For instance, Coşar et al. (2016) find that trade integration in Colombia increases national income at the cost of greater wage inequality and higher unemployment, and Han et al. (2012) show that China's trade liberalization (the WTO accession) significantly raises wage inequality. Several papers study how trade globalization affects income inequality, such as Jaumotte et al. (2013), Rojas-Vallejos and Turnovsky (2017) and Turnovsky and Rojas-Vallejos (2018). Furthermore, Lee and Yi (2018) interpret the role of global value chains on inequality, and Basco and Mestieri (2013) compare the effects of trade liberalization on inequality during two important periods of time.[7] Regarding the discussion of FDI, Ranjan (2013) finds that there is "non-monotonic relationship between

[5] The future exercise can be done to study the impact on the middle-income group. From this perspective, we may expect to see higher income inequality when we compare the income share held by the richest with that held by the middle-income group

[6] Ductor and Leiva-Leon (2016) highlight a substantial and gradual upsurge in the interconnectedness of the global business cycle during the 2000s, a trend attributed to the emerging market economies.

[7] Lee and Yi (2018) investigate the role of global value chains in the effect of increased trade on inequality.

the cost of offshoring and unemployment".[8] Studies with a focus on the macroeconomic consequences for the labor market include Mandelman and Zlate (2012), Furlanetto and Ørjan Robstad (2019) and Docquier and Rapoport (2012).[9] In fact, there are only a few papers that take more than one dimension of globalization into account.[10] The main contribution of this paper is incorporating three aspects of globalization (trade, FDI, and labor migration) in the analysis of labor market outcomes.

The literature that examines the effects of globalization on the labor market through VAR analysis is still limited. Kim et al. (2022) employ a panel VAR model to analyze "the dynamic interactions between trade integration and financial integration". Furlanetto and Ørjan Robstad (2019) propose a sign-restricted SVAR model to study the effect of immigration on unemployment applying Norwegian quarterly data and find that an exogenous immigration shock lowers the unemployment rate. This paper uses a panel SVAR approach with sign restrictions to explore how trade, financial, and interpersonal globalization affect several key labor market variables.

Section 3.2 presents the empirical methodology. Section 3.3 explains the results. Section 3.4 concludes.

3.2 Empirical Methodology

We exhibit the empirical methodology of the paper in this section.

[8]Ranjan (2016) also demonstrates that the effects of globalization on wages and unemployment depend on the degree of substitution between domestic labor and imported inputs.

[9]Furlanetto and Ørjan Robstad (2019) highlight the impact of immigration on the labor market in Norway. Docquier and Rapoport (2012) argue that high-skilled migration is a major aspect of globalization that generates positive network externalities.

[10]Rama (2003) is the one exception, which considers the effects of trade and FDI simultaneously and finds that wages decline with trade integration and rise with more foreign direct investment in the short run. In addition, other papers examine if globalization improves the efficiency of the matching process in the labor market, such as Davidson et al. (2014).

3.2.1 Panel Structural VAR

We assume the following structural vector autoregressive process represents our economic model for any country j ($j = 1, 2, 3, ...M$):

$$A(L)y_t^j = C^j + \epsilon_t^j \tag{3.1}$$

where $A(L) = A_0 - \sum_{k=1}^{\infty} A_k L^k$ is a matrix of polynomials in the lag operator L, y_t^j is an $N \times 1$ vector of endogenous variables, C^j is a $N \times 1$ vector of constants, and ϵ_t^j is a $N \times 1$ vector of structural innovations that are i.i.d. normally distributed, i.e., $\epsilon_t^j \backsim N(0, I_N^j)$. The covariance matrix satisfies $E(\epsilon_t^j \epsilon_t^{j'}) = I_N^j$.

If we multiply both sides of the equation by the inverse of A_0, we get the so-called reduced form representation, which can be solved easily by standard procedures. However, in order to solve the structural VAR model, we need to impose additional restrictions. Traditionally, short-run or long-run restrictions are employed.

Regarding the methods to estimate panel VAR, Canova (2007) suggests that one approach is to take the average of model estimations and impulse responses for the countries. Alternatively, Pedroni (2013) points out that decomposing "the shocks and impulse responses into member-specific idiosyncratic structural shocks and common structural shocks" is another way to study structural VARs in panels.

3.2.2 Estimation

The benchmark specification includes five macroeconomic variables: GDP per person employed, gross fixed capital formation, exports of goods and services, net migration, and net inflows of foreign direct investment. Additionally, we add these labor market variables to our VAR one at a time: unemployment rate, labor force participation rate, Gini index, and income/wealth shares held by the top 10% and the bottom 50%. Moreover, we also investigate the macroeconomic effects of globalization shocks on education and innovation by checking how they contribute to variations in government spending on education and the number of researchers in R&D.

Following Uhlig (2005), Kilian and Murphy (2012) and Furlanetto and Ørjan Robstad (2019), we impose a number of sign restrictions on the variables shown in Table 3.2. Labor productivity is measured by GDP per person employed, and there is a positive co-movement between labor productivity and output. Higher labor productivity boosts output and makes the economy more attractive, resulting in more trade, inflows of FDI and immigrants, so we impose those positive sign restrictions. Investment is interpreted as the gross fixed capital formation, which stimulates more trade according to previous studies. There are three globalization aspects, i.e., trade, FDI, and labor migration. Changes in exports of goods and services refer to the degree of trade openness. Alcalá and Ciccone (2004) demonstrate that there is a positive relationship between trade and productivity, and Bond et al. (2003) analyze that trade leads to physical capital growth. Thus, these two positive sign restrictions are also imposed. More FDI flows across countries due to fewer restrictions or lower FDI costs enhance financial globalization, and it also positively affects trade integration based on the empirical findings in Kim et al. (2022). The main driver of interpersonal globalization is labor movement around the world, as measured by net migration.[11] FDI and labor migration are assumed to be in synchronization because of the positive network externality effect.

In the sensitivity analysis section, we impose zero short run restrictions since we assume any changes in tariff rates are due to new policies or agreements, which cannot be anticipated by the public. Thus, tariff rates have no contemporaneous impact on other endogenous variables in the model.

3.2.3 Data

In the empirical analysis, we use panel data for 141 countries from 1991 to 2021. The sample countries are selected primarily on the basis of the availability of data on GDP per person employed, gross fixed capital formation, exports of goods and services, net FDI inflows, and net migration rates. The labor market variables include the unemployment rate, labor force participation rate, Gini index, income and wealth shares held by the top 10% and the bottom 50%. The main sources of data are from the World Bank's World Development Indicator, and income and wealth shares are from the World Inequality Database.[12]

[11] Net migration refers to the difference between the number of immigrants and the number of emigrants, encompassing both citizens and noncitizens.

[12] Please see Appendix B for details

Table 3.2: Restrictions in the baseline model

	Labor productivity	Investment	Exports of goods and services	Net FDI inflows	Net migration
Labor productivity	+	NA	+	NA	NA
Investment	NA	+	+	NA	NA
Exports of goods and services	+	+	+	+	NA
Net FDI inflows	+	NA	NA	+	+
Net migration	+	NA	NA	+	+
Unemployment or other variables	NA	NA	NA	NA	NA

Note: A plus sign (+) means that the impulse response of the corresponding variable is restricted to be positive in the first period following the positive shocks.

We use GDP per person employed to study labor productivity and gross fixed capital formation for investment. To measure the effects on education and innovation, we use data on government spending on education and the number of researchers in R&D per million people from 1996 to 2014. In terms of sensitivity analysis, we split the full sample group into high-income countries and middle- and low-income countries as defined by the World Bank. The weighted average of applied tariff rates rather than export values is considered a quantity to measure changes in trade globalization since it is an exogenous variable and can reflect the adjustment of trade policies among countries. In each empirical exercise, we also control the country fixed effect.[13]

3.3 Results

In each exercise, we include one or two labor market variables: unemployment rate, labor force participation rate, Gini index, income shares, and wealth shares held by the top 10% and the bottom 50%. Lastly, we discuss if globalization has different results in the labor market between high-income countries and the rest of the world.

[13] Some dummy variables to control for country characteristics are membership of WTO, participation in regional trade agreements, English speaking status, and colony status.

3.3.1 Interactions between economic and interpersonal globalization

First, we plot the impulse responses to a positive labor productivity shock in Figure 3.2. An increase in labor productivity has strong and persistent positive effects on investments and exports. Labor migration across countries also goes up immediately, but the impact of labor productivity shocks is slight. Though the net inflows of FDI increase after about 5 periods of the shock, the effect on FDI lasts for a long time. Overall, greater labor productivity strengthens globalization by increasing exports, FDI, and labor inflows. Positive investment shocks also stimulate more exports and labor migration, and the effect on FDI is not strong, albeit persistent, as shown in Figure 3.3.

To investigate the interconnection among trade, financial, and interpersonal globalization, we analyze variance decomposition of exports, FDI, and labor migration. Figure 3.4 indicates that exports of goods and services are mainly driven by trade shocks and labor productivity shocks.[14] Changes in FDI inflows and labor migration rates have nearly no impact on export values. As shown in Figure 3.5, although the fluctuation of net FDI inflows mainly comes from its own shock, labor migration shocks start to slightly affect FDI after 5 periods. Similarly, FDI shocks contribute to changes in labor migration flows to some extent, as shown in Figure 3.6. Thus, FDI and labor migration are moderately interconnected.

3.3.2 Labor market outcomes

In this section, we discuss the impacts of globalization on the labor market by examining the dynamics of several key variables, including GDP per person employed (labor productivity), unemployment rate, Gini index, income and wealth shares held by the top 10% and the bottom 50% groups.

Labor productivity. Figure 3.7 displays the impulse responses of labor productivity to one standard deviation of globalization shocks. An increase in exports contributes to labor productivity growth instantly, while more inflows of labor migration reduce labor productivity. In the sub-sample analysis, we find that international labor inflows in either high- or low-income countries negatively affect labor productivity because there are more

[14] Trade shocks can refer to changes in trade policies such as tariff rates and trade agreements.

low-skilled immigrants than high-skilled immigrants in most countries.

Unemployment rate. Positive labor productivity and investment shocks reduce unemployment rate as increased productivity and investment result in economic growth. Figure 3.8 shows that more trade openness is good for the economy as it lowers the unemployment rate to a great degree, but FDI and labor migration have no significant impact on the unemployment rate.

Labor force participation rate. In Figure 3.9, positive trade and investment shocks boost the labor force in the economies, while inflows of labor migration have no significant effects on the labor force in most countries because the share of the immigrant population is still very low. Moreover, higher labor productivity reduces the labor supply modestly.

Income inequality. To discuss how globalization affects income inequality, we analyze three variables: the Gini index and income shares held by the top 10% and the bottom 50% groups. Neither positive labor productivity shocks nor globalization shocks have significant effects on the Gini index, as shown in Figure 3.10. On the other hand, Figure 3.11 indicates that labor productivity and export growth contribute to higher income shares held by the top 10% and the bottom 50% groups simultaneously, while the low-income population actually benefits more from labor productivity improvement and trade boost. Meanwhile, positive investment shocks also increase income share held by the bottom 50%. Therefore, following an increase in productivity, investment, or trade, the income gap decreases to some degree. Financial and interpersonal globalization might have no contribution to income inequality. When the top 10% income group becomes richer, the income share held by the bottom 50% also increases significantly. The rich population affects the low-income group in terms of income levels, but not the other way around.

Wealth inequality. Wealth shares held by the top 10% and the bottom 50% groups are two indicators to study how globalization alters wealth inequality. In Figure 3.12, an increase in either trade or FDI inflows raises the wealth share held by the bottom 50%, with the effect of trade shocks being stronger. Compared to the impact of globalization on income shares, economic globalization significantly increases the wealth share held by the bottom 50%. Thus, wealth inequality decreases due to trade and financial integration across countries. Regarding the linkages between income and wealth shares between the top 10%

and the bottom 50%, Figure 3.11 and Figure 3.12 show that a greater wealth share held by the top 10% is followed by a reduced share held by the bottom 50%. In contrast, a greater income share by the richest leads to a greater income share of the bottom 50%.

3.3.3 Education, innovation and investment

After studying how economic and interpersonal globalization influence the labor market, we also investigate if globalization has positive effects on government spending on education, the number of researchers in R&D, and domestic investment. First, the impulse response results indicate that trade, FDI, and migration shocks have no significant dynamic consequences for government spending on education, but Figure 3.13 displays that approximately 10% of the variation in education spending is from globalization shocks. The contribution of labor migration among the three globalization dimensions is the largest. In terms of innovation, most of the variation in the number of researchers in R&D is due to its own shocks, and the remaining is due to labor productivity shocks, as shown in Figure 3.14. In Figure 3.15, the contribution of exports to variation in gross fixed capital formation rises starting from period 10, whereas FDI and labor migration shocks exert no effects on fluctuations in investment.

3.3.4 Sensitivity analysis

For sensitivity analysis and robustness checks, we split the world into two groups, i.e., high-income countries and other countries in the world. We also replace export value with a weighted average of applied tariff rates. Because tariff policy actions are not anticipated by economic agents as any changes in applied tariff rates are immediately announced to agents, shocks associated with other endogenous variables have no contemporaneous effects on tariff rates. This assumption is embodied by imposing zero short-run restrictions.

Sub-sample analysis. Now we turn to two groups of countries, high-income countries and the remaining countries in the world. The results are almost not affected by this alternative identification with the exception of three points. First, compared to the baseline scenario, net FDI inflows and net migration deviate more from zero following a positive labor productivity shock in middle- and low-income countries.[15] Second, exports also contribute to the variations in net FDI inflows starting around period 15 in middle- and low-income countries (Figure C.2), while the full sample results (Figure 3.5) show that labor migration rather than exports affects the variations in net FDI inflows. Nevertheless, FDI, trade, and labor movement across countries interact with each other to some degree. Third, with regard to income inequality, more gross fixed capital formation results in higher Gini index in high-income countries after 10 periods of the investment shock (Figure C.3). Furthermore, more FDI inflows increase the income share held by the bottom 50%, so financial globalization helps reduce income inequality in middle- and low-income countries (Figure C.4).

Alternative specification of trade shocks. Trade shocks in this section are characterized by changes in the weighted average of applied tariff rates. Under the tariff specification, the impulse response results of several key variables, including labor productivity, unemployment rate, labor force participation rate, and Gini index, are quite similar to those in the baseline case.[16] Both income shares increase more following a reduction in tariff rates compared to the baseline case (Figure C.9). However, lower tariff rates have no positive impact on the wealth share held by the bottom 50% (Figure C.10).

3.4 Conclusion

This paper proposes a panel SVAR to examine the effects of globalization on the labor market by analyzing the impulse responses of the unemployment rate, labor force participation rate, Gini index, income and wealth shares. Overall, trade globalization is beneficial for the labor market. In particular, the unemployment rate decreases, the labor force participation rate increases, income and wealth gaps reduce, and labor productivity expands following positive trade shocks. On the contrary, more inflows of labor migration create a negative impact on labor productivity since there are more low-skilled immigrants than high-skilled immigrants in most countries. Financial globalization (FDI) mainly affects income and wealth inequality.

We also investigate if globalization contributes to education and innovation investment.

---

[15] Compare Figure C.1 with Figure 3.2.

[16] Refer to Appendix A Figure 5-8.

Our findings indicate that the main drivers of government spending on education and the number of researchers in R&D are exogenous policies related to education, research, and development instead of globalization shocks.

In addition, we conduct a sub-sample analysis by splitting the full sample into two groups, high-income countries and the remaining countries in the world. Our empirical results show that the impact of globalization on the labor market is very similar in these two groups.

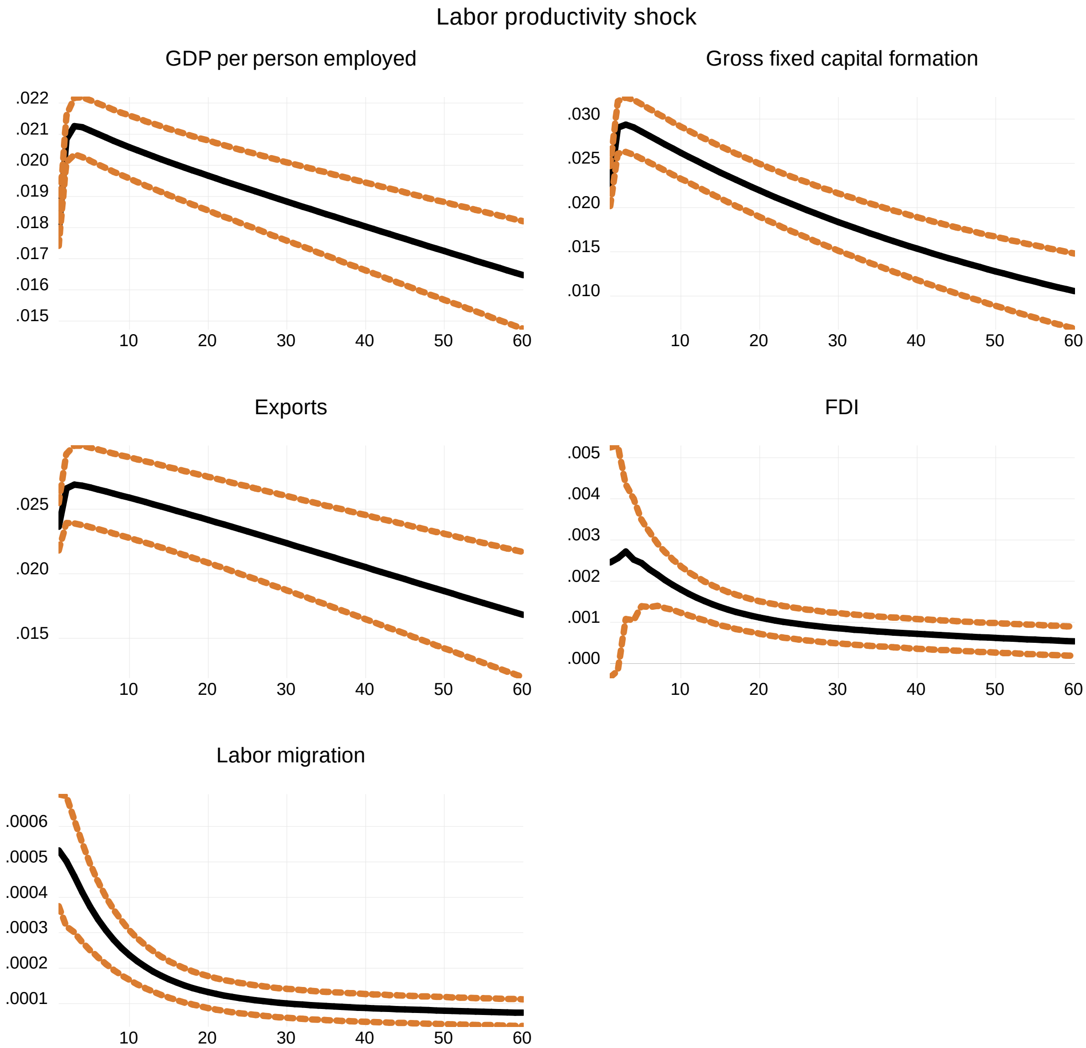

Figure 3.2: Impulse response to an increase in GDP per person employed

The solid lines depict the impulse response functions corresponding to a one S.D. labor productivity shock. The dashed lines are ± 2 asymptotic S.E.s.

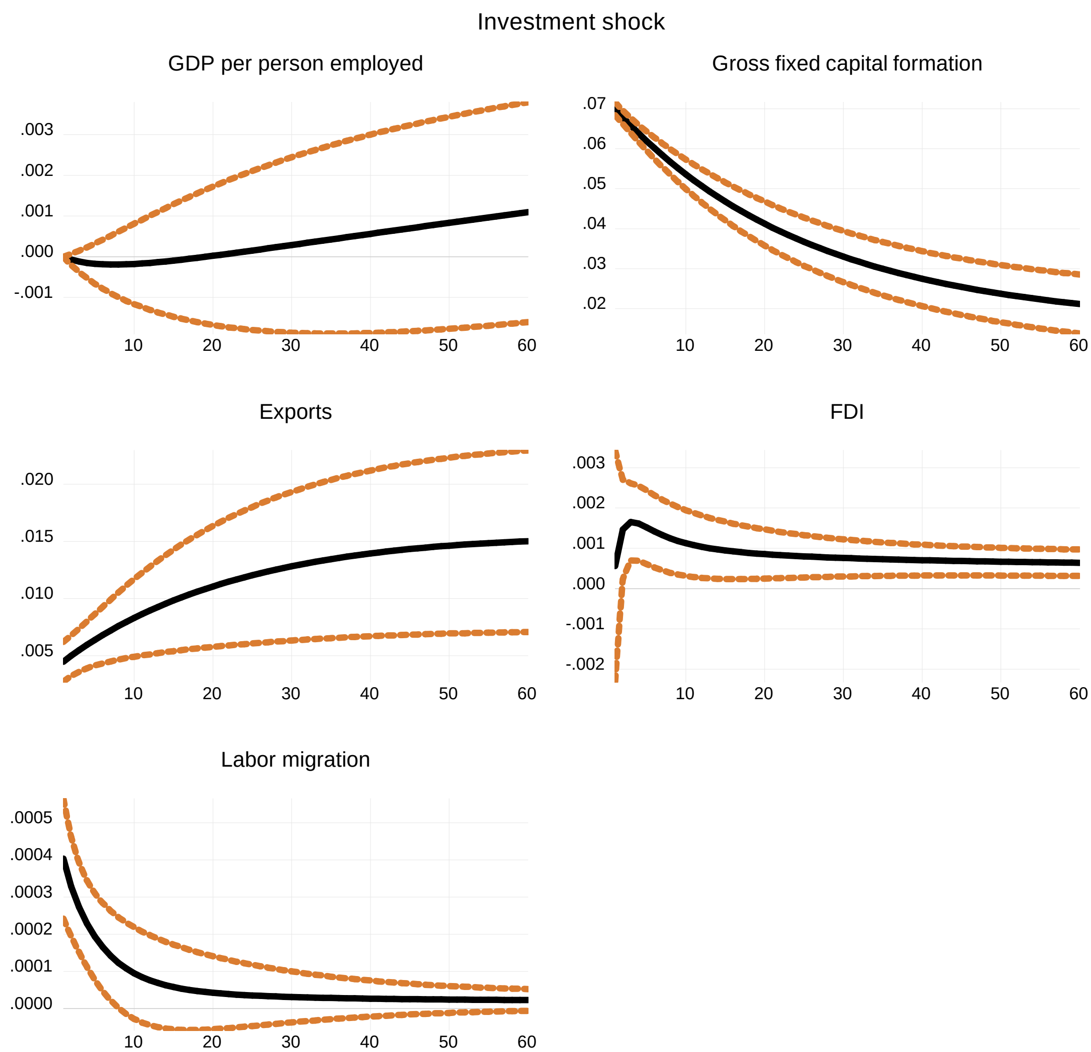

Figure 3.3: Impulse response to an increase in gross fixed capital formation

The solid lines depict the impulse response functions corresponding to a one S.D. investment shock. The dashed lines are ± 2 asymptotic S.E.s.

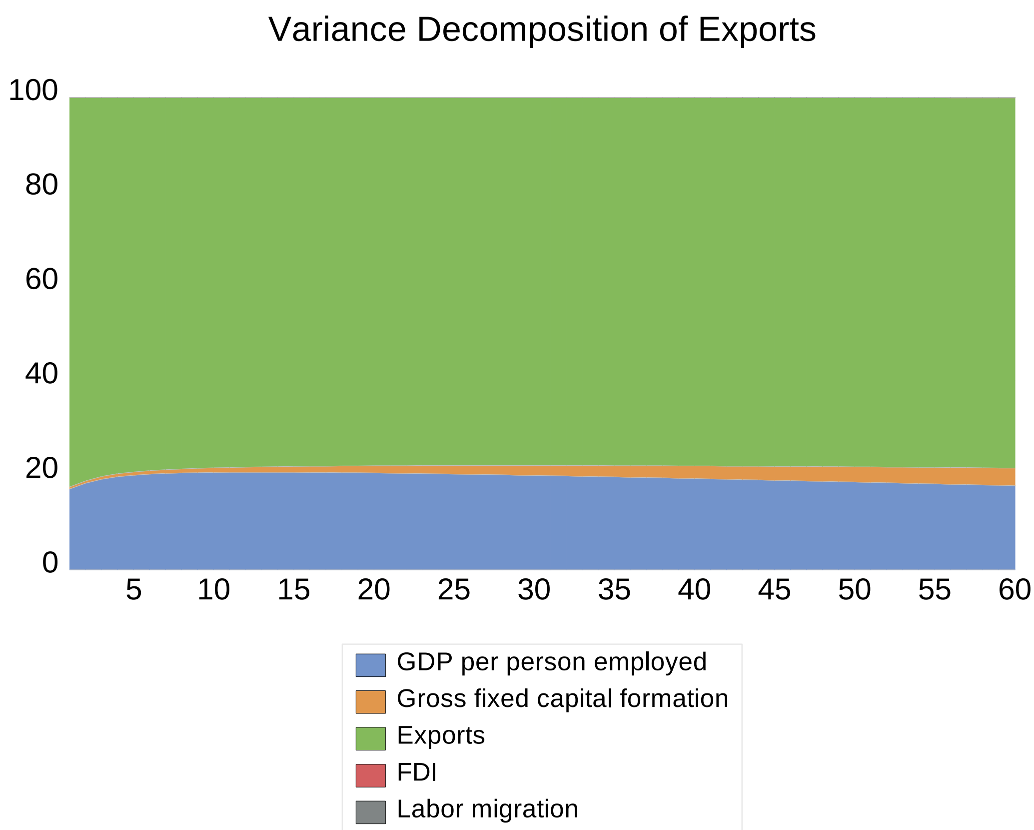

Figure 3.4: Variance decomposition of exports of goods and services.

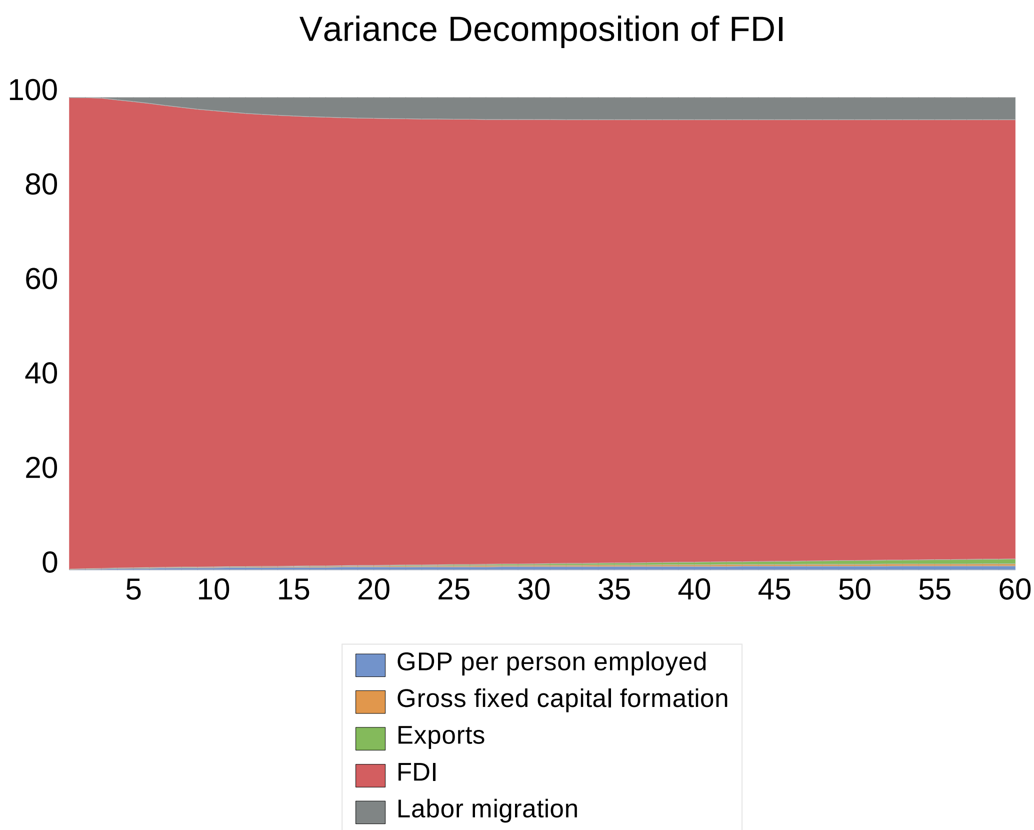

Figure 3.5: Variance decomposition of net FDI inflows.

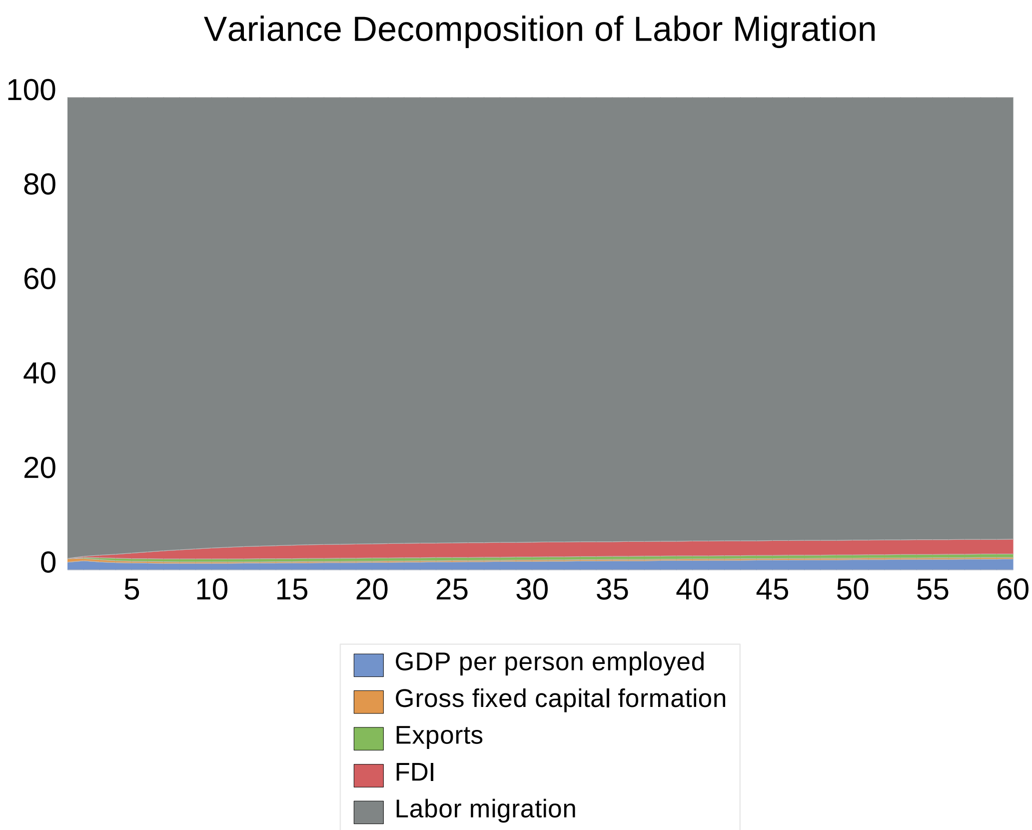

Figure 3.6: Variance decomposition of net labor migration.

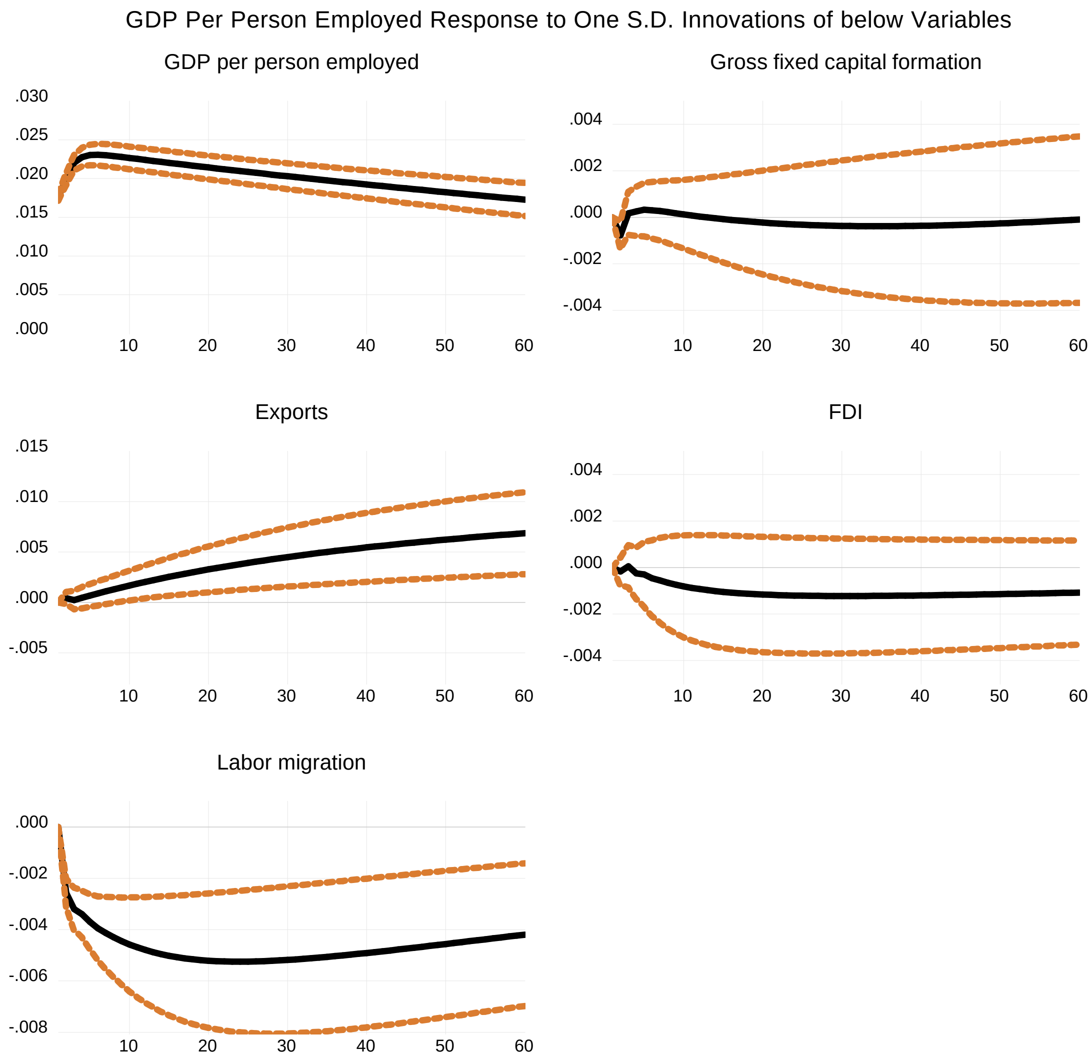

Figure 3.7: Labor productivity response to one S.D. innovations of key variables

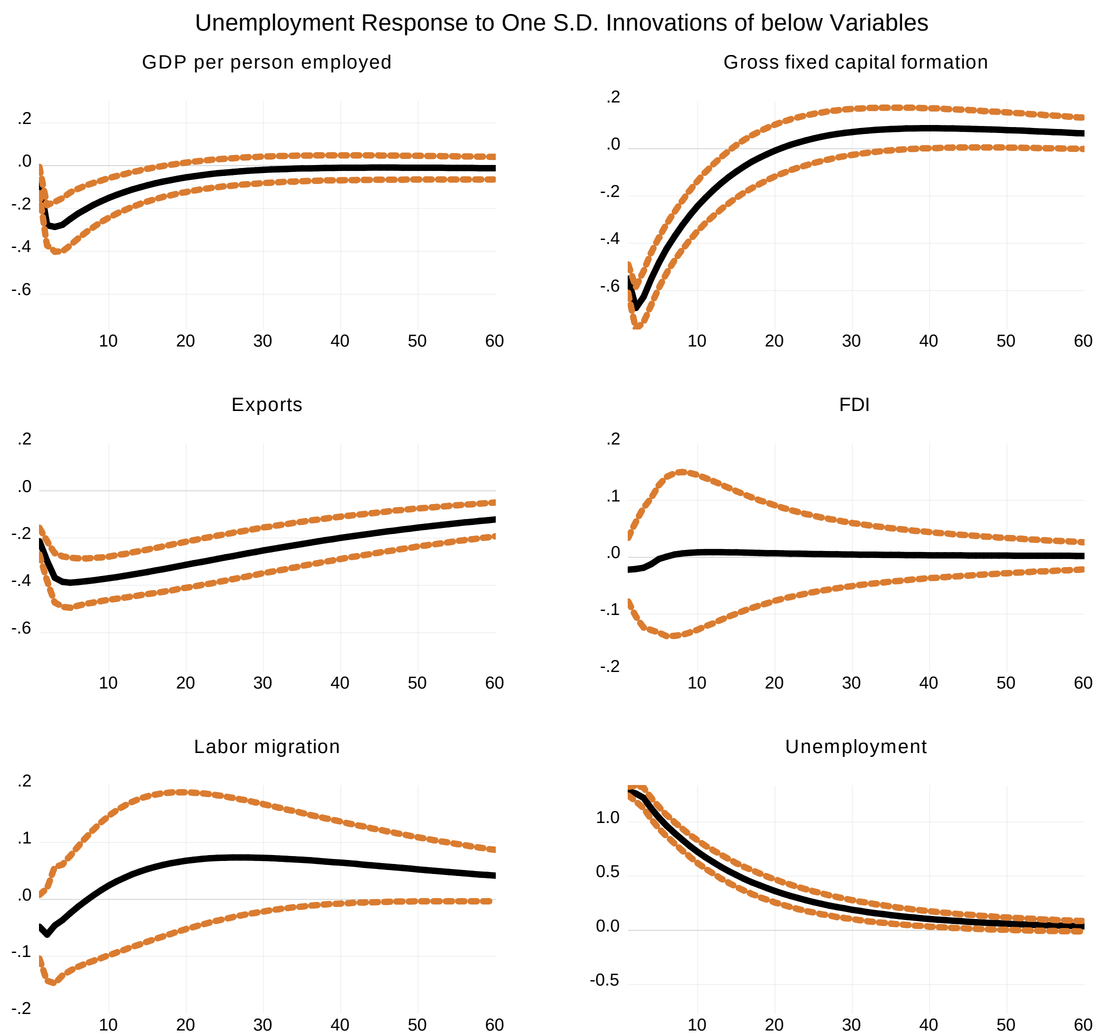

Figure 3.8: Unemployment rate response to one S.D. innovations of key variables

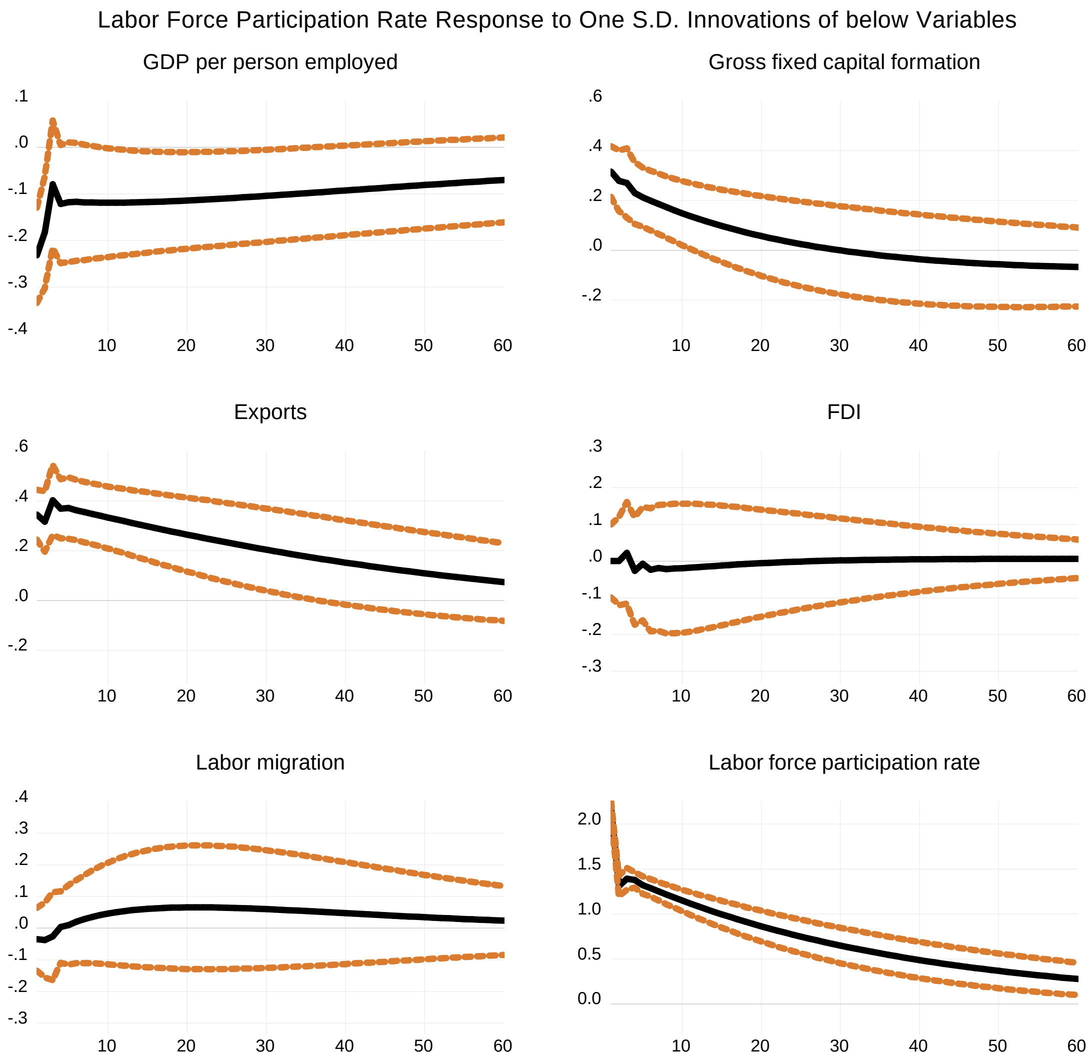

Figure 3.9: Labor force participation rate response to one S.D. innovations of key variables

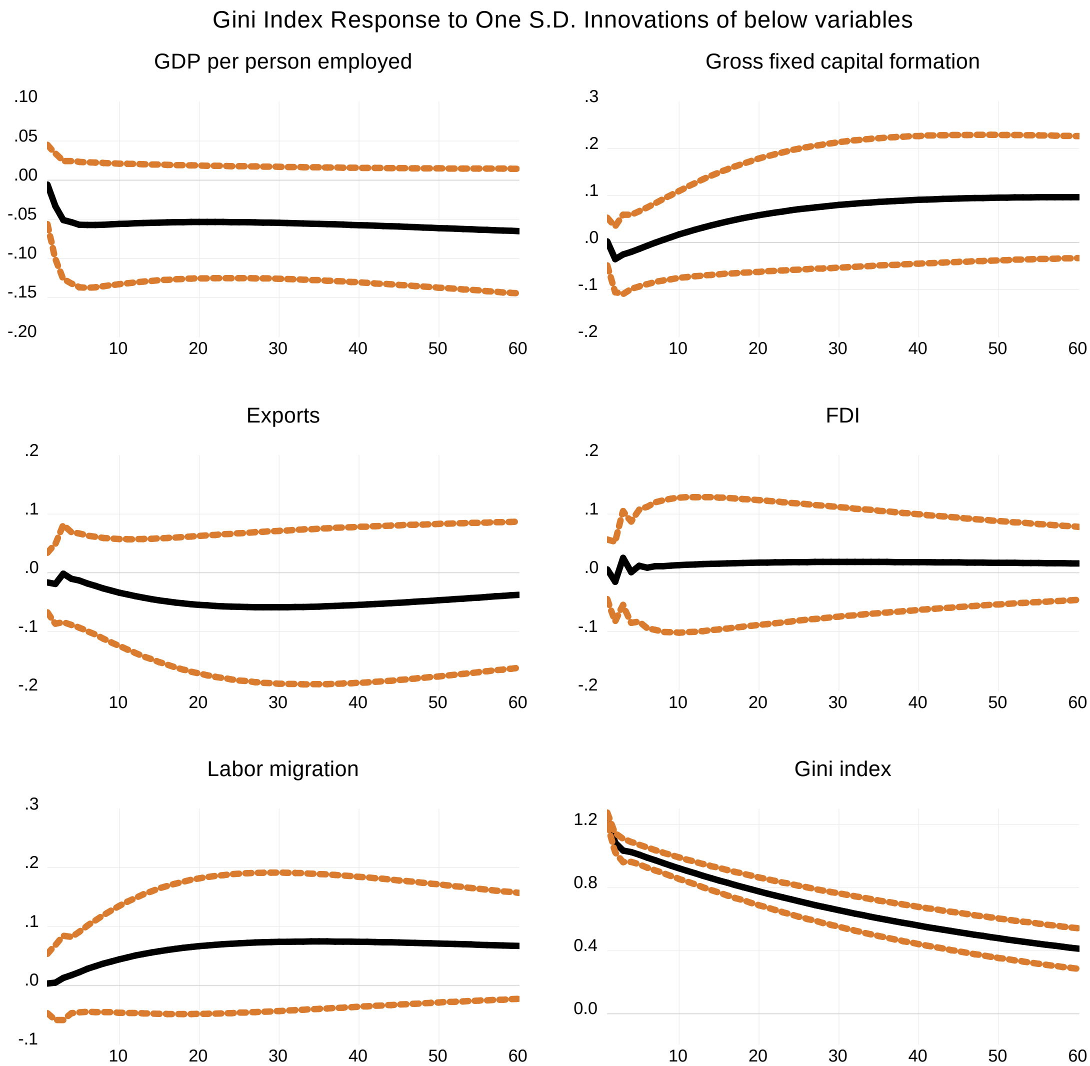

Figure 3.10: Gini index response to one S.D. innovations of key variables

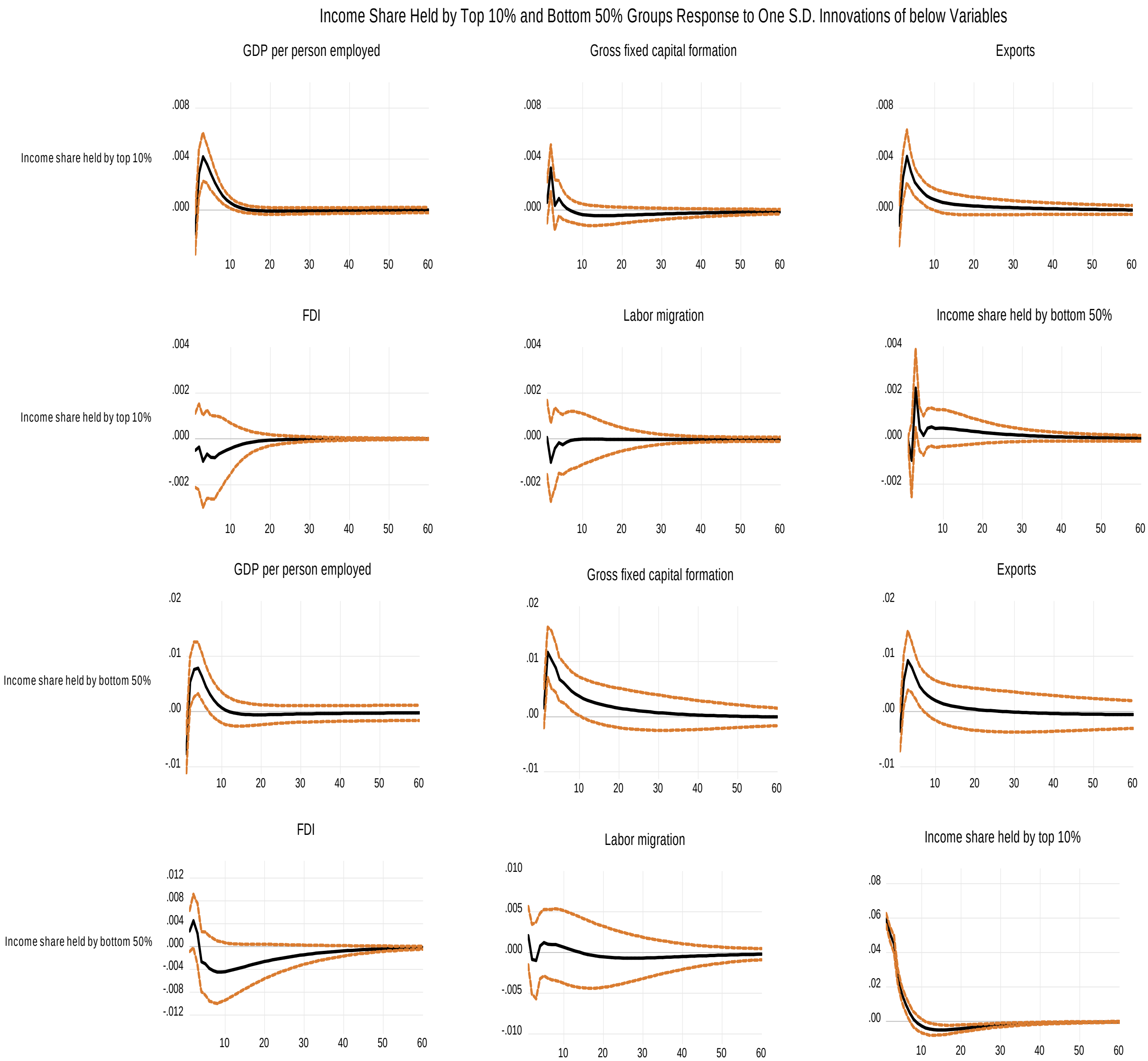

Figure 3.11: Income share held by the top 10% and the bottom 50% groups response to one S.D. innovations of key variables

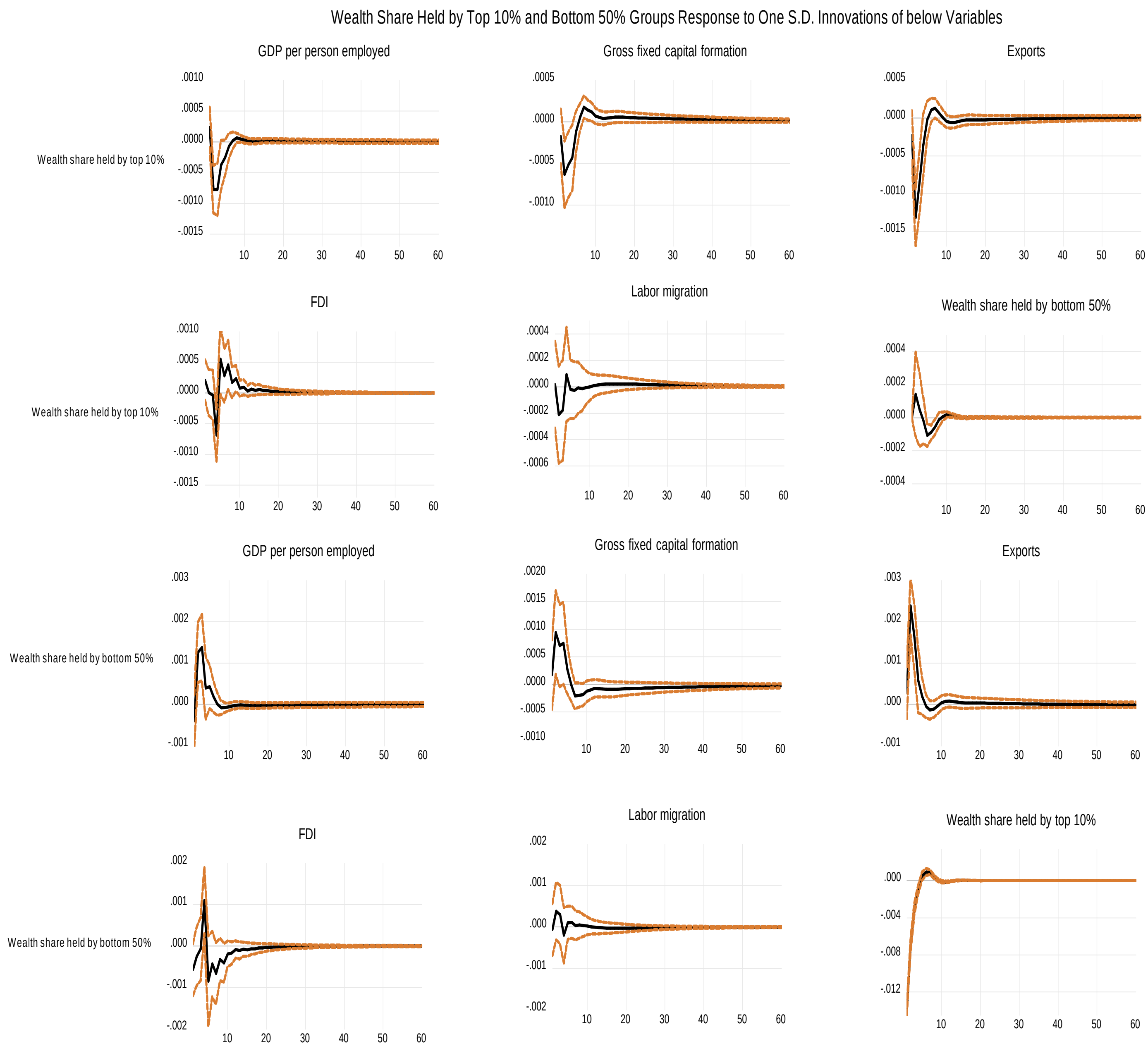

Figure 3.12: Wealth share held by the top 10% and the bottom 50% groups response to one S.D. innovations of key variables

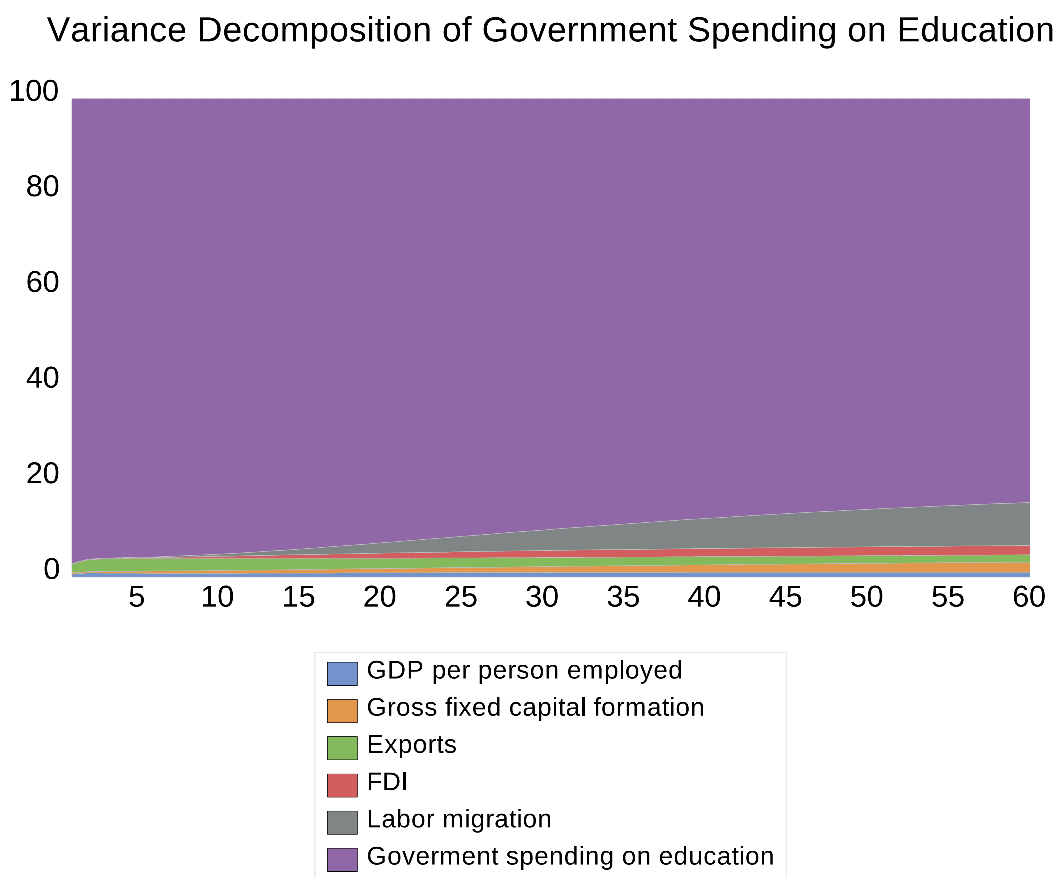

Figure 3.13: Variance decomposition of government spending on education.

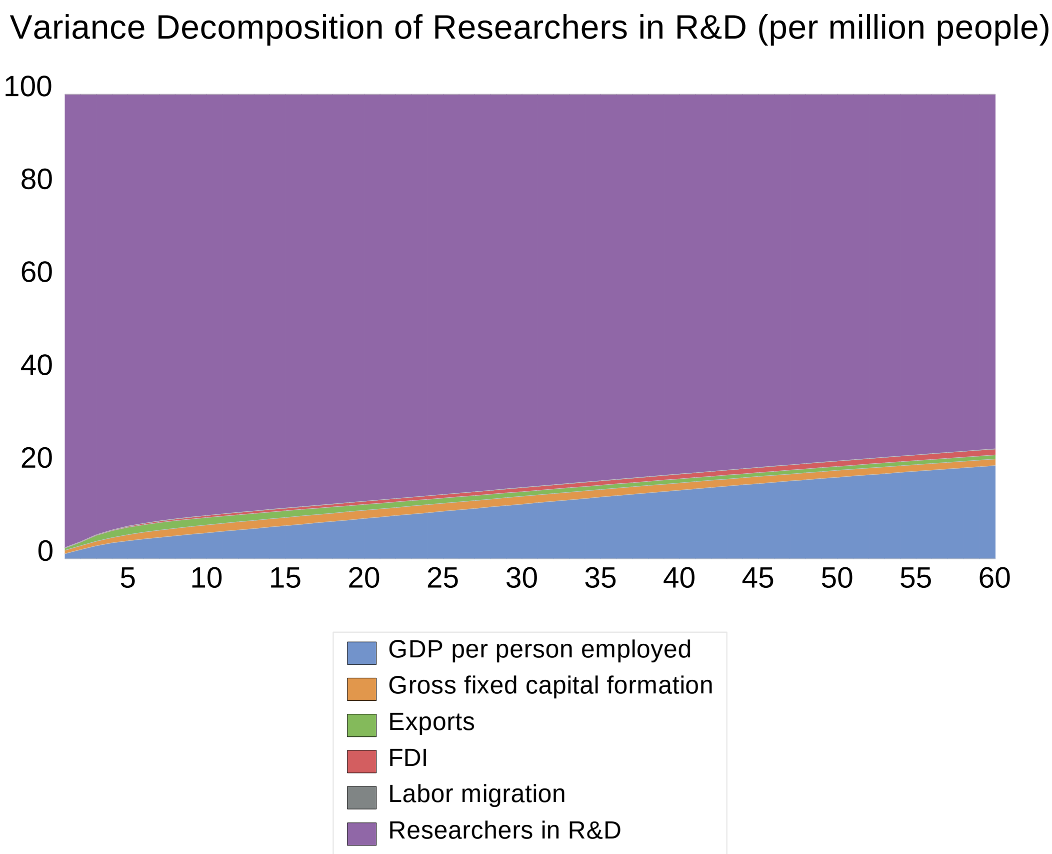

Figure 3.14: Variance decomposition of researchers in R&D.

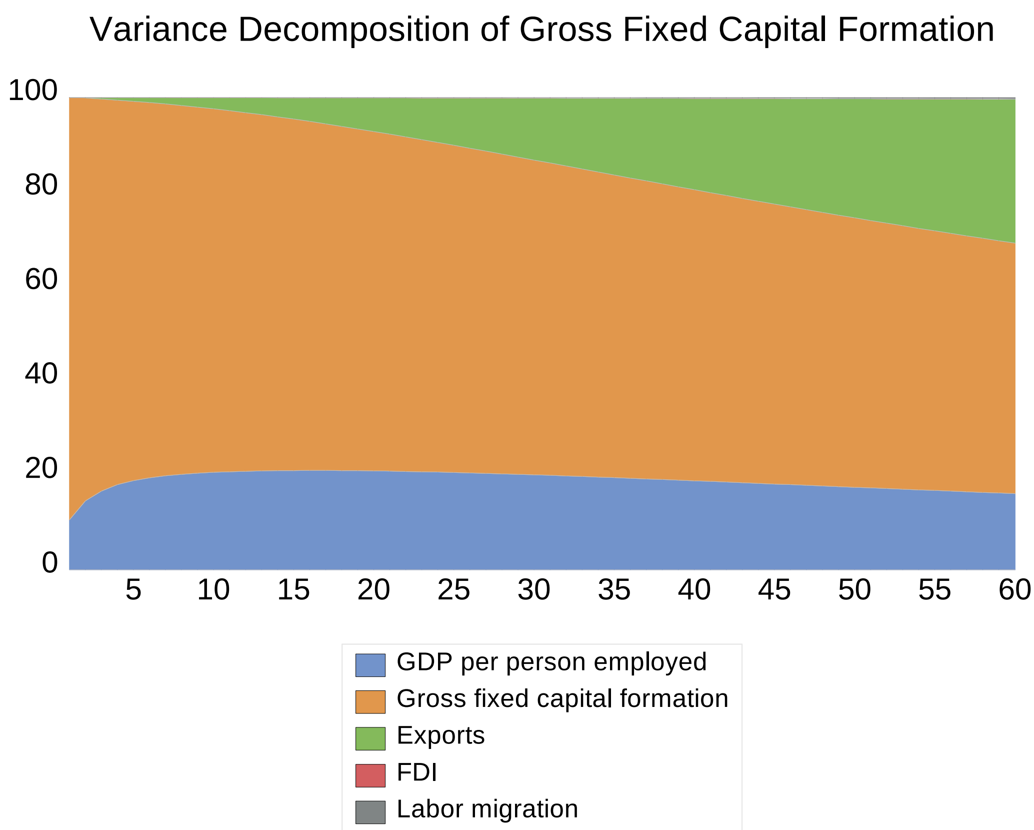

Figure 3.15: Variance decomposition of gross fixed capital formation.

BIBLIOGRAPHY

Daron Acemoglu. Patterns of skill premia. *The Review of Economic Studies*, 70(2):199–230, 2003.

J. Aitken Brian and E. Harrison Ann. Do domestic firms benefit from direct foreign investment? Evidence from Venezuela. *American Economic Review*, 89(3):605–618, 1999.

Francisco Alcalá and Antonio Ciccone. Trade and productivity. *The Quarterly journal of economics*, 119(2):613–646, 2004.

Laura Alfaro and Andrew Charlton. Intra-industry foreign direct investment. *American Economic Review*, 99(5):2096–2119, 2009.

Mary Amiti and Jozef Konings. Trade liberalization, intermediate inputs, and productivity: Evidence from Indonesia. *American Economic Review*, 97(5):1611–1638, December 2007. doi: 10.1257/aer.97.5.1611. URL https://www.aeaweb.org/articles?id=10.1257/aer.97.5.1611.

Maria Bas. Technology adoption, export status, and skill upgrading: Theory and evidence. *Review of International Economics*, 20(2):315–331, 2012.

Sergi Basco and Martí Mestieri. Heterogeneous trade costs and wage inequality: A model of two globalizations. *Journal of International Economics*, 89(2):393–406, 2013.

Samuel Bazzi, Arya Gaduh, Alexander D. Rothenberg, and Maisy Wong. Skill transferability, migration, and development: Evidence from population resettlement in Indonesia. *American Economic Review*, 106(9):2658–98, 2016.

Andrew B. Bernard, Jonathan Eaton, J. Bradford Jensen, and Samuel Kortum. Plants and productivity in international trade. *American Economic Review*, 93(4):1268–1290, 2003.

Sheng Bin. China's trade development strategy and trade policy reforms: overview and prospect. *International Institute for sustainable development. Draft Paper*, 2015.

Eric W. Bond, Kathleen Trask, and Ping Wang. Factor accumulation and trade: dynamic comparative advantage with endogenous physical and human capital. *International Economic Review*, 44(3):1041–1060, 2003.

Loren Brandt, Johannes Van Biesebroeck, Luhang Wang, and Yifan Zhang. WTO accession and performance of chinese manufacturing firms. *American Economic Review*, 107(9): 2784–2820, 2017.

Christian Broda and David E. Weinstein. Globalization and the gains from variety. *The Quarterly Journal of Economics*, 121(2):541–585, 2006.

Christian Broda, Nuno Limao, and David E. Weinstein. Optimal tariffs and market power: the evidence. *American Economic Review*, 98(5):2032–65, 2008.

Ariel Burstein and Marc J. Melitz. Trade liberalization and firm dynamics. *Advances in Economics and Econometrics Tenth World Congress. Applied Economics, Econometric Society Monographs*, 2, 2013.

Paula Bustos. The impact of trade liberalization on skill upgrading: Evidence from Argentina. Barcelona GSE Working Paper 559, Barcelona School of Economics, 2011a.

Paula Bustos. Trade liberalization, exports, and technology upgrading: Evidence on the impact of MERCOSUR on Argentinian firms. *American Economic Review*, 101(1):304–340, 2011b.

Fabio Canova. *Methods for applied macroeconomic research*. Princeton university press, 2007.

Juan Carluccio, Alejandro Cunat, Harald Fadinger, and Christian Fons-Rosen. Offshoring and skill-upgrading in French manufacturing. *Journal of International Economics*, 118: 138–159, 2019.

Raj Chetty, Day Manoli Adam Guren, and Andrea Weber. Does indivisible labor explain the difference between micro and macro elasticities? A meta-analysis of extensive margin elasticities. *NBER Macroeconomics Annual*, 27(1):1–56, 2013.

Hyelin Choi. Labor market flexibility and FDI: Evidence from OECD countries. Working Paper 16–06, Korea Institute for International Economic Policy, 2016.

A. Kerem Coşar, Nezih Guner, and James Tybout. Firm dynamics, job turnover, and wage distributions in an open economy. *American Economic Review*, 106(3):625–663, 2016.

Carl Davidson, Fredrik Heyman, Steven Matusz, Fredrik Sjöholm, and Susan Chun Zhu. Globalization and imperfect labor market sorting. *Journal of International Economics*, 94(2):177–194, 2014.

Steven J. Davis and John Haltiwanger. Gross job creation and destruction: Microeconomic evidence and macroeconomic implications. *NBER Macroeconomics Annual*, pages 123–168, 1990.

Frédéric Docquier and Hillel Rapoport. Globalization, brain drain, and development. *Journal of economic literature*, 50(3):681–730, 2012.

Axel Dreher. Does globalization affect growth? evidence from a new index of globalization. *Review of International Organizations*, 38(10):1091–1110, 2006.

Nigel Driffield and Karl Taylor. FDI and the labour market: A review of the evidence and policy implications. *Oxford Review of Economic Policy*, 16(3):90–103, 2000.

Lorenzo Ductor and Danilo Leiva-Leon. Dynamics of global business cycle interdependence. *Journal of International Economics*, 102:110–127, 2016.

John H. Dunning and Sarianna M. Lundan. Technology and innovatory capacity: the role of firms. In *Multinational Enterprises and the Global Economy*. Edward Elgar Publishing, 2008.

Eric V. Edmonds, Nina Pavcnik, and Petia Topalova. Trade adjustment and human capital investments: Evidence from Indian tariff reform. *American Economic Journal: Applied Economics*, 2(4):42–75, 2010.

Rod Falvey, David Greenaway, and Joana Silva. Trade liberalisation and human capital adjustment. *Journal of International Economics*, 81(2):230–239, 2010.

Jesús Fernández-Villaverde, Juan F. Rubio-Ramírez, Thomas J. Sargent, and Mark W. Watson. ABCs (and Ds) of understanding VARs. *American Economic Review*, 97(3): 1021–1026, 2007.

Nicole Fortin, Thomas Lemieux, and Sergio Firpo. Decomposition methods in economics. In *Handbook of Labor Economics*, volume 4, pages 1–102. Elsevier, 2011.

Francesco Furlanetto and Ørjan Robstad. Immigration and the macroeconomy: Some new empirical evidence. *Review of Economic Dynamics*, 34:1–19, 2019.

Fabio Ghironi and Marc J. Melitz. International trade and macroeconomic dynamics with heterogeneous firms. *Quarterly Journal of Economics*, 120(3):865–915, 2005.

Gene M. Grossman and Elhanan Helpman. Globalization and growth. *American Economic Review*, 105(5):100–104, 2015.

Savina Gygli, Florian Haelg, Niklas Potrafke, and Jan-Egbert Sturm. The KOF globalisation index – revisited. *Review of International Organizations*, 14(3):543–574, 2019.

Katariina Nilsson Hakkala, Fredrik Heyman, and Fredrik Sjöholm. Multinational firms, acquisitions and job tasks. *European Economic Review*, 66:248–265, 2014.

Galina Hale and Mingzhi Xu. FDI effects on the labor market of host countries. Working Paper 2016–25, Federal Reserve Bank of San Francisco, 2015. URL https://www.frbsf.org/economic-research/files/wp2016-25.pdf.

Jun Han, Runjuan Liu, and Junsen Zhang. Globalization and wage inequality: Evidence from urban china. *Journal of International Economics*, 87(2):288–297, 2012.

Wontae Han, Jian Wang, and Xiao Wang. FDI and firm productivity in host countries: The role of financial constraints. *Journal of International Money and Finance*, 124(102623), 2022.

Keith Head and John Ries. Offshore production and skill upgrading by Japanese manufacturing firms. *Journal of International Economics*, 58(1):81–105, 2002.

Elhanan Helpman, Marc J. Melitz, and Stephen R. Yeaple. Export versus FDI with heterogeneous firms. *American Economic Review*, 94(1):300–316, 2004.

Dierk Herzer. How does foreign direct investment really affect developing countries' growth? *Review of International Economics*, 20(2):396–414, 2012.

Alexander Hijzen, Pedro S. Martins, Thorsten Schank, and Richard Upward. Foreign-owned firms around the world: A comparative analysis of wages and employment at the micro-level. *European Economic Review*, 60:170–188, 2013.

Hanns Günther Hilpert. China's trade policy: dominance without the will to lead. SWP Research Paper, German Institute for International and Security Affairs, 2014.

Chang-Tai Hsieh and Peter J. Klenow. Misallocation and manufacturing TFP in China and India. *Quarterly Journal of Economics*, 124(4):1403–1448, 2009.

Qifan Huang and Castiel Chen Zhuang. Training, productivity and wages: An investigation of China's manufacturing enterprises in a privatization era. *Economics of Transition and Institutional Change*, 00:1–20, 2021. doi: https://doi.org/10.1111/ecot.12285. URL https://onlinelibrary.wiley.com/doi/abs/10.1111/ecot.12285.

Florence Jaumotte, Subir Lall, and Chris Papageorgiou. Rising income inequality: technology, or trade and financial globalization? *IMF economic review*, 61(2):271–309, 2013.

Jaewon Jung and Jean Mercenier. On modeling task, skill and technology upgrading effects of globalization with heterogeneous labor. *Economic Modelling*, 39:49–62, 2014.

Nathan Kallus, Xiaojie Mao, and Masatoshi Uehara. Localized debiased machine learning: Efficient inference on quantile treatment effects and beyond, 2020.

Wolfgang Keller and Stephen R. Yeaple. Multinational enterprises, international trade, and productivity growth: firm-level evidence from the united states. *The review of economics and statistics*, 91(4):821–831, 2009.

Lutz Kilian and Daniel P. Murphy. Why agnostic sign restrictions are not enough: Understanding the dynamics of oil market VAR models. *Journal of the European Economic Association*, 10(5):1166–1188, 2012.

Soyoung Kim, Seri Shim, and Donghyun Park. Dynamic interactions between trade globalization and financial globalization: A heterogeneous panel VAR approach. *Journal of International Money and Finance*, 122:102547, 2022.

Patrick Kline. Oaxaca-blinder as a reweighting estimator. *American Economic Review*, 101 (3):532–37, 2011.

Michael Koch and Marcel Smolka. Foreign ownership and skill-biased technological change. *Journal of International Economics*, 118:84–104, 2019.

Eunhee Lee and Kei-Mu Yi. Global value chains and inequality with endogenous labor supply. *Journal of International Economics*, 115:223–241, 2018.

Christian Lessmann. Foreign direct investment and regional inequality: A panel data analysis. *China Economic Review*, 24:129–149, 2013.

Hongbin Li, Prashant Loyalka, Scott Rozelle, and Binzhen Wu. Human capital and china's future growth. *Journal of Economic Perspectives*, 31(1):25–48, 2017.

Qing Liu and Ruosi Lu. On-the-job training and productivity: Firm-level evidence from a large developing country. *China Economic Review*, 40:254–264, 2016.

Qing Liu and Larry D. Qiu. Labor training and foreign direct investment. *Review of International Economics*, 22(1):151–166, 2014.

Federico S. Mandelman and Andrei Zlate. Immigration, remittances and business cycles. *Journal of Monetary Economics*, 59(2):196–213, 2012.

Federico S. Mandelman and Andrei Zlate. Offshoring, automation, low-skilled immigration, and labor market polarization. *American Economic Journal: Macroeconomics*, 14(1): 355–89, 2022.

Hidehiko Matsumoto. Foreign reserve accumulation, foreign direct investment, and economic growth. *Review of Economic Dynamics*, 43:241–262, 2022.

Marc J. Melitz. The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6):1695–1725, 2003.

Peter Pedroni. Structural panel VARs. *Econometrics*, 1(2):180–206, 2013.

David Powell. A new framework for estimation of quantile treatment effects: Nonseparable disturbance in the presence of covariates. RAND Working Paper Series WR-824-1, 2013.

Martin Rama. Globalization and the labor market. *The World Bank Research Observer*, 18 (2):159–186, 2003.

Priya Ranjan. Offshoring, unemployment, and wages: The role of labor market institutions. *Journal of International Economics*, 89(1):172–186, 2013.

Priya Ranjan. Globalization and risk averse workers: The roles of labor market and trade policies. *Journal of International Economics*, 103:64–79, 2016.

Jorge Rojas-Vallejos and Stephen J. Turnovsky. Tariff reduction and income inequality: Some empirical evidence. *Open Economies Review*, 28:603–631, 2017.

Li Ruiqin, Yipeng Liu, and Oscar F. Bustinza. FDI, service intensity, and international marketing agility: The case of export quality of Chinese enterprises. *International Marketing Review*, 36(2):213–238, 2019.

Beata Smarzynska Javorcik. Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. *American Economic Review*, 94(3):605–627, 2004.

Zheng Song, Kjetil Storesletten, and Fabrizio Zilibotti. Growing like China. *American Economic Review*, 101(1):196–233, 2011.

Nuno Sousa. Multinationals and technology transfer through labour training. *CEPR Workshop on Labour Market Effects of European Foreign Investsments*, 2001.

Stephen J. Turnovsky and Jorge Rojas-Vallejos. The distributional consequences of trade liberalization: Consumption tariff versus investment tariff reduction. *Journal of Development Economics*, 134:392–415, 2018.

Harald Uhlig. What are the effects of monetary policy on output? results from an agnostic identification procedure. *Journal of Monetary Economics*, 52(2):381–419, 2005.

Ngo Van Long, Raymond Riezman, and Antoine Soubeyran. Trade, wage gaps, and specific human capital accumulation. *Review of International Economics*, 15(1):75–92, 2007.

Marcio Jose Vargas Da Cruz, Gerhard Toews Gaurav Nayyar, and Pierre-Louis Vézina. FDI and the skill premium: Evidence from emerging economies. Working Paper 8613, World Bank Policy Research, 2018.

Yanling Wang. Trade, human capital, and technology spillovers: An industry-level analysis. *Review of International Economics*, 15(2):269–283, 2007.

Nobuaki Yamashita. The impact of production fragmentation on skill upgrading: New evidence from Japanese manufacturing. *Journal of the Japanese and International Economies*, 22(4):545–565, 2008.

Stephen Ross Yeaple. Firm heterogeneity and the structure of US multinational activity. *Journal of International Economics*, 78(2):206–215, 2009.

Andrei Zlate. Offshore production and business cycle dynamics with heterogeneous firms. *Journal of International Economics*, 100:34–49, 2016.

Appendix A

FOREIGN DIRECT INVESTMENT, SKILL UPGRADING, AND WAGE INEQUALITY

A.1 Additional Figures

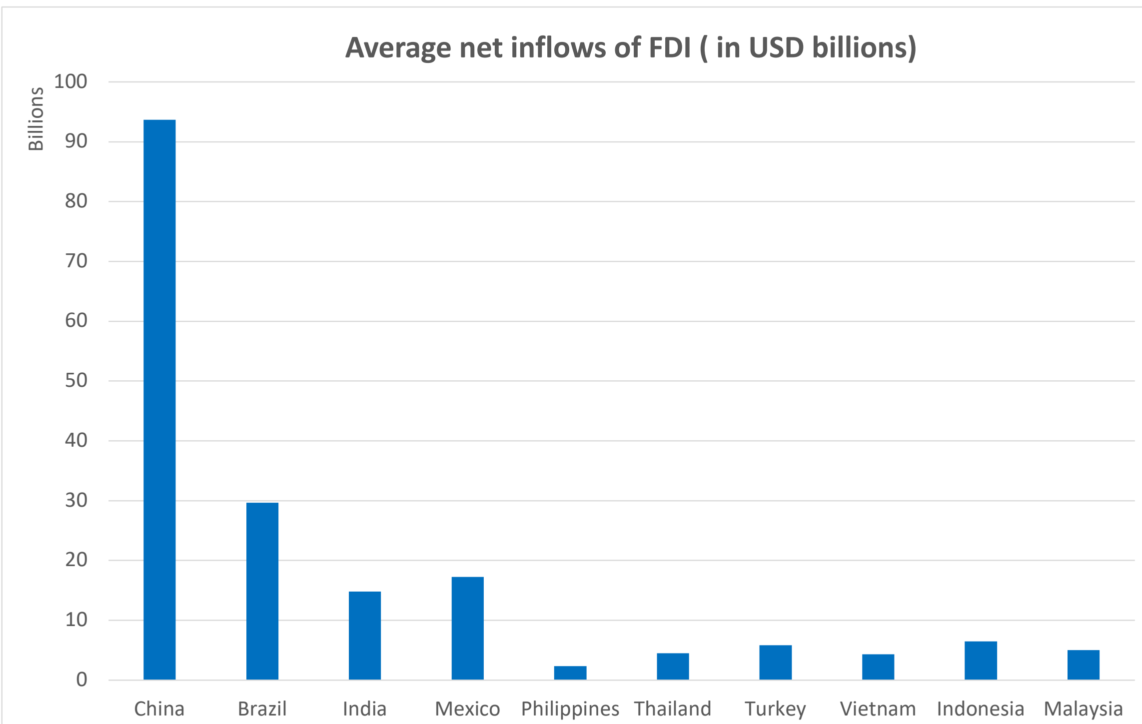

Figure A.1: Average net FDI inflows of 10 developing countries over 40 years in 1980 - 2020

Sources: International Monetary Fund, Balance of Payments database, supplemented by data from the United Nations Conference on Trade and Development and official national sources.

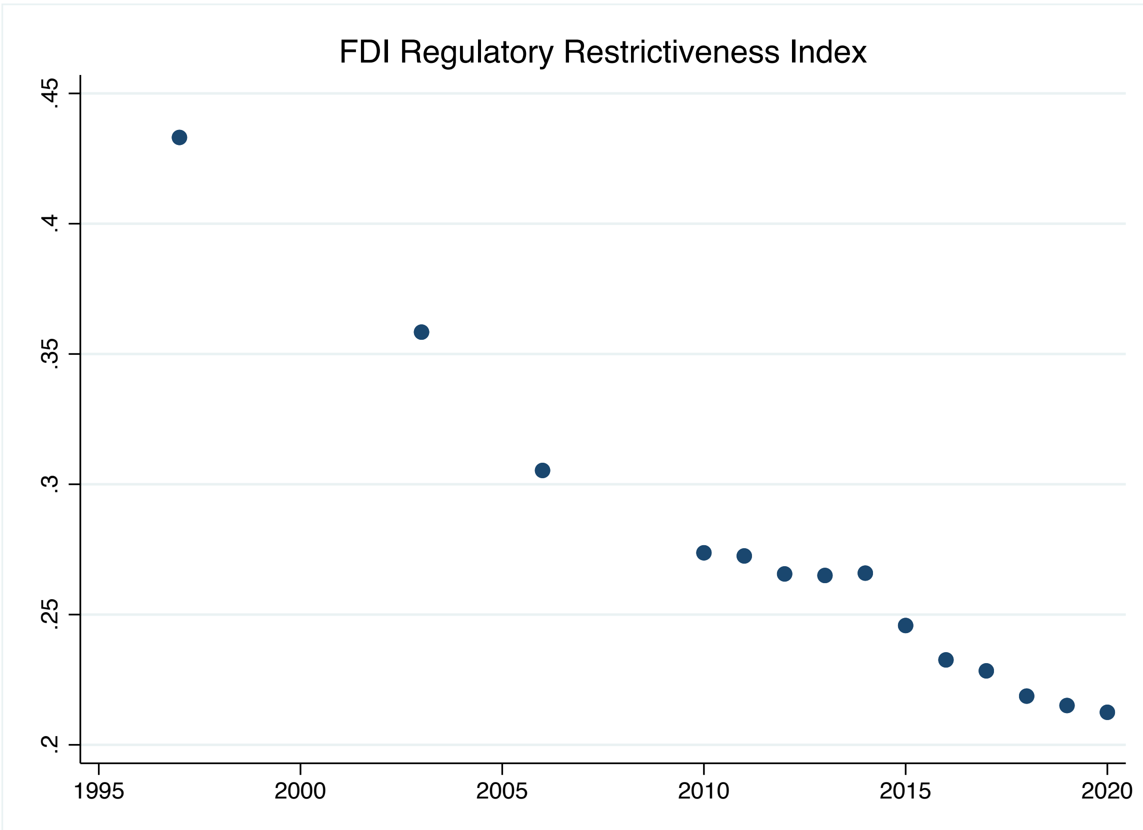

Figure A.2: FDI regulatory restrictiveness index

Note: This graph shows the average FDI index of 10 developing countries (China, Brazil, India, Mexico, Philippines, Thailand, Turkey, Vietnam, Indonesia and Malaysia). According to OECD, there are these types of restrictions on FDI: "foreign equity limitations; discriminatory screening or approval mechanisms; restrictions on the employment of foreigners as key personnel; and operational restrictions".

A.2 Data

To present some stylized facts about FDI flows, we gather data from the OECD FDI database and the IMF's Balance of Payments database, complemented by information from the United Nations Conference on Trade and Development and official national sources.

In terms of calibration, we obtain the income share of different groups and the inflows of FDI to GDP ratio from the World Bank. The data source for educational attainment, at least a bachelor's or equivalent, of population over 25 years old is from the UNESCO Institute for Statistics (UIS). The FDI regulatory restrictiveness index, measuring the types of restrictions on FDI, is collected from the OECD.

A.3 Model Equations

A.3.1 Skill Premium Maximization

$$\max_{n_{d,t}(a)} p^d_{h,t} H_{d,t} - \int w_{d,t}(a) n_{d,t}(a) \mathrm{d}a$$

$$n_{d,t}(a) = \left(\frac{w_{d,t}(a)}{p^d_{h,t}} \right)^{-\theta} H_{d,t}$$

$$\begin{aligned}
\pi_{d,t}(a) &= w_{d,t}(a) n_{d,t}(a) - \frac{w_{u,t}}{z} n_{d,t}(a) \\
&= w_{d,t}(a) \left(\frac{w_{d,t}(a)}{p^d_{h,t}} \right)^{-\theta} H_{d,t} - \frac{\theta - 1}{\theta} w_{d,t}(a) \left(\frac{w_{d,t}(a)}{p^d_{h,t}} \right)^{-\theta} H_{d,t} \\
&= \frac{1}{\theta} (w_{d,t}(a))^{1-\theta} (p^d_{h,t})^{\theta} H_{d,t}
\end{aligned}$$

The average skill premium for high-skilled tasks demanded by local firms is

$$\tilde{\pi}_{d,t} = \frac{1}{\theta} (\tilde{w}_{d,t})^{1-\theta} (p^d_{h,t})^{\theta} H_{d,t}$$

$$\max_{n_{m,t}(a)} p^m_{h,t} H_{m,t} - \int w_{m,t}(a) n_{m,t}(a) \mathrm{d}a$$

$$n_{m,t}(a) = \left(\frac{w_{m,t}(a)}{p^m_{h,t}} \right)^{-\theta} H_{m,t}$$

$$\pi_{m,t}(a) = w_{m,t}(a)n_{m,t}(a) - w_{u,t}l_{m,t}(a) - f_{h,t}$$
$$= w_{m,t}(a)\left(\frac{w_{m,t}(a)}{p^m_{h,t}}\right)^{-\theta} H_{m,t} - \frac{\theta-1}{\theta} w_{m,t}(a)\left(\frac{w_{m,t}(a)}{p^m_{h,t}}\right)^{-\theta} H_{m,t} - f_{h,t}$$
$$= \frac{1}{\theta}(w_{m,t}(a))^{1-\theta}(p^m_{h,t})^{\theta} H_{m,t} - f_{h,t}$$

The average skill premium for high-skilled tasks demanded by multinational firms is

$$\tilde{\pi}_{m,t} = \frac{1}{\theta}(\tilde{w}_{m,t})^{1-\theta}(p^m_{h,t})^{\theta} H_{m,t} - f_{h,t}$$

Steady State for Baseline Model

In this section, variables without time subscripts represent steady-state values. We solve the steady state numerically using a system of 28 unknowns C, Y, L, $\tilde{\pi}$, $\tilde{\pi}_d$, $\tilde{\pi}_m$, N, N_d, N_m, p^d_h, p^m_h, $\tilde{w}_m$, $\tilde{w}_d$, w_u, $\tilde{a}_d$, $\tilde{a}_m$, a_m, $\tilde{h}_d$, $\tilde{h}_m$, z_d, z_m, $\tilde{z}_d$, $\tilde{z}_m$, $\tilde{\rho}_d$, $\tilde{\rho}_m$, $\tilde{n}_d$, $\tilde{n}_m$ and $\tilde{l}_u$ with 28 non-linear equations.

Labor supply:

$$w_u = \chi L^{\psi_l} C^{\gamma} \tag{A.1}$$

Average skill premiums:

$$\tilde{\pi}_d = \frac{1}{\theta}(\tilde{w}_d)^{1-\theta}(p^d_h)^{\theta} H_d \tag{A.2}$$

$$\tilde{\pi}_m = \frac{1}{\theta}(\tilde{w}_m)^{1-\theta}(p^m_h)^{\theta} H_m - f_h \tag{A.3}$$

where $H_d = M_d\tilde{h}_d$ and $H_m = M_m\tilde{h}_m$.

Total skill premium:

$$N\tilde{\pi} = N_d\tilde{\pi}_d + N_m\tilde{\pi}_m \tag{A.4}$$

The number of high-skilled workers:

$$N = N_m + N_d \tag{A.5}$$

The share of high-skilled workers executing tasks for multinational firms:

$$\frac{N_m}{N} = \left(\frac{1}{a_m}\right)^{\lambda} \tag{A.6}$$

Zero-profit cutoff for skill upgrading

$$\tilde{\pi}_m = \frac{a_m^{\lambda} - 1}{a_m^{\lambda-(\theta-1)} - 1}\tilde{\pi}_d + \frac{\theta - 1}{\lambda - (\theta - 1)} f_h \tag{A.7}$$

Free entry condition for labor training:

$$f_e = \frac{\beta(1-\delta)}{1-\beta(1-\delta)}\tilde{\pi} \tag{A.8}$$

The consumer budget constraint:

$$N\tilde{\pi} + w_u L = C + f_e N_e \tag{A.9}$$

Resource constraint:

$$Y = C + (M_d + M_m) f_d + M_m f_o \tag{A.10}$$

Average wage and productivity for high-skilled workers demanded by local firms:

$$\tilde{w}_d = \frac{\theta}{\theta - 1}\frac{w_u}{\tilde{a}_d} \tag{A.11}$$

$$\tilde{a}_d = \phi a_m \left(\frac{a_m^{\lambda-(\theta-1)} - 1}{a_m^{\lambda} - 1} \right)^{\frac{1}{\theta-1}} \tag{A.12}$$

Average wage and productivity for high-skilled workers demanded by multinational firms:

$$\tilde{w}_m = \frac{\theta}{\theta - 1}\frac{w_u}{\tilde{a}_m} \tag{A.13}$$

$$\tilde{a}_m = \phi a_m \tag{A.14}$$

Price indexes of high-skilled tasks:

$$p_h^d = [N_d(\tilde{w}_d)^{1-\theta}]^{\frac{1}{1-\theta}} \tag{A.15}$$

$$p_h^m = [N_m(\tilde{w}_m)^{1-\theta}]^{\frac{1}{1-\theta}} \tag{A.16}$$

Demand for high-skilled variety bundles:

$$Z\tilde{z}_d \tilde{h}_d^{\eta} \tilde{l}_u^{1-\eta} = \tilde{\rho}_d^{-\sigma} Y \tag{A.17}$$

$$Z\tilde{z}_m\tilde{h}_m = \tilde{\rho}_m^{-\sigma}Y \tag{A.18}$$

Aggregate price index:

$$1 = \left[M_d(\tilde{\rho}_d)^{1-\sigma} + M_m(\tilde{\rho}_m)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{A.19}$$

Price indexes of intermediate goods

$$\tilde{\rho}_d = \frac{\sigma}{\sigma-1}\frac{1}{\tilde{z}_d Z}\left(\frac{p_h^d}{\eta}\right)^{\eta}\left(\frac{w_u}{1-\eta}\right)^{1-\eta} \tag{A.20}$$

$$\tilde{\rho}_m = \frac{\sigma}{\sigma-1}\frac{p_h^m}{\tilde{z}_m Z} \tag{A.21}$$

Average firm productivity:

$$\tilde{z}_d = \nu z_d \tag{A.22}$$

$$\tilde{z}_m = \nu z_m \tag{A.23}$$

Zero-profit cutoff conditions for firms:

$$\frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\frac{1}{z_d Z}\left(\frac{p_h^d}{\eta}\right)^{\eta}\left(\frac{w_u}{1-\eta}\right)^{1-\eta}\right)^{1-\sigma} Y = f_d \tag{A.24}$$

$$\frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\frac{p_h^m}{z_m Z}\right)^{1-\sigma} Y = f_d + f_o \tag{A.25}$$

Labor market clearing condition:

$$L = M_d(\tilde{l}_u + \tilde{l}_h^d) + M_m\tilde{l}_h^m + N_e f_e + N_m f_h \tag{A.26}$$

where $\tilde{l}_h^d = \tilde{n}_d/\tilde{a}_d$, $\tilde{l}_h^m = \tilde{a}_m/\tilde{n}_m$

Average high-skilled labor supply:

$$\tilde{n}_d = \left(\frac{\tilde{w}_d}{p_h^d}\right)^{-\theta} H_d \tag{A.27}$$

$$\tilde{n}_m = \left(\frac{\tilde{w}_m}{p_h^m}\right)^{-\theta} H_m \tag{A.28}$$

Next, we use the steady-state solutions above to obtain solutions for the remaining variables N_e, $\tilde{d}_d$, $\tilde{d}_m$, H_d. H_m

The law of motion for the quantity of high-skilled workers:

$$N = \frac{1-\delta}{\delta} N_e \tag{A.29}$$

Average profits:

$$\tilde{d}_d = \frac{1}{\sigma} \tilde{\rho}_d^{1-\sigma} Y - f_d \tag{A.30}$$

$$d_{m,t}(z^*) = \frac{1}{\sigma} \tilde{\rho}_m^{1-\sigma} Y - f_d - f_o \tag{A.31}$$

Total high-skilled bundles

$$H_d = M_d \tilde{h}_d \tag{A.32}$$

$$H_m = M_m \tilde{h}_m \tag{A.33}$$

The income share of high-skill workers demanded by domestic firms is

$$S_d = \frac{N_d(\tilde{\pi}_d + w_u(\tilde{a}_d/\tilde{n}_d))}{N\tilde{\pi} + w_u L} \tag{A.34}$$

The income share of high-skill workers demanded by FDI firms is

$$S_m = \frac{N_m(\tilde{\pi}_m + w_u(\tilde{a}_m/\tilde{n}_m))}{N\tilde{\pi} + w_u L} \tag{A.35}$$

The income share of low-skilled worker is

$$S_u = 1 - S_d - S_m \tag{A.36}$$

A.3.2 Solving for steady state

Labor supply:

$$w_u = \chi L^{\psi_l} C^{\gamma} \tag{A.37}$$

Total skill premium:

$$(N_d + N_m) f_e \left(\frac{1-\beta(1-\gamma)}{\beta(1-\delta)} \right) = \frac{1}{1-\theta} \left(N_d^{\frac{1}{1-\theta}} \right) \frac{w_u}{\tilde{a}_d} M_d \tilde{h}_d + \frac{1}{1-\theta} \left(N_m^{\frac{1}{1-\theta}} \right) \frac{w_u}{\tilde{a}_m} M_m \tilde{h}_m - N_m f_h \tag{A.38}$$

The share of high-skilled workers executing tasks for multinational firms:

$$\frac{N_m}{N_m + N_d} = \left(\frac{\phi}{\tilde{a}_m}\right)^{\lambda} \tag{A.39}$$

Zero-profit cutoff for skill upgrading

$$\left(N_m^{\frac{\theta}{1-\theta}}\right)\frac{w_u}{\tilde{a}_m}M_m\tilde{h}_m - (1-\theta)f_h =$$
$$\left(\frac{(\frac{\tilde{a}_m}{\phi})^{\lambda} - 1}{(\frac{\tilde{a}_m}{\phi})^{\lambda-(\theta-1)} - 1}\right)\left(N_d^{\frac{\theta}{1-\theta}}\right)\frac{w_u}{\tilde{a}_d}M_d\tilde{h}_d - \frac{1}{\lambda-(\theta-1)}f_h \tag{A.40}$$

The consumer budget constraint:

$$(N_d + N_m)f_e\left(\frac{1-\beta(1-\gamma)}{\beta(1-\delta)}\right) + w_u L = C + f_e\frac{\delta}{1-\delta}(N_d + N_m) \tag{A.41}$$

Resource constraint:

$$Y = C + (M_d + M_m)f_d + M_m f_o \tag{A.42}$$

Average productivity for high-skilled workers demanded by local firms:

$$\tilde{a}_d = \tilde{a}_m\left(\frac{(\frac{\tilde{a}_m}{\phi})^{\lambda-(\theta-1)} - 1}{(\frac{\tilde{a}_m}{\phi})^{\lambda} - 1}\right)^{\frac{1}{\theta-1}} \tag{A.43}$$

Demand for high-skilled variety bundles:

$$Z\tilde{z}_d\tilde{h}_d^{\eta}\tilde{l}_u^{1-\eta} = \tilde{\rho}_d^{-\sigma}Y \tag{A.44}$$

$$Z\tilde{z}_m\tilde{h}_m = \tilde{\rho}_m^{-\sigma}Y \tag{A.45}$$

Aggregate price index:

$$1 = \left[M_d(\tilde{\rho}_d)^{1-\sigma} + M_m(\tilde{\rho}_m)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{A.46}$$

Price indexes of intermediate goods

$$\begin{aligned}\tilde{\rho}_d &= \frac{\sigma}{\sigma-1}\frac{1}{\tilde{z}_d Z}\left(\frac{p_h^d}{\eta}\right)^{\eta}\left(\frac{w_u}{1-\eta}\right)^{1-\eta}\\ &= \frac{\sigma}{\sigma-1}\frac{1}{\tilde{z}_d Z}\left(\frac{N_d^{\frac{1}{1-\theta}}}{\eta}\left(\frac{\theta}{\theta-1}\frac{w_u}{\tilde{a}_d}\right)\right)^{\eta}\left(\frac{w_u}{1-\eta}\right)^{1-\eta}\end{aligned}$$

$$\tilde{\rho}_m = \frac{\sigma}{\sigma-1}\frac{p_h^m}{\tilde{z}_m Z} = \frac{\sigma}{\sigma-1}\frac{\theta}{\theta-1}\frac{N_m^{\frac{1}{1-\theta}} w_u}{\tilde{a}_m \tilde{z}_m Z}$$

Zero-profit cutoff conditions for firms:

$$\frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\frac{1}{z_d Z}\left(\frac{p_h^d}{\eta}\right)^{\eta}\left(\frac{w_u}{1-\eta}\right)^{1-\eta}\right)^{1-\sigma} Y = f_d \tag{A.47}$$

$$\frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\frac{1}{Z\tilde{z}_d/\nu}\left(\frac{N_d^{\frac{1}{1-\theta}}}{\eta}\left(\frac{\theta}{\theta-1}\frac{w_u}{\tilde{a}_d}\right)\right)^{\eta}\left(\frac{w_u}{1-\eta}\right)^{1-\eta}\right)^{1-\sigma} Y = f_d$$

$$\frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\frac{p_h^m}{z_m Z}\right)^{1-\sigma} Y = f_d + f_o \tag{A.48}$$

$$\frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\frac{1}{Z\tilde{z}_m/\nu}N_m^{\frac{1}{1-\theta}}\left(\frac{\theta}{\theta-1}\frac{w_u}{\tilde{a}_m}\right)\right)^{1-\sigma} Y = f_d + f_o$$

Labor market clearing condition:

$$\begin{aligned} L =& M_d(\tilde{l}_u + \tilde{l}_h^d) + M_m \tilde{l}_h^m + N_e f_e + N_m f_h \\ =& M_d(N_d^{\frac{1}{\theta-1}} M_d \tilde{h}_d/\tilde{a}_d + \tilde{l}_u) + M_m \tilde{N}_m^{\frac{1}{\theta-1}} M_m \tilde{h}_m/\tilde{a}_m + N_e f_e + N_m f_h \end{aligned} \tag{A.49}$$

where $\tilde{l}_h^d = \tilde{n}_d/\tilde{a}_d$, $\tilde{l}_h^m = \tilde{a}_m/\tilde{n}_m$

Other variables:

Average wage and productivity for high-skilled workers demanded by local firms:

$$\tilde{w}_d = \frac{\theta}{\theta-1}\frac{w_u}{\tilde{a}_d} \tag{A.50}$$

Average wage and productivity for high-skilled workers demanded by multinational firms:

$$\tilde{w}_m = \frac{\theta}{\theta-1}\frac{w_u}{\tilde{a}_m} \tag{A.51}$$

Price indexes of high-skilled tasks:

$$p_h^d = \left[N_d \tilde{w}_d^{1-\theta}\right]^{\frac{1}{1-\theta}} = N_d^{\frac{1}{1-\theta}}\left(\frac{\theta}{\theta-1}\frac{w_u}{\tilde{a}_d}\right) \tag{A.52}$$

$$p_h^m = \left[N_m \tilde{w}_m^{1-\theta}\right]^{\frac{1}{1-\theta}} = N_m^{\frac{1}{1-\theta}} \left(\frac{\theta}{\theta-1}\frac{w_u}{\tilde{a}_m}\right) \tag{A.53}$$

Average high-skilled labor supply:

$$\tilde{n}_d = \left(\frac{\tilde{w}_d}{p_h^d}\right)^{-\theta} H_d = N_d^{\frac{1}{\theta-1}} M_d \tilde{h}_d \tag{A.54}$$

$$\tilde{n}_m = \left(\frac{\tilde{w}_m}{p_h^m}\right)^{-\theta} H_m = N_m^{\frac{1}{\theta-1}} M_m \tilde{h}_m \tag{A.55}$$

Average skill premiums:

$$\tilde{\pi}_d = \frac{1}{1-\theta}\left((N_d)^{\frac{\theta}{1-\theta}}\right)\frac{w_u}{\tilde{a}_d} M_d \tilde{h}_d \tag{A.56}$$

$$\tilde{\pi}_m = \frac{1}{1-\theta}\left((N_m)^{\frac{\theta}{1-\theta}}\right)\frac{w_m}{\tilde{a}_m} M_m \tilde{h}_m - f_h \tag{A.57}$$

Appendix B

HETEROGENEOUS IMPACTS OF TRADE LIBERALIZATION ON SKILL UPGRADING: EVIDENCE FROM APTA

B.1 Additional Figures

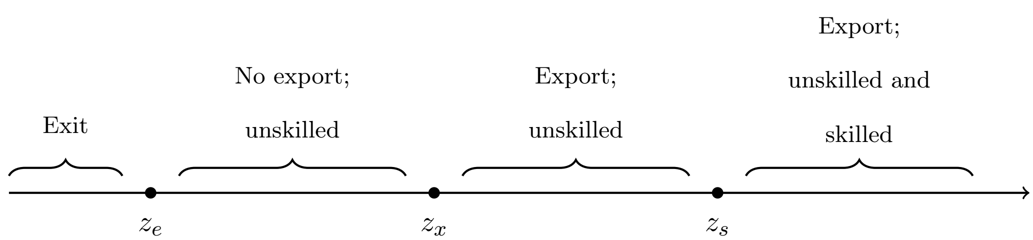

Figure B.1: Productivity cutoffs in Bustos (2011b)'s model

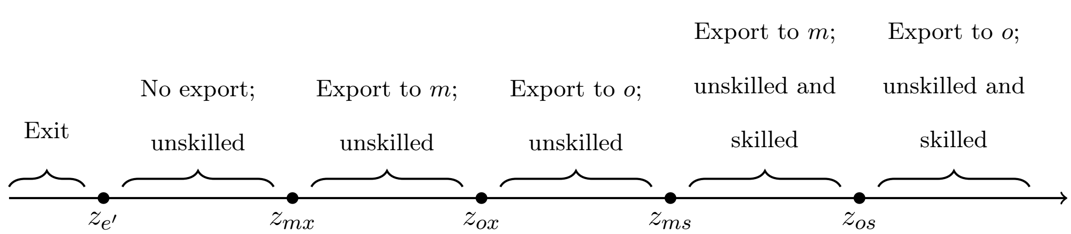

Figure B.2: Productivity cutoffs in the advanced setting

B.2 More Details of the Theoretical Model

B.2.1 Production

There is a continuum of firms with heterogeneous productivity z. Let $z \in \Omega$ be a particular variety. Firms endogenously choose to produce unskilled or skilled goods. Firm technology is represented by a total cost function, and the total cost in the unskilled sector is

$$TC_u(z) = f_u + \frac{w_l}{z} y_u(z)$$

where f_u is fixed production costs of the unskilled sector measured in units of aggregate consumption goods, and w_l is the real wage of low-skilled workers. More productive firms can hire high-skilled workers to produce skill-intensive goods by paying higher fixed costs $f_s > f_u$, and delivering lower marginal production costs with $\gamma > 1$ and $\beta \in (0,1)$. w_h is the real wage of high-skilled workers. The total cost of skill-intensive goods is

$$TC_s(z) = f_s + \frac{w_h^{\beta} w_l^{1-\beta}}{\gamma z} y_s(z)$$

The profit maximization of these two sectors yields the following pricing rules for domestic sales:

$$\rho_u^d(z) = \frac{\theta}{\theta - 1} \frac{w_l}{z}$$
$$\rho_s^d(z) = \frac{\theta}{\theta - 1} \frac{w_h^{\beta} w_l^{1-\beta}}{\gamma z}$$

The two pricing rules for exporting are $\rho_s^x(z) = \tau \rho_s^d(z)$, $\rho_u^x(z) = \tau \rho_u^d(z)$. Hence, $\rho_s^d(z) = \rho_u^d(z)/\lambda$ where $\lambda \equiv \gamma \left(\frac{w_l}{w_h}\right)^{\beta}$.

Profits if producing unskilled goods and only serving the domestic market:

$$\begin{aligned} \pi_u^d(z) &= \frac{1}{\theta} \left(\frac{\theta}{\theta - 1} \frac{w_l}{z} \right)^{1-\theta} \rho_1^{\theta - \rho} Y - f_u \\ &= \frac{r_u^d(z)}{\theta} - f_u \end{aligned}$$

where firm revenue $r_u^d(z) = \left(\frac{\theta}{\theta-1}\frac{w_l}{z}\right)^{1-\theta} \rho_1^{\theta-\rho} Y$.

Profits if producing unskilled goods and exporting:

$$\begin{aligned} \pi_u^x(z) &= (1 + \tau^{1-\theta}) \frac{1}{\theta} \left(\frac{\theta}{\theta - 1} \frac{w_l}{z} \right)^{1-\theta} \rho_1^{\theta - \rho} Y - f_u - f_x \\ &= (1 + \tau^{1-\theta}) \frac{r_u^d(z)}{\theta} - f_u - f_x \end{aligned}$$

Exporting is costly, incurring iceberg trade costs τ and fixed exporting costs, f_x, measured in units of aggregate consumption goods.

Profits if producing skill-intensive goods and only serving the domestic market:

$$\pi_s^d(z) = \frac{1}{\theta}\left(\frac{\theta}{\theta-1}\frac{w_h^{\beta}w_l^{1-\beta}}{\gamma z}\right)^{1-\theta}\rho_2^{\theta-\rho}Y - f_s$$
$$= \lambda^{\theta-1}\frac{r_u^d(z)}{\theta}\left(\frac{\rho_2}{\rho_1}\right)^{\theta-\rho} - \phi f_u$$

Profits if producing skill-intensive goods and exporting:

$$\pi_s^x(z) = (1+\tau^{1-\theta})\frac{1}{\theta}\left(\frac{\theta}{\theta-1}\frac{w_h^{\beta}w_l^{1-\beta}}{\gamma z}\right)^{1-\theta}\rho_2^{\theta-\rho}Y - f_s - f_x$$
$$= \lambda^{\theta-1}(1+\tau^{1-\theta})\frac{r_u^d(z)}{\theta}\left(\frac{\rho_2}{\rho_1}\right)^{\theta-\rho} - \phi f_u - f_x$$

where $\phi > 1$ and $f_s > f_u$. High productivity firms find it profitable to export skilled goods after paying higher fixed production costs, ϕf_u.

After learning the idiosyncratic productivity z, firms endogenously choose to produce unskilled or skilled goods. The least productive firms must exit the market if the domestic sales profit is negative, so the exit cutoff z_e is defined as:

$$z_e = \{z|\pi_u^d(z) = 0\}$$

z_x denotes the productivity level above which firms produce unskilled goods and find exporting profitable, so

$$z_x = \{z|\pi_u^d(z) = \pi_u^x(z)\}$$

Hence, z_x can be represented as a function of z_e based on the zero-profit condition for marginal exporters:

$$z_x = \tau z_e\left(\frac{f_x}{f_u}\right)^{\frac{1}{\theta-1}} \tag{B.1}$$

This condition shows that $z_x > z_e$ as long as $\tau\left(\frac{f_x}{f_u}\right)^{\frac{1}{\theta-1}} > 1$.

More productive firms are able to provide training to upgrade workers' skill levels, so they can enter the skill-intensive sector. The productivity cutoff z_s is the cutoff level where firms obtain equal profits from producing unskilled and skilled goods:

$$z_s = \{z|\pi_s^x(z) = \pi_u^x(z)\}$$

The zero profit condition for the marginal firm to produce skill-intensive goods gives the following expression of z_s as a function of z_e:

$$z_s = z_e \left[\frac{\phi - 1}{(1 + \tau^{1-\theta})(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - 1)} \right]^{\frac{1}{\theta-1}} \tag{B.2}$$

The restriction required for $z_s > z_e$ is $\phi - 1 > (1 + \tau^{1-\theta})(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - 1)$. Given $\tau \left(\frac{f_x}{f_u}\right)^{\frac{1}{\theta-1}} > 1$, the ratio of z_s and z_x is larger than one:

$$\frac{z_s}{z_x} = \left[\frac{\tau^{1-\theta}(\phi - 1)f_u}{(1 + \tau^{1-\theta})(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - 1)f_x} \right]^{\frac{1}{\theta-1}} > 1$$

In equilibrium, there are four groups of firms. Firms with the lowest level of productivity ($z < z_e$) leave the market; low productivity firms ($z_e < z < z_x$) are not able to invest in labor training and only serve the domestic market; moderate productivity firms ($z_x < z < z_s$) also do not invest in human capital but they export to the foreign market; and firms with the highest productivity ($z > z_s$) are able to both export and upgrade the skill levels of their workers. The productivity cutoffs in the model $z_s > z_x$ are consistent with the data since some firms find it profitable to export but not profitable to provide labor training and produce skilled goods.

B.2.2 Equilibrium

labor Market

The aggregate demand for low-skilled workers in both the unskilled and skill-intensive sectors is:

$$\begin{aligned} L &= L_u + L_s \\ &= \int_{z_e}^{z_x} l_u^d(z)dz + \int_{z_x}^{z_s} l_u^x(z)dz + \int_{z_s}^{\infty} l_s^x(z)dz \end{aligned}$$

The aggregate demand for high-skilled workers in the skill-intensive sector is

$$H = \int_{z_s}^{\infty} h_s^x(z)dz$$

Free Entry

The present value of the average profits over time is $\tilde{v} = \sum_{t=0}^{\infty}(1-\delta)^t\tilde{\pi} = \frac{\tilde{\pi}}{\delta}$, and the net value of entry is $v_e = \frac{1}{1-G(z_e)}\tilde{v} - f_e$, so the free entry condition is

$$f_e = (1 - G(z_e))\frac{\tilde{\pi}}{\delta} \tag{B.3}$$

The average profit is $\tilde{\pi} = \tilde{\pi}_u^d + n_x\tilde{\pi}_u^x + n_s\tilde{\pi}_s^x$, where $\tilde{\pi}_u^d$ is the average profit for firms that produce unskilled goods and serve the domestic market only, $n_x \equiv \frac{1-G(z_x)}{1-G(z_e)} = \left(\frac{z_x}{z_e}\right)^{-\kappa}$ is the fraction of firms that export but employ low-skilled labor and produce unskilled goods, $\tilde{\pi}_u^x$ is the average profits for exporters producing unskilled goods, and $n_s \equiv \frac{1-G(z_s)}{1-G(z_e)} = \left(\frac{z_s}{z_e}\right)^{-\kappa}$ is the fraction of exporters providing labor training and producing skilled goods, and $\tilde{\pi}_s^x$ is their average profits.

In Appendix B.2, we derive the average revenues of surviving firms is

$$\tilde{r} = \theta f_u\left(\frac{\tilde{z}_e}{z_e}\right)^{\theta-1} + n_x\theta f_x\left(\frac{\tilde{z}_x}{z_x}\right)^{\theta-1} + n_s\theta f_u(\phi-1)\left(\frac{\tilde{z}_s}{z_s}\right)^{\theta-1}.$$

After substituting $\tilde{r}$ into the free entry condition, we obtain

$$z_e = \left(\frac{1}{f_e\delta}\frac{\theta-1}{\kappa-(\theta-1)}\right)^{\frac{1}{\kappa}}[f_u + n_xf_x + n_sf_u(\phi-1)]^{\frac{1}{\kappa}} \tag{B.4}$$

where $n_x = \left(\frac{z_x}{z_e}\right)^{-\kappa} = \tau\left(\frac{f_x}{f_u}\right)^{\frac{-\kappa}{\theta-1}}$ and $n_s = \left(\frac{z_s}{z_e}\right)^{-\kappa} = \left[\frac{\phi-1}{(1+\tau^{1-\theta})(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right]^{\frac{-\kappa}{\theta-1}}$

Substituting n_x and n_s into equation (B.4), we get

$$z_e = \Lambda\Phi \tag{B.5}$$

where $\Lambda \equiv \left(\frac{f_u}{f_e\delta}\frac{\theta-1}{\kappa-(\theta-1)}\right)^{\frac{1}{\kappa}}$ and

$\Phi \equiv \left[1 + \frac{f_x}{f_u}\left(\frac{f_x}{f_u}\right)^{\frac{-\kappa}{\theta-1}}\tau^{-\kappa} + (\phi-1)\left(\frac{\phi-1}{(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right)^{\frac{-\kappa}{\theta-1}}(1+\tau^{1-\theta})^{\frac{\kappa}{\theta-1}}\right]^{\frac{1}{\kappa}}.$

By substituting the solution for the exit cutoff, we can get a solution for the export and skill upgrading cutoffs below.

$$z_x = \tau\Lambda\Phi \tag{B.6}$$

$$z_s = \Lambda\Phi\left[\frac{\phi-1}{(1+\tau^{1-\theta})(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right]^{\frac{1}{\theta-1}} \tag{B.7}$$

B.2.3 Trade Liberalization

In this section, we delve into an examination of the effects of trade liberalization on export participation and skill upgrading. Our findings indicate that a reduction in iceberg trade costs leads to heightened export profitability, prompting an increased number of firms to venture into the export market. Additionally, this reduction encourages existing exporters to invest more in labor training and engage in the production of skilled goods.

Proposition 1. A reduction in iceberg trade costs (τ):

a. increases the equilibrium skill premium, $\frac{\partial \frac{w_h}{w_l}}{\tau} < 0$

b. increases the average profit, $\frac{\partial \tilde{\pi}}{\tau} < 0$

c. increases the productivity cutoff for exiting, $\frac{\partial z_e}{\tau} < 0$

d. reduces the productivity cutoff for exporting, $\frac{\partial z_x}{\tau} > 0$

e. reduces the skill upgrading cutoff, $\frac{\partial z_s}{\tau} > 0$

Proof: see Appendix B.2.4.

There is an asymmetric effect of trade liberalization since firms are heterogeneous. Market shares are reallocated from the firms producing unskilled goods to the firms providing skilled goods with a reduction in trade costs, which increases the relative demand for skilled labor. This leads to an increase in the skill premium. We also conclude that trade integration increases firms' revenues, stimulates a greater number of firms within the intermediate range of productivity levels to engage in export activities, and makes labor training more profitable for productive exporters.

B.2.4 Bustos (2011b)'s Model

Total Cost Function

Per-period fixed export cost f_x and iceberg trade cost τ are required for exporters, and thus the total costs for firms that export in the unskilled and skilled sectors are respectively

$$TC_u(z) = f_u + f_x + \frac{w_l}{z} y_u^d(z) + \tau \frac{w_l}{z} y_u^x(z)$$

$$TC_s(z) = f_s + f_x + \frac{w_h^\beta w_l^{1-\beta}}{\gamma z} y_s^d(z) + \tau \frac{w_h^\beta w_l^{1-\beta}}{\gamma z} y_s^x(z)$$

Average Profit and Revenue

The average profit $\tilde{\pi} = \tilde{\pi}_u^d + n_x \tilde{\pi}_x^d + n_s \tilde{\pi}_s^x$, where

$$\begin{aligned}
\tilde{\pi}_u^d &= \frac{1}{1-G(z_e)} \int_{z_e}^{z_x} z^{\theta-1} g(z) dz \\
\tilde{\pi}_u^x &= \frac{1}{1-G(z_e)} \int_{z_x}^{z_s} z^{\theta-1} g(z) dz \\
\tilde{\pi}_s^x &= \frac{1}{1-G(z_e)} \int_{z_s}^{\infty} z^{\theta-1} g(z) dz
\end{aligned}$$

The average profit also can be describe in this way: $\tilde{\pi} = \frac{\tilde{r}}{\theta} - f_u - n_x f_x - n_s(\phi - 1) f_u$. The average revenues of surviving firms is

$$\begin{aligned}
\tilde{r} &= \int_{z_e}^{z_x} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz + \int_{z_x}^{z_s} r_u^x(z) \frac{g(z)}{1-G(z_e)} dz + \int_{z_s}^{\infty} r_s^x(z) \frac{g(z)}{1-G(z_e)} dz \\
&= \int_{z_e}^{z_x} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz + (1+\tau^{1-\theta}) \int_{z_x}^{z_s} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz \\
&\quad + \lambda^{\theta-1}(1+\tau^{1-\theta}) \int_{z_s}^{\infty} r_d^x(z) \frac{g(z)}{1-G(z_e)} dz \\
&= \int_{z_e}^{z_x} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz + \int_{z_x}^{z_s} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz + \int_{z_s}^{\infty} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz \\
&\quad + \tau^{1-\theta} \int_{z_x}^{z_s} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz + \tau^{1-\theta} \int_{z_s}^{\infty} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz \\
&\quad + \left[\lambda^{\theta-1}(1+\tau^{1-\theta}) \left(\frac{\rho_2}{\rho_1} \right)^{\theta-\rho} - 1 - \tau^{1-\theta} \right] \int_{z_s}^{\infty} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz \\
&= \int_{z_e}^{\infty} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz \\
&\quad + \tau^{1-\theta} \int_{z_x}^{\infty} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz \\
&\quad + (1+\tau^{1-\theta}) \left(\lambda^{\theta-1} \left(\frac{\rho_2}{\rho_1} \right)^{\theta-\rho} - 1 \right) \int_{z_s}^{\infty} r_u^d(z) \frac{g(z)}{1-G(z_e)} dz
\end{aligned}$$

Using the zero profit condition, we get $r_u^d(z) = \theta f_u \left(\frac{z}{z_e}\right)^{\theta-1}$. We define $\tilde{z}_j^{\theta-1} = \int_{z_j}^{\infty} z_j \frac{g(z)}{1-G(z_j)} dz$ where $j \in (e, x, s)$, and we derive that both z_x and z_s can be a function of z_e, so

$$\tilde{r} = \theta f_u \left(\frac{\tilde{z}_e}{z_e}\right)^{\theta-1} + n_x \theta f_x \left(\frac{\tilde{z}_x}{z_x}\right)^{\theta-1} + n_s \theta f_u (\phi - 1) \left(\frac{\tilde{z}_s}{z_s}\right)^{\theta-1}$$

Since

$$\begin{aligned}\left(\frac{\tilde{z}_j}{z_j}\right)^{\theta-1} &= \int_{z_j}^{\infty} \left(\frac{z}{z_j}\right)^{\theta-1} \frac{g(z)}{1-G(z_j)} dz \\ &= z_j^{\kappa+1-\theta} \frac{\kappa z_j^{\theta-1-\kappa}}{\kappa-(\theta-1)} \\ &= \frac{\kappa}{\kappa-(\theta-1)}\end{aligned}$$

We get $\tilde{r} = \frac{\theta\kappa}{\kappa-(\theta-1)} [f_u + n_x f_x + n_s f_u(\phi-1)]$. After substituting $\tilde{r}$ into the free entry condition, we obtain

$$f_e = \frac{z_e^{-\kappa}}{\delta} \frac{\theta-1}{\kappa-(\theta-1)} [f_u + n_x f_x + n_s f_u(\phi-1)]$$

Substituting n_x and n_s,

$$\begin{aligned}z_e =& \left(\frac{1}{f_e\delta} \frac{\theta-1}{\kappa-(\theta-1)}\right)^{\frac{1}{\kappa}} [f_u + n_x f_x + n_s f_u(\phi-1)]^{\frac{1}{\kappa}} \\ =& \left(\frac{1}{f_e\delta} \frac{\theta-1}{\kappa-(\theta-1)}\right)^{\frac{1}{\kappa}} \times \\ & \left[f_u + f_x \tau^{-\kappa} \left(\frac{f_x}{f_u}\right)^{\frac{-\kappa}{\theta-1}} + f_u(\phi-1) \left(\frac{\phi-1}{(1+\tau^{1-\theta})(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right)^{\frac{-\kappa}{\theta-1}}\right]^{\frac{1}{\kappa}} \\ =& \Lambda \left[1 + \frac{f_x}{f_u}\left(\frac{f_x}{f_u}\right)^{\frac{-\kappa}{\theta-1}} \tau^{-\kappa} + (\phi-1)\left(\frac{\phi-1}{(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right)^{\frac{-\kappa}{\theta-1}} (1+\tau^{1-\theta})^{\frac{\kappa}{\theta-1}}\right]^{\frac{1}{\kappa}} \\ =& \Lambda\Phi\end{aligned}$$

where $\Lambda \equiv \left(\frac{f_u}{f_e\delta} \frac{\theta-1}{\kappa-(\theta-1)}\right)^{\frac{1}{\kappa}}$ and

$$\Phi = \left[1 + \frac{f_x}{f_u}\left(\frac{f_x}{f_u}\right)^{\frac{-\kappa}{\theta-1}} \tau^{-\kappa} + (\phi-1)\left(\frac{\phi-1}{(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right)^{\frac{-\kappa}{\theta-1}} (1+\tau^{1-\theta})^{\frac{\kappa}{\theta-1}}\right]^{\frac{1}{\kappa}}.$$

Trade Liberalization

Skill Premium:

$$\frac{R_u}{R_s} = \frac{\int_{z_e}^{z_x} r_u^d(z)\frac{g(z)}{1-G(z_e)}dz + \int_{z_x}^{z_s} r_u^x(z)\frac{g(z)}{1-G(z_e)}dz}{\int_{z_s}^{\infty} r_s(z)\frac{g(z)}{1-G(z_e)}dz} = \frac{1}{\lambda^{\theta-1}(1+\tau^{\theta-1})}$$

As τ has a positive effect on λ, $\frac{\partial R_u}{\partial R_s} > 0$. The decrease in trade costs raises the relative revenues of firms producing skilled goods, so the demand for skilled labor increases. This leads to a higher equilibrium skill premium.

Next, a decrease in trade costs results in a higher proportion of firms engaging in the production of skilled goods, $\frac{\partial n_s}{\partial \tau} < 0$.

Proof:

The parameter τ exerts a direct negative impact on n_s, while also inducing an indirect positive impact through λ. This is because the reduction in tariffs elevates the skill premium, thereby diminishing the cost advantage held by firms engaged in skilled goods production. However, the direct effect prevails. To show this, let's assume the opposite scenario where it wasn't the case, implying that n_s declines as trade costs decrease. Then, we derive that $\frac{\partial R_s}{\partial R_u} > 0$, which is a contradiction.

Average Profit:

Given $\tilde{\pi} = \frac{\theta-1}{\kappa-(\theta-1)}\left[f_u + n_x f_x + n_s f_u(\phi-1)\right] = \frac{\theta-1}{\kappa-(\theta-1)}\Phi^\kappa$, $\frac{\partial\tilde{\pi}}{\partial\tau} = \frac{\theta-1}{\kappa-(\theta-1)}\frac{\partial\Phi^\kappa}{\partial\tau}$.

$$\frac{\partial\Phi^\kappa}{\partial\tau} = -\kappa\frac{f_x}{f_u}\left(\frac{f_x}{f_u}\right)^{\frac{-\kappa-1}{\theta-1}}\tau^{-\kappa} - (\theta-1)\frac{\kappa}{\theta-1}(\phi-1)\left(\frac{\phi-1}{(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right)^{\frac{-\kappa}{\theta-1}}(1+\tau^{1-\theta})^{\frac{\kappa-\theta+1}{\theta-1}}\tau^{-\theta} < 0$$

Since $\theta > 1$ and $\kappa > (\theta-1)$, we get $\frac{\partial\tilde{\pi}}{\partial\tau} < 0$.

Exit productivity cutoff:

Since $z_e = \Lambda\Phi$ and $\frac{\partial\Phi^\kappa}{\partial\tau} < 0$, we get $\frac{\partial z_e}{\partial\tau} < 0$.

Export productivity cutoff:

Since $z_x = \tau\Lambda\Phi$,

$$\frac{\partial z_x}{\partial \tau} = \left(\frac{f_x}{f_u}\right)^{\frac{1}{\theta-1}} \Lambda\Phi + \left(\frac{f_x}{f_u}\right)^{\frac{1}{\theta-1}} \Lambda\frac{\partial \Phi\tau}{\partial \tau}$$

Given $\Phi\tau = \left[\tau^{\kappa} + \frac{f_x}{f_u}\left(\frac{f_x}{f_u}\right)^{\frac{-\kappa}{\theta-1}} + \tau^{\kappa}(\phi-1)\left(\frac{\phi-1}{(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right)^{\frac{-\kappa}{\theta-1}}(1+\tau^{1-\theta})^{\frac{\kappa}{\theta-1}}\right]^{\frac{1}{\kappa}}$

$$\frac{\partial \Phi\tau}{\partial \tau} = (\Phi\tau)^{1/\kappa-1}\left[\tau^{\kappa-1} + \Xi(\phi-1)\left(\frac{\phi-1}{(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right)^{\frac{-\kappa}{\theta-1}}\right]$$

where $\Xi \equiv \tau^{\kappa-1}(1+\tau^{1-\theta})^{\frac{\kappa}{\theta-1}} - \tau^{\kappa-\theta}(1+\tau^{1-\theta})^{\frac{\kappa}{\theta-1}-1} = \tau^{\kappa-1}(1+\tau^{1-\theta})^{\frac{\kappa}{\theta-1}}\left(1-\frac{\tau^{1-\theta}}{(1+\tau^{1-\theta})}\right)$

As $\frac{\tau^{1-\theta}}{(1+\tau^{1-\theta})} < 1$, $\Xi > 0$. Then, $\frac{\partial\Phi\tau}{\partial\tau} > 0$ and all other terms are positive, thus $\frac{\partial z_x}{\partial\tau} > 0$.

Skill upgrading productivity cutoff:

Since $z_s = z_e\left[\frac{\phi-1}{(1+\tau^{1-\theta})(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right]^{\frac{1}{\theta-1}} = \Lambda\Phi\left[\frac{\phi-1}{(1+\tau^{1-\theta})(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right]^{\frac{1}{\theta-1}}$,

$$\begin{aligned}\Phi^{\kappa}(1+\tau^{1-\theta})^{\frac{-\kappa}{\theta-1}} =& (1+\tau^{1-\theta})^{\frac{-\kappa}{\theta-1}} \\ &+ (1+\tau^{1-\theta})^{\frac{-\kappa}{\theta-1}}\left(\frac{f_x}{f_u}\right)^{1-\frac{\kappa}{\theta-1}}\tau^{\kappa} \\ &+ (\phi-1)\left(\frac{\phi-1}{(\lambda^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-1)}\right)^{\frac{-\kappa}{\theta-1}}\end{aligned}$$

$$\begin{aligned}\frac{\partial\Phi^{\kappa}(1+\tau^{1-\theta})^{\frac{-\kappa}{\theta-1}}}{\partial\tau} =& \kappa(1+\tau^{1-\theta})^{\frac{-\kappa}{\theta-1}}\times \\ &\left[(1+\tau^{1-\theta})^{-1}\tau^{-\theta}\left(1+\left(\frac{f_x}{f_u}\right)^{1-\frac{\kappa}{\theta-1}}\tau^{\kappa}\right) - \left(\frac{f_x}{f_u}\right)^{1-\frac{\kappa}{\theta-1}}\tau^{-\kappa-1}\right]\end{aligned}$$

As $\kappa(1+\tau^{1-\theta})^{\frac{-\kappa}{\theta-1}} > 0$, the sign of $\frac{\partial\Phi^{\kappa}(1+\tau^{1-\theta})^{\frac{-\kappa}{\theta-1}}}{\partial\tau}$ depends on the second term. We can derive that $\frac{\partial\Phi^{\kappa}(1+\tau^{1-\theta})^{\frac{-\kappa}{\theta-1}}}{\partial\tau} > 0$ as long as $\tau^{\theta-1}f_x > f_u$. Then $\frac{\partial z_s}{\partial\tau} > 0$ as all terms are positive.

B.2.5 Our Model

Total cost and Price

$$TC_u^d(z) = f_u + \frac{w_l}{z}y_u^d(z)$$

$$TC_u^{mx}(z) = f_u + f_{mx} + \frac{w_l}{z} y_u^d(z) + \tau_m \frac{w_l}{z} y_u^{mx}(z)$$

$$TC_u^{ox}(z) = f_u + f_{ox} + \frac{w_l}{\gamma_u z} y_u^d(z) + \tau_o \frac{w_l}{\gamma_u z} y_u^{ox}(z)$$

$$TC_s^{mx}(z) = f_{ms} + f_{mx} + \frac{w_h^\beta w_l^{1-\beta}}{\gamma_m z} y_s^{md}(z) + \tau_m \frac{w_h^\beta w_l^{1-\beta}}{\gamma_m z} y_s^{mx}(z)$$

$$TC_s^{ox}(z) = f_{os} + f_{ox} + \frac{w_h^\alpha w_l^{1-\alpha}}{\gamma_o z} y_s^{od}(z) + \tau_o \frac{w_h^\alpha w_l^{1-\alpha}}{\gamma_o z} y_s^{ox}(z)$$

where $f_{ox} > f_{mx}$, $f_{os} > f_{ms} > f_u$, $\alpha > \beta$ and $\gamma_o > \gamma_m > \gamma_u > 1$.

The profit maximization of both sectors yields the following pricing rules of domestic sales:

$$\rho_u^{md}(z) = \frac{\theta}{\theta - 1} \frac{w_l}{z}$$
$$\rho_u^{od}(z) = \frac{\theta}{\theta - 1} \frac{w_l}{\gamma_u z}$$
$$\rho_s^{md}(z) = \frac{\theta}{\theta - 1} \frac{w_h^\beta w_l^{1-\beta}}{\gamma_m z}$$
$$\rho_s^{od}(z) = \frac{\theta}{\theta - 1} \frac{w_h^\alpha w_l^{1-\alpha}}{\gamma_o z}$$

The four pricing rules of exporting are $\rho_u^{mx}(z) = \tau_m \rho_u^{md}(z)$, $\rho_u^{ox}(z) = \tau_o \rho_u^{od}(z)$, $\rho_s^{mx}(z) = \tau_m \rho_s^{md}(z)$, $\rho_s^{ox}(z) = \tau_o \rho_s^{od}(z)$. Hence, $\rho_s^{md}(z) = \rho_u^{md}(z)/\lambda_m$ where $\lambda_m = \gamma_m \left(\frac{w_l}{w_h}\right)^\beta$; $\rho_s^{od}(z) = \rho_u^{od}(z)/\lambda_o$ where $\lambda_o = \gamma_o \left(\frac{w_l}{w_h}\right)^\alpha$.

Average Profit and Revenue

The average profit $\tilde{\pi}' = \tilde{\pi}_u^{d'} + n_{mx}\tilde{\pi}_u^{mx} + n_{ox}\tilde{\pi}_u^{ox} + n_{ms}\tilde{\pi}_s^{mx} + n_{os}\pi_s^{ox}$, where

$$\tilde{\pi}_u^{d'} = \frac{1}{1-G(z_e')}\int_{z_e'}^{z_{mx}} z^{\theta-1}g(z)dz$$
$$\tilde{\pi}_u^{mx} = \frac{1}{1-G(z_e')}\int_{z_{mx}}^{z_{ox}} z^{\theta-1}g(z)dz$$
$$\tilde{\pi}_u^{ox} = \frac{1}{1-G(z_e')}\int_{z_{ox}}^{z_{ms}} z^{\theta-1}g(z)dz$$
$$\tilde{\pi}_s^{mx} = \frac{1}{1-G(z_e')}\int_{z_{ms}}^{z_{os}} z^{\theta-1}g(z)dz$$
$$\tilde{\pi}_s^{ox} = \frac{1}{1-G(z_e')}\int_{z_{os}}^{\infty} z^{\theta-1}g(z)dz$$

The average profit also can be describe in this way:

$$\begin{aligned}
\tilde{\pi}' =& \frac{\tilde{r}'}{\theta} - (1-n_{ms})f_u - n_{mx}f_{mx} - n_{ox}(f_{ox}-f_{mx}) - n_{ms}(\phi_m f_u + f_{mx} - f_{ox}) \\
&- n_{os}(\phi_o f_u - \phi_m f_u + f_{ox} - f_{mx}) \\
=& \frac{\tilde{r}'}{\theta} - f_u - n_{mx}f_{mx} - n_{ox}(f_{ox}-f_{mx}) - n_{ms}((\phi_m - 1)f_u + f_{mx} - f_{ox}) \\
&- n_{os}((\phi_o - \phi_m)f_u + f_{ox} - f_{mx})
\end{aligned}$$

The average revenues of surviving firms is

$$\begin{aligned}
\tilde{r}' =& \int_{z_e}^{z_{mx}} r_u^d(z)\frac{g(z)}{1-G(z_e)}dz + \int_{z_{mx}}^{z_{ox}} r_u^{mx}(z)\frac{g(z)}{1-G(z_e)}dz + \int_{z_{ox}}^{z_{ms}} r_u^{ox}(z)\frac{g(z)}{1-G(z_e)}dz \\
&+ \int_{z_{ms}}^{z_{os}} r_s^{ms}(z)\frac{g(z)}{1-G(z_e)}dz + \int_{z_{os}}^{\infty} r_s^{os}(z)\frac{g(z)}{1-G(z_e)}dz \\
=& \int_{z_e}^{\infty} r_u^d(z)\frac{g(z)}{1-G(z_e)}dz \\
&+ \tau_m^{1-\theta}\int_{z_{mx}}^{\infty} r_u^d(z)\frac{g(z)}{1-G(z_e)}dz \\
&+ ((1+\tau_o^{1-\theta})\gamma_u^{\theta-1} - 1 - \tau_m^{1-\theta})\int_{z_{ox}}^{\infty} r_u^d(z)\frac{g(z)}{1-G(z_e)}dz \\
&+ \left[(1+\tau_m^{1-\theta})\lambda_m^{\theta-1}\left(\frac{\rho_2}{\rho_1}\right)^{\theta-\rho} - (1+\tau_o^{1-\theta})\gamma_u^{\theta-1}\right]\int_{z_{ms}}^{\infty} r_u^d(z)\frac{g(z)}{1-G(z_e)}dz \\
&+ \left[\lambda_o^{\theta-1}(1+\tau_o^{1-\theta})\left(\frac{\rho_2}{\rho_1}\right)^{\theta-\rho} - \lambda_m^{\theta-1}(1+\tau_m^{1-\theta})\left(\frac{\rho_2}{\rho_1}\right)^{\theta-\rho}\right]\int_{z_{os}}^{\infty} r_u^d(z)\frac{g(z)}{1-G(z_e)}dz
\end{aligned}$$

We derive that z_{mx}, z_{ox}, z_{ms} and z_{ox} can be a function of $z_e^{'}$, so

$$\begin{aligned}\tilde{r}^{'} =&\theta f_u \left(\frac{\tilde{z}_e^{'}}{z_e^{'}}\right)^{\theta-1} + n_{mx}\theta f_{mx}\left(\frac{\tilde{z}_{mx}}{z_{mx}}\right)^{\theta-1} + n_{ox}\theta(f_{ox}-f_{mx})\left(\frac{\tilde{z}_{ox}}{z_{ox}}\right)^{\theta-1}\\ &+ n_{ms}\theta(f_u(\phi_m-1)+f_{mx}-f_{ox})\left(\frac{\tilde{z}_{ms}}{z_{ms}}\right)^{\theta-1}\\ &+ n_{os}\theta(f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u)\left(\frac{\tilde{z}_{os}}{z_{os}}\right)^{\theta-1}\end{aligned}$$

Given $\left(\frac{\tilde{z}_j}{z_j}\right)^{\theta-1} = \frac{\kappa}{\kappa-(\theta-1)}$ and the free entry condition, we get

$$z_e^{'} = \left(\frac{\theta-1}{\kappa-(\theta-1)}\frac{1}{\delta f_e}\Psi\right)^{1/\kappa}$$

$$\begin{aligned}\Psi^{\kappa} =&f_u + n_{mx}f_{mx} + n_{ox}(f_{ox}-f_{mx})\\ &+ n_{ms}(f_u(\phi_m-1)+f_{mx}-f_{ox}) + n_{os}(f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u)\\ =&f_u + f_{mx}\tau_m^{-\kappa}\left(\frac{f_{mx}}{f_u}\right)^{\frac{-\kappa}{\theta-1}} + (f_{ox}-f_{mx})\left(\frac{f_{ox}-f_{mx}}{((1+\tau_o^{1-\theta})\gamma_u^{\theta-1}-1-\tau_m^{1-\theta})f_u}\right)^{\frac{-\kappa}{\theta-1}}\\ &+ (f_u(\phi_m-1)+f_{mx}-f_{ox})\\ &\times\left[\frac{((\phi_m-1)f_u+f_{mx}-f_{ox}}{((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-(1+\tau_o^{1-\theta})\gamma_u^{\theta-1})f_u}\right]^{\frac{-\kappa}{\theta-1}}\\ &+ (f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u)\\ &\times\left[\frac{f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u}{(\lambda_o^{\theta-1}(1+\tau_o^{1-\theta})-\lambda_m^{\theta-1}(1+\tau_m^{1-\theta}))(\rho_2/\rho_1)^{\theta-\rho}f_u}\right]^{\frac{-\kappa}{\theta-1}}\\ =&f_u + f_{mx}\tau_m^{-\kappa}\left(\frac{f_{mx}}{f_u}\right)^{\frac{-\kappa}{\theta-1}} + (f_{ox}-f_{mx})^{\frac{-\kappa}{\theta-1}}A + (f_u(\phi_m-1)+f_{mx}-f_{ox})B^{\frac{-\kappa}{\theta-1}}\\ &+ (f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u)C^{\frac{-\kappa}{\theta-1}}\end{aligned}$$

where $A \equiv (1+\tau_o^{1-\theta})\gamma_u^{\theta-1}-1-\tau_m^{1-\theta}$, $B \equiv \frac{((\phi_m-1)f_u+f_{mx}-f_{ox}}{((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-(1+\tau_o^{1-\theta})\gamma_u^{\theta-1})f_u}$ and $C \equiv \frac{f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u}{(\lambda_o^{\theta-1}(1+\tau_o^{1-\theta})-\lambda_m^{\theta-1}(1+\tau_m^{1-\theta}))(\rho_2/\rho_1)^{\theta-\rho}f_u}$.

Changes in Trade Costs to Country m

Average Profit:

Given $\tilde{\pi}' = \frac{\theta-1}{\kappa-(\theta-1)}\Psi^\kappa$, $\frac{\partial\tilde{\pi}'}{\partial\tau_m} = \frac{\theta-1}{\kappa-(\theta-1)}\frac{\partial\Psi^\kappa}{\partial\tau_m}$.

$$\frac{\partial\Psi^\kappa}{\partial\tau_m} = -\kappa f_{mx}\left(\frac{f_{mx}}{f_u}\right)^{\frac{-\kappa}{\theta-1}}\tau_m^{-\kappa-1} + \kappa A^{\frac{\theta-1-\kappa}{\theta-1}} f_u\tau_m^{-\theta} - \kappa B^{\frac{\theta-1-\kappa}{\theta-1}} f_u\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}\tau_m^{-\theta} + \kappa C^{\frac{\theta-1-\kappa}{\theta-1}} f_u\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}\tau_m^{-\theta}$$

Since $f_{mx} > f_u$, $\left(\frac{f_{mx}}{f_u}\right)^{\frac{-\kappa}{\theta-1}}\tau_m^{-\kappa} > A$, $\tau_m^{-1} > \tau_m^{-\theta}$ and $B > C$, $\frac{\partial\Psi^\kappa}{\partial\tau_m} < 0$. Thus, $\frac{\partial\tilde{\pi}'}{\partial\tau_m} < 0$.

Exit productivity cutoff:

$$z_e' = \left(\frac{\theta-1}{\kappa-(\theta-1)}\frac{1}{\delta f_e}\Psi\right)^{1/\kappa}$$

Thus, $\frac{\partial z_e'}{\partial\tau_m} < 0$

Export Productivity Cutoff, Country m:

$$z_{mx} = \left(\frac{\theta-1}{\kappa-(\theta-1)}\frac{1}{\delta f_e}\right)^{1/\kappa}\left[\frac{1}{n_{mx}}f_u + f_{mx} + \frac{n_{ox}}{n_{mx}}(f_{ox}-f_{mx}) + \frac{n_{ms}}{n_{mx}}(f_u(\phi_m-1) + f_{mx} - f_{ox}) + \frac{n_{os}}{n_{mx}}(f_{ox} - f_{mx} + (\phi_o-\phi_m)f_u)\right]$$

Proof:

(1)

$$\frac{1}{n_{mx}} = \left(\frac{z_{mx}}{z_e'}\right)^\kappa = \left(\tau_m\left(\frac{f_{mx}}{f_u}\right)^{\frac{1}{\theta-1}}\right)^\kappa$$

When τ_m falls, $\frac{1}{n_{mx}}$ goes down.

(2)

$$\frac{n_{ox}}{n_{mx}} = \left(\frac{z_{mx}}{z_{ox}}\right)^\kappa = \left(\frac{f_{mx}}{f_{ox}-f_{mx}}\right)^{\frac{\kappa}{\theta-1}}\left[\tau_m^{\theta-1}(\gamma_u^{\theta-1}(1+\tau_o^{1-\theta}) - \tau_m^{1-\theta} - 1)\right]^{\frac{\kappa}{\theta-1}}$$

Let $D \equiv \tau_m^{\theta-1}(\gamma_u^{\theta-1}(1+\tau_o^{1-\theta}) - \tau_m^{1-\theta} - 1)$

$$\frac{\partial\frac{n_{ox}}{n_{mx}}}{\partial\tau_m} = \left(\frac{f_{mx}}{f_{ox}-f_{mx}}\right)^{\frac{\kappa}{\theta-1}}\kappa D^{\frac{\kappa}{\theta-1}-1}\tau_m\theta\left(\gamma_u^{\theta-1}(1+\tau_o^{1-\theta}) - 1\right) > 0$$

Since $\gamma_u^{\theta-1}(1+\tau_o^{1-\theta}) > 1$, $\frac{n_{ox}}{n_{mx}}$ falls when τ_m drops.

(3)

$$\begin{aligned}
\frac{n_{ms}}{n_{mx}} &= \left(\frac{z_{mx}}{z_{ms}}\right)^{\kappa} \\
&= \left(\frac{f_{mx}}{(\phi_m - 1)f_u + f_{mx} - f_{ox}}\right)^{\frac{\kappa}{\theta-1}} \times \\
&\quad \left[\tau_m^{\theta-1}((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - (1+\tau_o^{1-\theta})\gamma_u^{\theta-1})\right]^{\frac{\kappa}{\theta-1}} \\
&= \left(\frac{f_{mx}}{(\phi_m - 1)f_u + f_{mx} - f_{ox}}\right)^{\frac{\kappa}{\theta-1}} \times \\
&\quad \left[\frac{1+\tau_m^{1-\theta}}{\tau_m^{1-\theta}}\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - \frac{1+\tau_o^{1-\theta}}{\tau_m^{1-\theta}}\gamma_u^{\theta-1}\right]^{\frac{\kappa}{\theta-1}}
\end{aligned}$$

When τ_m falls, $\tau_m^{1-\theta}$ increases, $\frac{1+\tau_m^{1-\theta}}{\tau_m^{1-\theta}}$ decreases and λ_m also decreases. Thus, $\frac{n_{ms}}{n_{mx}}$ falls.

(4)

$$\begin{aligned}
\frac{n_{os}}{n_{mx}} &= \left(\frac{z_{mx}}{z_{os}}\right)^{\kappa} \\
&= \left(\frac{f_{mx}}{f_{ox} - f_{mx} + (\phi_o - \phi_m)f_u}\right)^{\frac{\kappa}{\theta-1}} \times \\
&\quad \left[(\tau_m^{\theta-1}(\lambda_o^{\theta-1} - \lambda_m^{\theta-1}) + \tau_m^{\theta-1}\lambda_o^{\theta-1}\tau_o^{\theta-1} - \lambda_m^{\theta-1})(\rho_2/\rho_1)^{\theta-\rho}\right]^{\frac{\kappa}{\theta-1}}
\end{aligned}$$

Since $(\lambda_o^{\theta-1} - \lambda_m^{\theta-1}) > 0$, $\frac{n_{os}}{n_{mx}}$ decreases with a lower τ_m.

Therefore,

- $\tau_m \downarrow \Rightarrow \frac{1}{n_{mx}} \downarrow$
- $\tau_m \downarrow \Rightarrow \frac{n_{ox}}{n_{mx}} \downarrow$
- $\tau_m \downarrow \Rightarrow \frac{n_{ms}}{n_{mx}} \downarrow$
- $\tau_m \downarrow \Rightarrow \frac{n_{os}}{n_{mx}} \downarrow$,

We show that $\frac{\partial z_{mx}}{\partial \tau_m} > 0$.

Skill Upgrading Productivity Cutoff, Country m

$$z_{ms} = \left(\frac{\theta-1}{\kappa-(\theta-1)}\frac{1}{\delta f_e}\right)^{1/\kappa}\left[\frac{1}{n_{ms}}f_u + \frac{n_{mx}}{n_{ms}}f_{mx} + \frac{n_{ox}}{n_{ms}}(f_{ox}-f_{mx}) + (f_u(\phi_m - 1)\right.$$
$$\left. + f_{mx} - f_{ox}) + \frac{n_{os}}{n_{ms}}(f_{ox} - f_{mx} + (\phi_o - \phi_m)f_u)\right]$$

Proof:

(1)

$$\frac{1}{n_{ms}} = \left(\frac{z_{ms}}{z_e}\right)^{\kappa}$$
$$= \left[\frac{(\phi_m - 1)f_u + f_{mx} - f_{ox}}{((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - (1+\tau_o^{1-\theta})\gamma_u)f_u}\right]^{\frac{\kappa}{\theta-1}}$$

Since $\theta > 1$ and $\kappa > \theta - 1$, $\frac{1}{n_{ms}}$ falls when τ_m decreases.

(2)

When τ_m falls, $\frac{n_{ms}}{n_{mx}}$ decreases; thus $\frac{n_{mx}}{n_{ms}}$ increases.

(3)

$$\frac{n_{ox}}{n_{ms}} = \left(\frac{z_{ms}}{z_{ox}}\right)^{\kappa}$$
$$= \left[\frac{(\phi_m - 1)f_u + f_{mx} - f_{ox}}{f_{ox} - f_{mx}}\frac{((1+\tau_o^{1-\theta})\gamma_u^{\theta-1} - \tau_m^{1-\theta} - 1)}{((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - (1+\tau_o^{1-\theta})\gamma_u)}\right]^{\frac{\kappa}{\theta-1}}$$

Since $\tau_m \downarrow \Rightarrow \tau_m^{1-\theta} \uparrow$, $\frac{n_{ox}}{n_{ms}}$ falls with a lower τ_m.

(4)

$$\frac{n_{os}}{n_{ms}} = \left(\frac{z_{ms}}{z_{os}}\right)^{\kappa}$$
$$= \left[\frac{(\phi_m - 1)f_u + f_{mx} - f_{ox}}{f_{ox} - f_{mx} + (\phi_o - \phi_m)f_u}\frac{(\lambda_o^{\theta-1}(1+\tau_o^{1-\theta}) - \lambda_m^{\theta-1}(1+\tau_m^{1-\theta}))(\rho_2/\rho_1)^{\theta-\rho}}{((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - (1+\tau_o^{1-\theta})\gamma_u)}\right]^{\frac{\kappa}{\theta-1}}$$

Since $\tau_m \downarrow \Rightarrow \tau_m^{1-\theta} \uparrow$, $\frac{n_{os}}{n_{ms}}$ falls with a lower τ_m.

Therefore,

- $\tau_m \downarrow \Rightarrow \frac{1}{n_{ms}} \downarrow$
- $\tau_m \downarrow \Rightarrow \frac{n_{mx}}{n_{ms}} \uparrow$
- $\tau_m \downarrow \Rightarrow \frac{n_{ox}}{n_{ms}} \downarrow$
- $\tau_m \downarrow \Rightarrow \frac{n_{os}}{n_{ms}} \downarrow$,

We can get $\frac{\partial z_{ms}}{\partial \tau_m} > 0$ when the second effect $\frac{n_{mx}}{n_{ms}}$ is dominated by the other three effects.

Changes in Trade Costs to Country o

Average Profit:

Given $\tilde{\pi}' = \frac{\theta-1}{\kappa-(\theta-1)}\Psi^\kappa$, $\frac{\partial \tilde{\pi}'}{\partial \tau_o} = \frac{\theta-1}{\kappa-(\theta-1)}\frac{\partial \Psi^\kappa}{\partial \tau_o}$.

$$\frac{\partial \Psi^\kappa}{\partial \tau_o} = -\kappa A^{\frac{\theta-1-\kappa}{\theta-1}} f_u \gamma_u^{\theta-1} \tau_o^{-\theta} + \kappa B^{\frac{\theta-1-\kappa}{\theta-1}} f_u \gamma_u^{\theta-1} \tau_o^{-\theta} - \kappa C^{\frac{\theta-1-\kappa}{\theta-1}} f_u \lambda_o^{\theta-1} (\rho_2/\rho_1)^{\theta-\rho} \tau_o^{-\theta}$$

As $A > B$, $\frac{\partial \Psi^\kappa}{\partial \tau_o} < 0$ and then, $\frac{\partial \tilde{\pi}'}{\partial \tau_o} < 0$.

Exit Productivity Cutoff:

Similarly, $\frac{\partial z_e'}{\partial \tau_o} < 0$.

Export Productivity Cutoff, Country o:

$$z_{ox} = \left(\frac{\theta-1}{\kappa-(\theta-1)}\frac{1}{\delta f_e}\right)^{1/\kappa} \left[\frac{1}{n_{ox}} f_u + \frac{n_{mx}}{n_{ox}} f_{mx} + (f_{ox} - f_{mx}) + \frac{n_{ms}}{n_{ox}}(f_u(\phi_m - 1) + f_{mx} - f_{ox}) + \frac{n_{os}}{n_{ox}}(f_{ox} - f_{mx} + (\phi_o - \phi_m) f_u)\right]$$

Proof:

(1)

$$\frac{1}{n_{ox}} = \left(\frac{z_{ox}}{z_e}\right)^\kappa = \left[\frac{f_{ox} - f_{mx}}{((1+\tau_o^{1-\theta})\gamma_u^{\theta-1} - \tau_m^{1-\theta} - 1) f_u}\right]^{\frac{\kappa}{\theta-1}}$$

Since $\theta > 1$ and $\kappa > \theta - 1$, $\frac{1}{n_{ox}}$ falls when τ_o decreases.

(2)

$$\begin{aligned}\frac{n_{mx}}{n_{ox}} &= \left(\frac{z_{ox}}{z_{mx}}\right)^{\kappa} \\ &= \left(\frac{f_{ox} - f_{mx}}{f_{mx}}\right)^{\frac{\kappa}{\theta-1}} \left[\frac{(\gamma_u^{\theta-1}(1+\tau_o^{1-\theta}) - \tau_m^{1-\theta} - 1)}{\tau_m^{\theta-1}}\right]^{\frac{\kappa}{\theta-1}}\end{aligned}$$

Since $\tau_o \downarrow \Rightarrow \tau_o^{1-\theta} \uparrow$, $\frac{n_{mx}}{n_{ox}}$ increases with a lower τ_o.

(3)

$$\begin{aligned}\frac{n_{ms}}{n_{ox}} &= \left(\frac{z_{ox}}{z_{ms}}\right)^{\kappa} \\ &= \left[\frac{f_{ox} - f_{mx}}{(\phi_m - 1)f_u + f_{mx} - f_{ox}} \frac{((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - (1+\tau_o^{1-\theta})\gamma_u)}{((1+\tau_o^{1-\theta})\gamma_u^{\theta-1} - \tau_m^{1-\theta} - 1)}\right]^{\frac{\kappa}{\theta-1}}\end{aligned}$$

Since $\tau_o \downarrow \Rightarrow \tau_o^{1-\theta} \uparrow$, $\frac{n_{ms}}{n_{ox}}$ falls with a lower τ_o.

(4)

$$\begin{aligned}\frac{n_{os}}{n_{ox}} &= \left(\frac{z_{ox}}{z_{os}}\right)^{\kappa} \\ &= \left[\frac{f_{ox} - f_{mx}}{f_{ox} - f_{mx} + (\phi_o - \phi_m)f_u} \frac{(\lambda_o^{\theta-1}(1+\tau_o^{1-\theta}) - \lambda_m^{\theta-1}(1+\tau_m^{1-\theta}))(\rho_2/\rho_1)^{\theta-\rho}}{((1+\tau_o^{1-\theta})\gamma_u^{\theta-1} - \tau_m^{1-\theta} - 1)}\right]^{\frac{\kappa}{\theta-1}}\end{aligned}$$

Let $E \equiv (\lambda_o^{\theta-1}(1+\tau_o^{1-\theta}) - \lambda_m^{\theta-1}(1+\tau_m^{1-\theta}))(\rho_2/\rho_1)^{\theta-\rho}$ and $F \equiv ((1+\tau_o^{1-\theta})\gamma_u^{\theta-1} - \tau_m^{1-\theta} - 1)$.

$$\frac{\partial \frac{n_{os}}{n_{ox}}}{\tau_o} = \left[\frac{f_{ox} - f_{mx}}{f_{ox} - f_{mx} + (\phi_o - \phi_m)f_u}\right]^{\frac{\kappa}{\theta-1}} \kappa \frac{-\lambda_o^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}\tau_o^{-\theta}F - \gamma_u^{\theta-1}\tau_o^{-\theta}E}{F^2}$$

Since $-\lambda_o^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}\tau_o^{-\theta}F - \gamma_u^{\theta-1}\tau_o^{-\theta}E < 0$ and other terms are positive, $\frac{\partial \frac{n_{os}}{n_{ox}}}{\tau_o} < 0$.

Hence,

- $\tau_o \downarrow \Rightarrow \frac{1}{n_{ox}} \downarrow$
- $\tau_o \downarrow \Rightarrow \frac{n_{mx}}{n_{ox}} \uparrow$

- $\tau_o \downarrow \Rightarrow \frac{n_{ms}}{n_{ox}} \downarrow$

- $\tau_o \downarrow \Rightarrow \frac{n_{os}}{n_{ox}} \uparrow$,

$\frac{\partial z_{ox}}{\partial \tau_o} > 0$ if and only if the total effects of τ_o on $\frac{1}{n_{ox}}$ and $\frac{n_{ms}}{n_{ox}}$ dominate the other two effects.

Skill Upgrading Productivity Cutoff, Country o:

$$z_{os} = \left(\frac{\theta-1}{\kappa-(\theta-1)}\frac{1}{\delta f_e}\right)^{1/\kappa}\left[\frac{1}{n_{os}}f_u + \frac{n_{mx}}{n_{os}}f_{mx} + \frac{n_{ox}}{n_{os}}(f_{ox}-f_{mx}) + \frac{n_{ms}}{n_{os}}(f_u(\phi_m-1)+f_{mx}-f_{ox}) + (f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u)\right]$$

Proof:

(1)

$$\frac{1}{n_{os}} = \left(\frac{z_{os}}{z_e}\right)^{\kappa} = \left[\frac{f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u}{(\lambda_o^{\theta-1}(1+\tau_o^{1-\theta})-\lambda_m^{\theta-1}(1+\tau_m^{1-\theta}))(\rho_2/\rho_1)^{\theta-\rho}f_u}\right]^{\frac{\kappa}{\theta-1}}$$

Since $\tau_o \downarrow \Rightarrow \tau_o^{1-\theta} \uparrow$, $\frac{1}{n_{os}}$ falls with a lower τ_o.

(2)

$$\frac{n_{mx}}{n_{os}} = \left(\frac{z_{os}}{z_{mx}}\right)^{\kappa} = \left[\frac{f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u}{f_{mx}}\frac{\tau_m^{1-\theta}}{(\lambda_o^{\theta-1}(1+\tau_o^{1-\theta})-\lambda_m^{\theta-1}(1+\tau_m^{1-\theta}))(\rho_2/\rho_1)^{\theta-\rho}f_u}\right]^{\frac{\kappa}{\theta-1}}$$

Since $\tau_o \downarrow \Rightarrow \tau_o^{1-\theta} \uparrow$, $\frac{n_{mx}}{n_{os}}$ falls with a lower τ_o.

(3)

As $\frac{\partial \frac{n_{os}}{n_{ox}}}{\tau_o} < 0$, $\frac{n_{ox}}{n_{os}}$ decreases if τ falls.

(4)

$$\frac{n_{ms}}{n_{os}} = \left(\frac{z_{os}}{z_{ms}}\right)^{\kappa} = \left[\frac{f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u}{(\phi_m-1)f_u+f_{mx}-f_{ox}}\frac{((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho}-(1+\tau_o^{1-\theta})\gamma_u)}{(\lambda_o^{\theta-1}(1+\tau_o^{1-\theta})-\lambda_m^{\theta-1}(1+\tau_m^{1-\theta}))(\rho_2/\rho_1)^{\theta-\rho}f_u}\right]^{\frac{\kappa}{\theta-1}}$$

Since $\tau_o \downarrow \Rightarrow \tau_o^{1-\theta} \uparrow$, $\frac{n_{ms}}{n_{os}}$ falls with a lower τ_o.

Hence,

- $\tau_o \downarrow \Rightarrow \frac{1}{n_{os}} \downarrow$
- $\tau_o \downarrow \Rightarrow \frac{n_{mx}}{n_{os}} \downarrow$
- $\tau_o \downarrow \Rightarrow \frac{n_{ox}}{n_{os}} \downarrow$
- $\tau_o \downarrow \Rightarrow \frac{n_{ms}}{n_{os}} \downarrow$,

We prove that $\frac{\partial z_{os}}{\partial \tau_o} > 0$.

Export Productivity Cutoff, Country m:

$$z_{mx} = \left(\frac{\theta-1}{\kappa-(\theta-1)}\frac{1}{\delta f_e}\right)^{1/\kappa}\left[\frac{1}{n_{mx}}f_u + f_{mx} + \frac{n_{ox}}{n_{mx}}(f_{ox}-f_{mx}) + \frac{n_{ms}}{n_{mx}}(f_u(\phi_m-1) + f_{mx} - f_{ox}) + \frac{n_{os}}{n_{mx}}(f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u)\right]$$

Proof:

(1)

$$\frac{1}{n_{mx}} = \left(\frac{z_{mx}}{z_e'}\right)^{\kappa} = \left(\tau_m\left(\frac{f_{mx}}{f_u}\right)^{\frac{1}{\theta-1}}\right)^{\kappa}$$

τ_o has no effects on $\frac{1}{n_{mx}}$.

(2)

$$\frac{n_{ox}}{n_{mx}} = \left(\frac{z_{mx}}{z_{ox}}\right)^{\kappa} = \left(\frac{f_{mx}}{f_{ox}-f_{mx}}\right)^{\frac{\kappa}{\theta-1}}\left[\tau_m^{\theta-1}(\gamma_u^{\theta-1}(1+\tau_o^{1-\theta}) - \tau_m^{1-\theta} - 1)\right]^{\frac{\kappa}{\theta-1}}$$

When τ_o falls, $\tau_0^{1-\theta}$ increases and $\frac{n_{ox}}{n_{mx}}$ goes up.

(3)

$$\begin{aligned}
\frac{n_{ms}}{n_{mx}} &= \left(\frac{z_{mx}}{z_{ms}}\right)^{\kappa} \\
&= \left(\frac{f_{mx}}{(\phi_m - 1)f_u + f_{mx} - f_{ox}}\right)^{\frac{\kappa}{\theta-1}} \times \\
&\quad \left[\tau_m^{\theta-1}((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - (1+\tau_o^{1-\theta})\gamma_u^{\theta-1})\right]^{\frac{\kappa}{\theta-1}} \\
&= \left(\frac{f_{mx}}{(\phi_m - 1)f_u + f_{mx} - f_{ox}}\right)^{\frac{\kappa}{\theta-1}} \times \\
&\quad \left[\frac{1+\tau_m^{1-\theta}}{\tau_m^{1-\theta}}\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - \frac{1+\tau_o^{1-\theta}}{\tau_m^{1-\theta}}\gamma_u^{\theta-1}\right]^{\frac{\kappa}{\theta-1}}
\end{aligned}$$

When τ_o falls, $\tau_o^{1-\theta}$ increases; thus $\frac{n_{ms}}{n_{mx}}$ falls.

(4)

$$\begin{aligned}
\frac{n_{os}}{n_{mx}} &= \left(\frac{z_{mx}}{z_{os}}\right)^{\kappa} \\
&= \left(\frac{f_{mx}}{f_{ox} - f_{mx} + (\phi_o - \phi_m)f_u}\right)^{\frac{\kappa}{\theta-1}} \times \\
&\quad \left[(\tau_m^{\theta-1}(\lambda_o^{\theta-1} - \lambda_m^{\theta-1}) + \tau_m^{\theta-1}\lambda_o^{\theta-1}\tau_o^{\theta-1} - \lambda_m^{\theta-1})(\rho_2/\rho_1)^{\theta-\rho}\right]^{\frac{\kappa}{\theta-1}}
\end{aligned}$$

When τ_o falls, $\tau_o^{\theta-1}$ falls and $\frac{n_{os}}{n_{mx}}$ goes down.

Therefore,

- $\tau_o \downarrow \Rightarrow \frac{n_{ox}}{n_{mx}} \uparrow$
- $\tau_o \downarrow \Rightarrow \frac{n_{ms}}{n_{mx}} \downarrow$
- $\tau_o \downarrow \Rightarrow \frac{n_{os}}{n_{mx}} \downarrow$.

A reduction in τ_o decreases z_{mx} when the impact of τ_o on $\frac{n_{ox}}{n_{mx}}$ is dominated by the other two effects.

Skill Upgrading Productivity Cutoff, Country m:

$$z_{ms} = \left(\frac{\theta-1}{\kappa-(\theta-1)}\frac{1}{\delta f_e}\right)^{1/\kappa}\left[\frac{1}{n_{ms}}f_u + \frac{n_{mx}}{n_{ms}}f_{mx} + \frac{n_{ox}}{n_{ms}}(f_{ox}-f_{mx}) + (f_u(\phi_m-1) + f_{mx} - f_{ox}) + \frac{n_{os}}{n_{ms}}(f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u)\right]$$

Proof:

(1)

$$\frac{1}{n_{ms}} = \left(\frac{z_{ms}}{z_e}\right)^{\kappa} = \left[\frac{(\phi_m-1)f_u + f_{mx} - f_{ox}}{((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - (1+\tau_o^{1-\theta})\gamma_u)f_u}\right]^{\frac{\kappa}{\theta-1}}$$

When τ_o falls, $\tau_o^{1-\theta}$ increases and $\frac{1}{n_{ms}}$ goes up.

(2)

When τ_o falls, $\frac{n_{ms}}{n_{mx}}$ decreases; thus $\frac{n_{mx}}{n_{ms}}$ increases.

(3)

$$\frac{n_{ox}}{n_{ms}} = \left(\frac{z_{ms}}{z_{ox}}\right)^{\kappa} = \left[\frac{(\phi_m-1)f_u + f_{mx} - f_{ox}}{f_{ox}-f_{mx}}\frac{((1+\tau_o^{1-\theta})\gamma_u^{\theta-1} - \tau_m^{1-\theta} - 1)}{((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - (1+\tau_o^{1-\theta})\gamma_u)}\right]^{\frac{\kappa}{\theta-1}}$$

Since $\tau_o \downarrow \Rightarrow \tau_o^{1-\theta} \uparrow$, $\frac{n_{ox}}{n_{ms}}$ increases with a lower τ_o.

(4)

$$\frac{n_{os}}{n_{ms}} = \left(\frac{z_{ms}}{z_{os}}\right)^{\kappa} = \left[\frac{(\phi_m-1)f_u + f_{mx} - f_{ox}}{f_{ox}-f_{mx}+(\phi_o-\phi_m)f_u}\frac{(\lambda_o^{\theta-1}(1+\tau_o^{1-\theta}) - \lambda_m^{\theta-1}(1+\tau_m^{1-\theta}))(\rho_2/\rho_1)^{\theta-\rho}}{((1+\tau_m^{1-\theta})\lambda_m^{\theta-1}(\rho_2/\rho_1)^{\theta-\rho} - (1+\tau_o^{1-\theta})\gamma_u)}\right]^{\frac{\kappa}{\theta-1}}$$

Since $\tau_o \downarrow \Rightarrow \tau_o^{1-\theta} \uparrow$, $\frac{n_{os}}{n_{ms}}$ rises with a lower τ_o.

Therefore,

- $\tau_o \downarrow \Rightarrow \frac{1}{n_{ms}} \uparrow$

- $\tau_o \downarrow \Rightarrow \frac{n_{mx}}{n_{ms}} \uparrow$
- $\tau_o \downarrow \Rightarrow \frac{n_{ox}}{n_{ms}} \uparrow$
- $\tau_o \downarrow \Rightarrow \frac{n_{os}}{n_{ms}} \uparrow$,

We derive that $\frac{z_{ms}}{\tau_o} < 0$.

B.3 Data Description

B.3.1 Computation of Input Tariffs

We calculated input tariffs for every 4-digit CIC industry following a methodology similar to that of Amiti and Konings (2007) and Bustos (2011b). The input tariff for each industry is calculated by taking the weighted average of the tariffs imposed on all inputs utilized. The weighting is determined by the cost proportion of each input, as illustrated by the following formula:

$$\tau_{jt}^{im} = \sum_i w_{ij} \times \tau_{it}^{im} \text{ where } w_{ij} = \frac{a_{ij}}{\sum_i a_{ij}} \tag{B.8}$$

In this context, j serves as an index for the 4-digit CIC industry for which the input tariff is being calculated; i is an index for the 4-digit CIC industry responsible for producing the input; and t functions as a time index. w_{ij} represents the cost share of each input i in the production of output j, while a_{ij} signifies the total expenditure on input i by industry j. It's important to note that these expenditure shares encompass both domestic and imported inputs. We estimated a_{ij} based on China's input-output (I-O) table in 2007. The data are aggregated at the sector level, and we use the same value for all the industries in the same sector.

B.3.2 Proxy for Initial Productivity

In this model, we consider heterogeneity as variations in labor productivity while keeping skill levels constant. However, this specific measure is not directly observable in the data. To approximate initial productivity, we employ the initial firm size in terms of employment relative to the average within the corresponding 4-digit industry.

B.3.3 Measures of Capital and Skill Intensity

The averages of capital and skill intensity within industries in the United States during the 1980s are acquired from the NBER productivity database. Capital intensity is quantified as capital per worker (i.e., real equipment and real structures), whereas skill intensity is gauged by the ratio of non-production to production workers within the industry.

B.3.4 Summary Statistics

Table B.1: Summary statistics of variables of interest in 2004

Variables	All	Exporters	Non-exporters	Observations	Firms
Employment	361.055	691.605	190.219	131,460	110,632
	[1806.685]	[2867.222]	[785.306]		
Total sales	160.362	373.104	50.412	131,460	110,632
	[1826.812]	[3061.618]	[426.793]		
Export share of sales, Exports>0		0.028		23,964	44,792
		[0.048]			
1{Export to India}, Exports>0		0.090		23,964	44,792
		[0.286]			
1{TS>0}	0.443	0.466	0.432	131,460	110,632
	[0.497]	[0.499]	[0.495]		
Total training spending	43.139	82.403	22.846	131,460	110,632
	[432.506]	[639.843]	[266.359]		
Total training spending, TS>0	97.279	176.890	52.899	58,296	48,525
	[645.421]	[928.517]	[403.346]		
Training spending per worker	111.912	117.462	109.044	131,460	110,632
	[591.856]	[561.849]	[606.766]		
Training spending per worker, TS>0	252.367	252.149	252.488	58,296	48,525
	[868.612]	[802.307]	[903.476]		
Observations	131,460	44,792	86,668		
Firms	110,632	23,964	86,668		

Standard deviations in brackets. Employment in number of workers, sales in millions of 2004 RMB yuan, total training spending in thousands of 2004 RMB yuan, and training spending per capita in 2004 RMB yuan.

Appendix C

THE EFFECTS OF GLOBALIZATION ON THE LABOR MARKET: A PANEL VAR ANALYSIS

C.1 Additional Figures

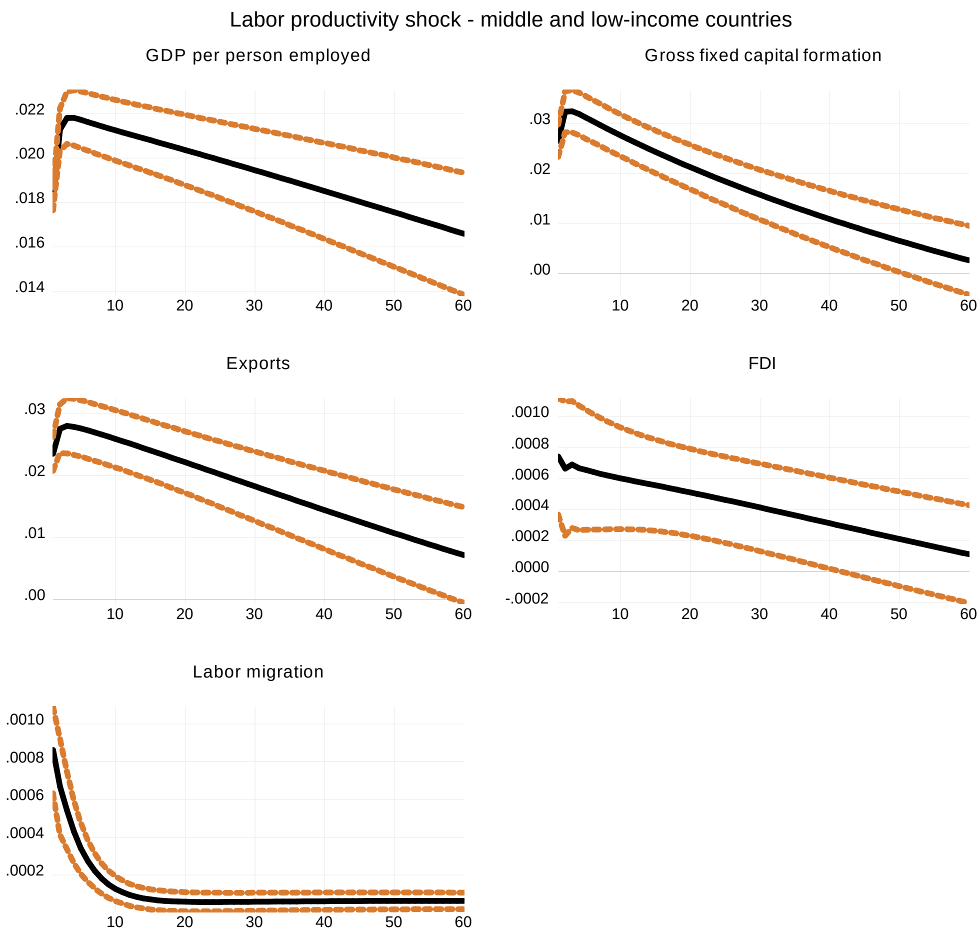

Figure C.1: Impulse response to an increase in GDP per person employed in middle and low-income countries.

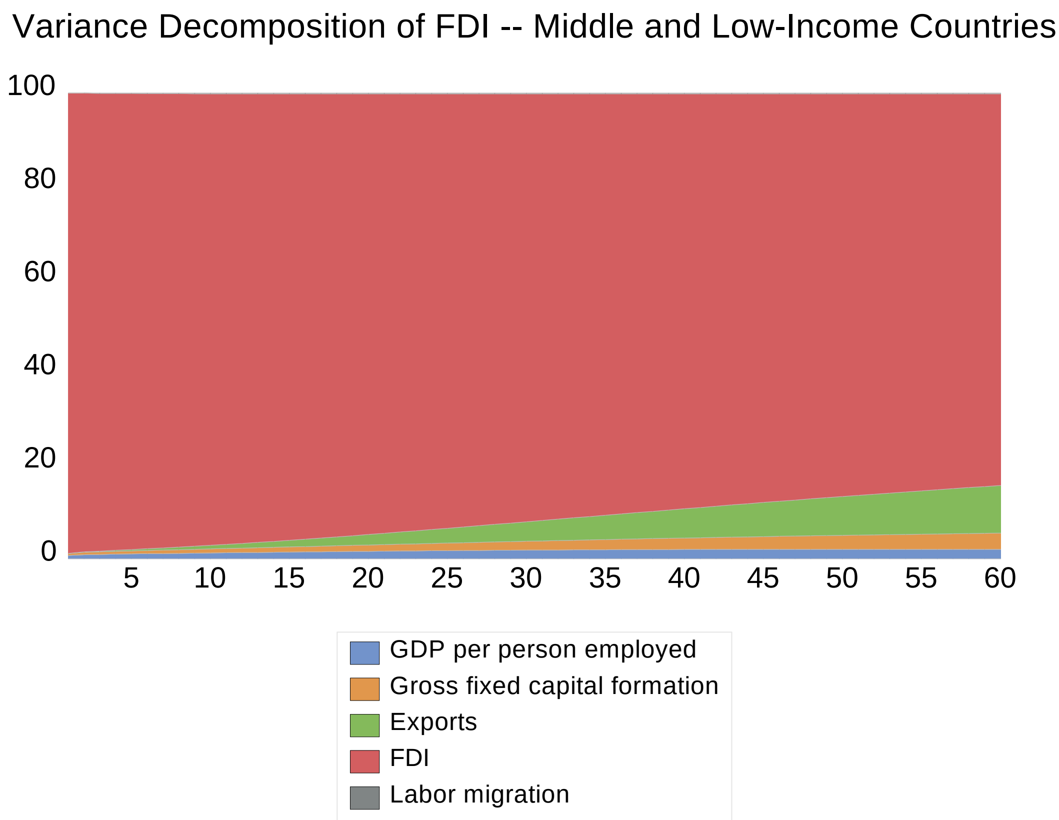

Figure C.2: Variance decomposition of FDI in middle and low-income countries

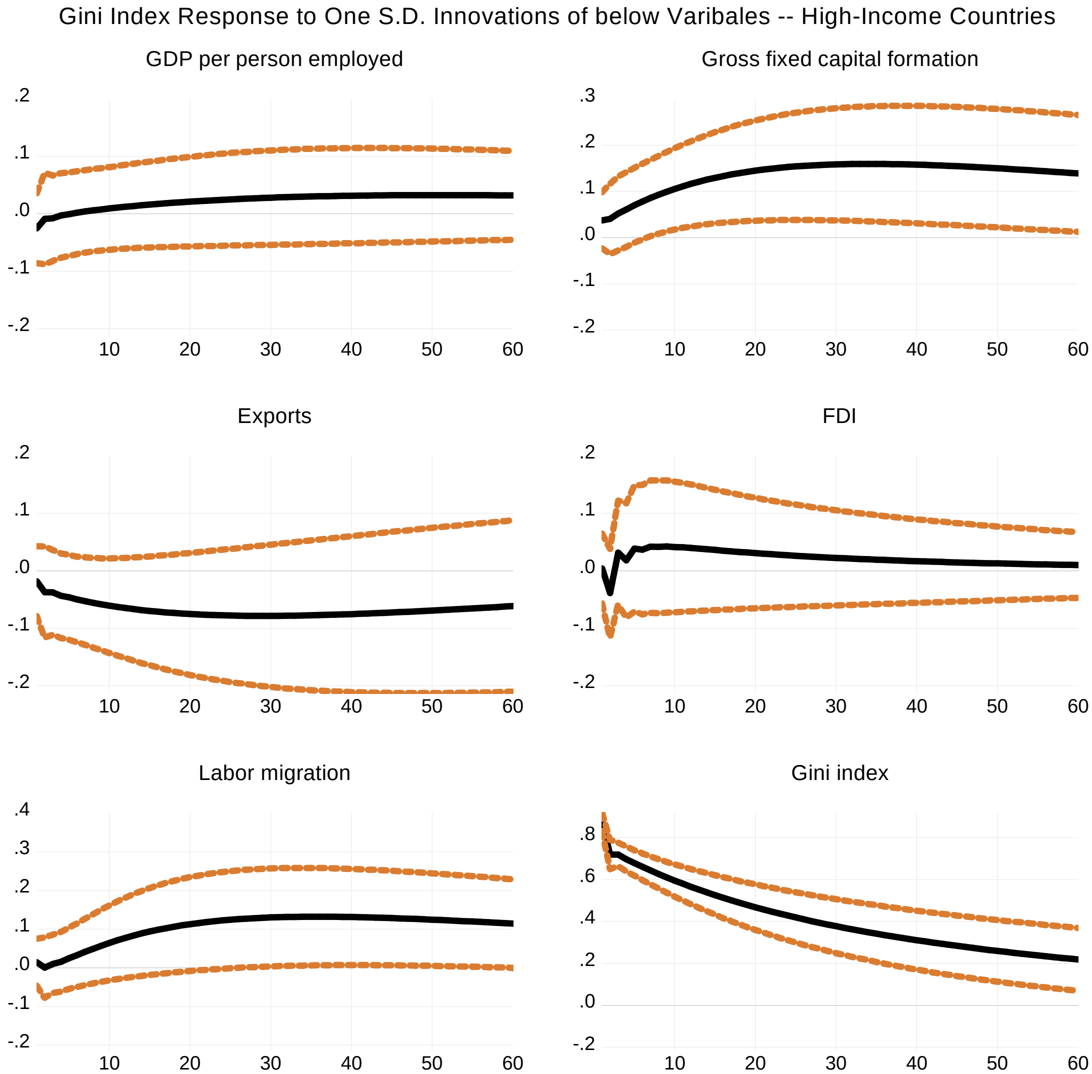

Figure C.3: Gini index response to one S.D. innovations of key variables in high-income countries

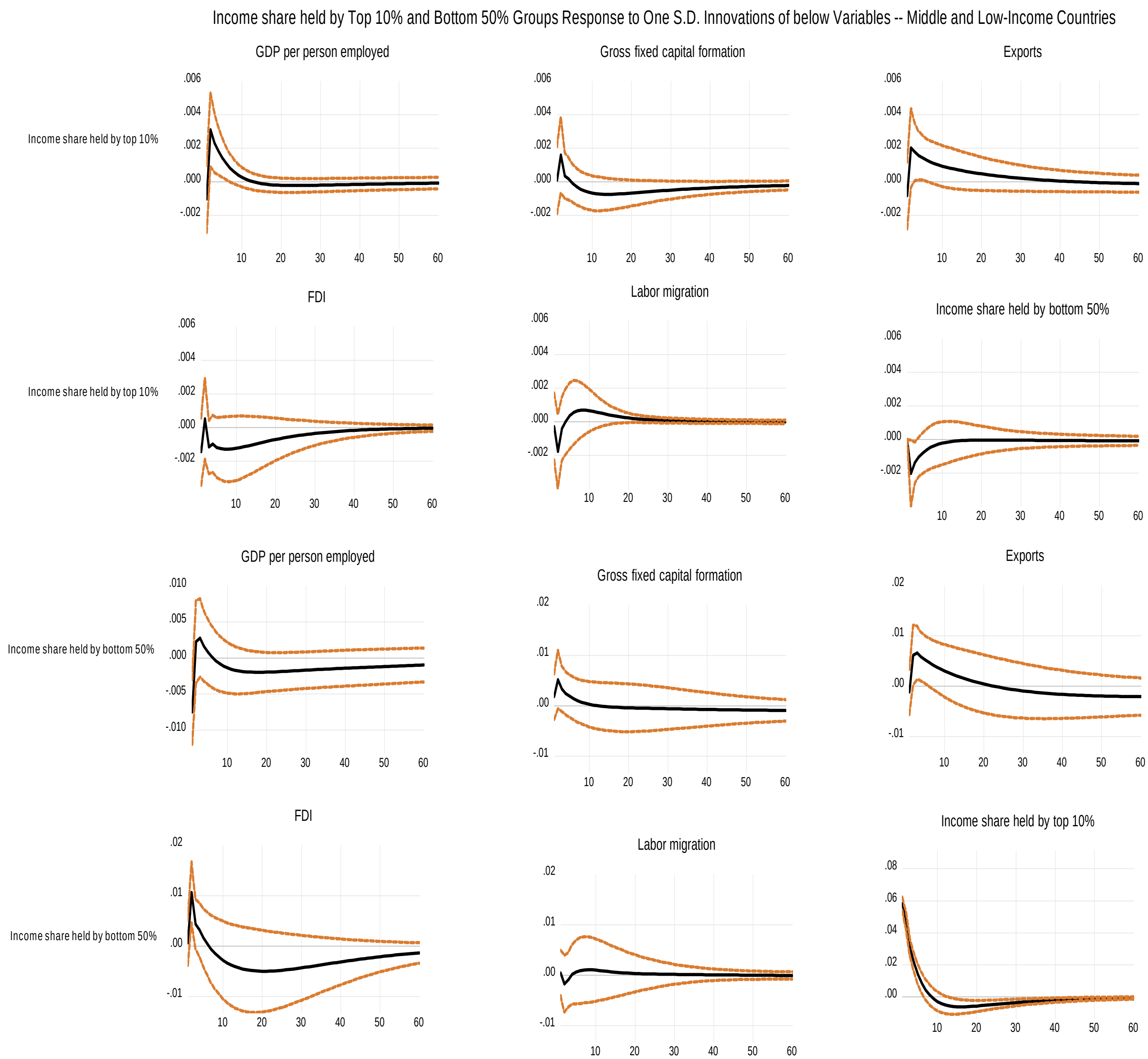

Figure C.4: Income shares response to one S.D. innovations of key variables in middle and low-income countries

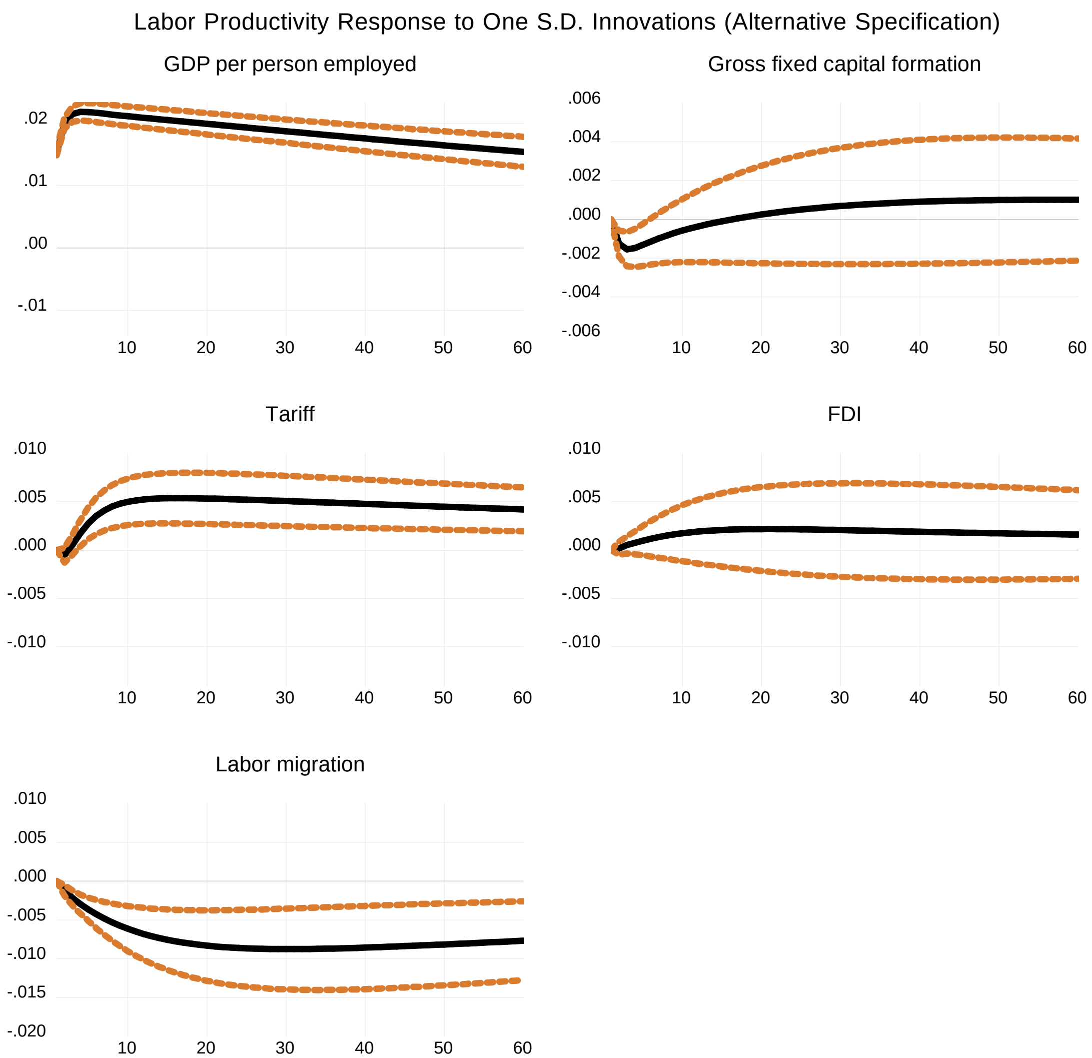

Figure C.5: Labor productivity response to one S.D. innovations of key variables under tariff specification

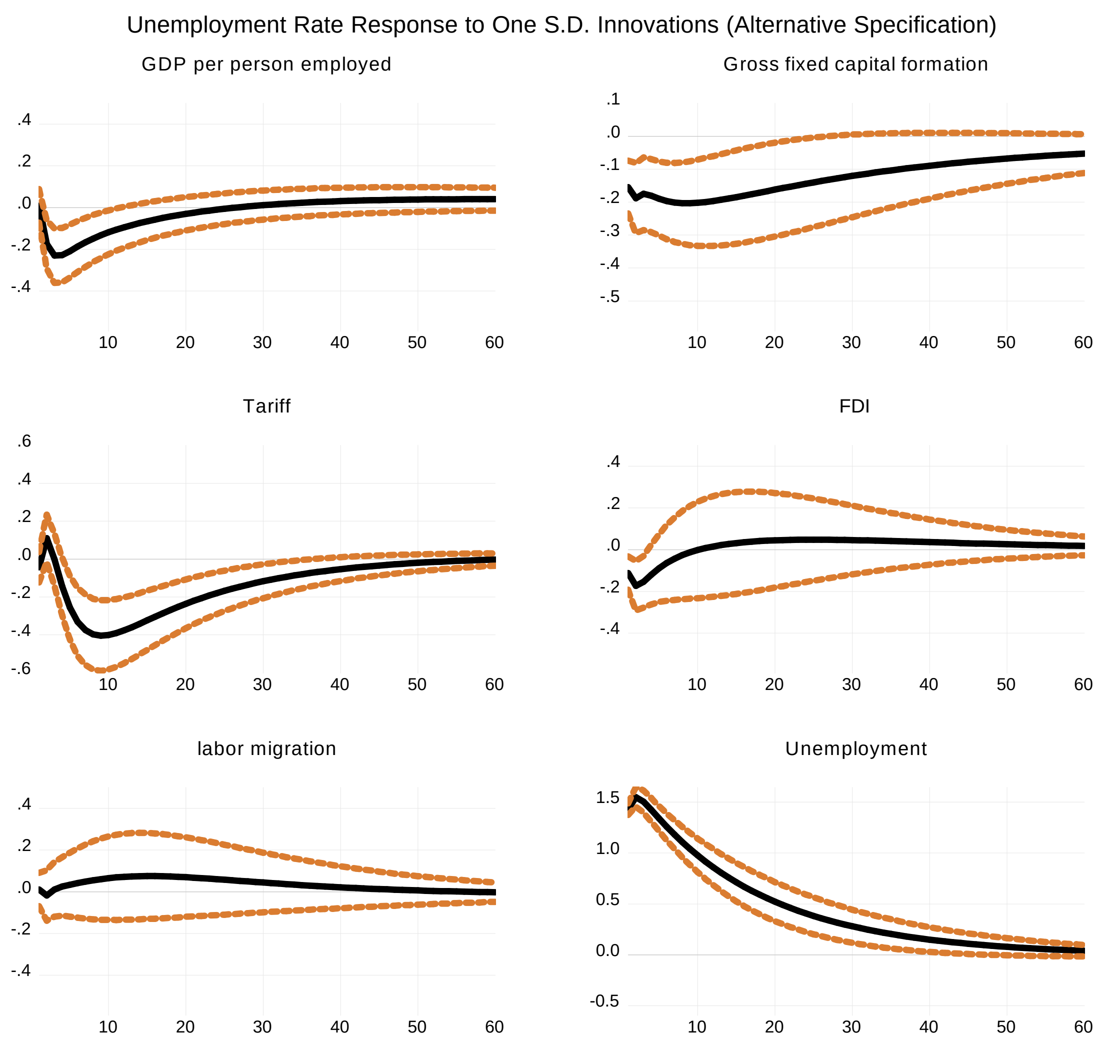

Figure C.6: Unemployment rate response to one S.D. innovations of key variables under tariff specification

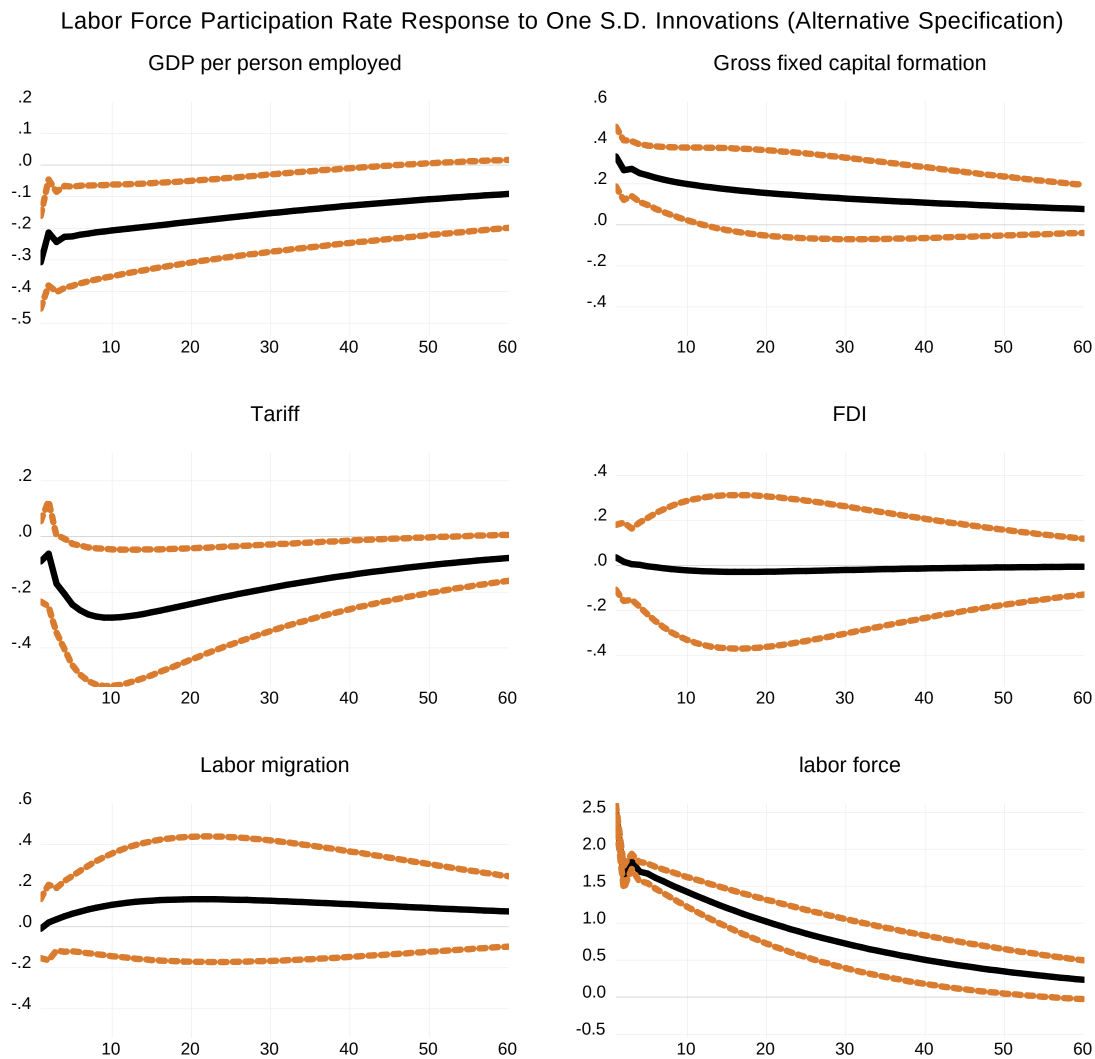

Figure C.7: Labor force participation rate response to one S.D. innovations of key variables under tariff specification

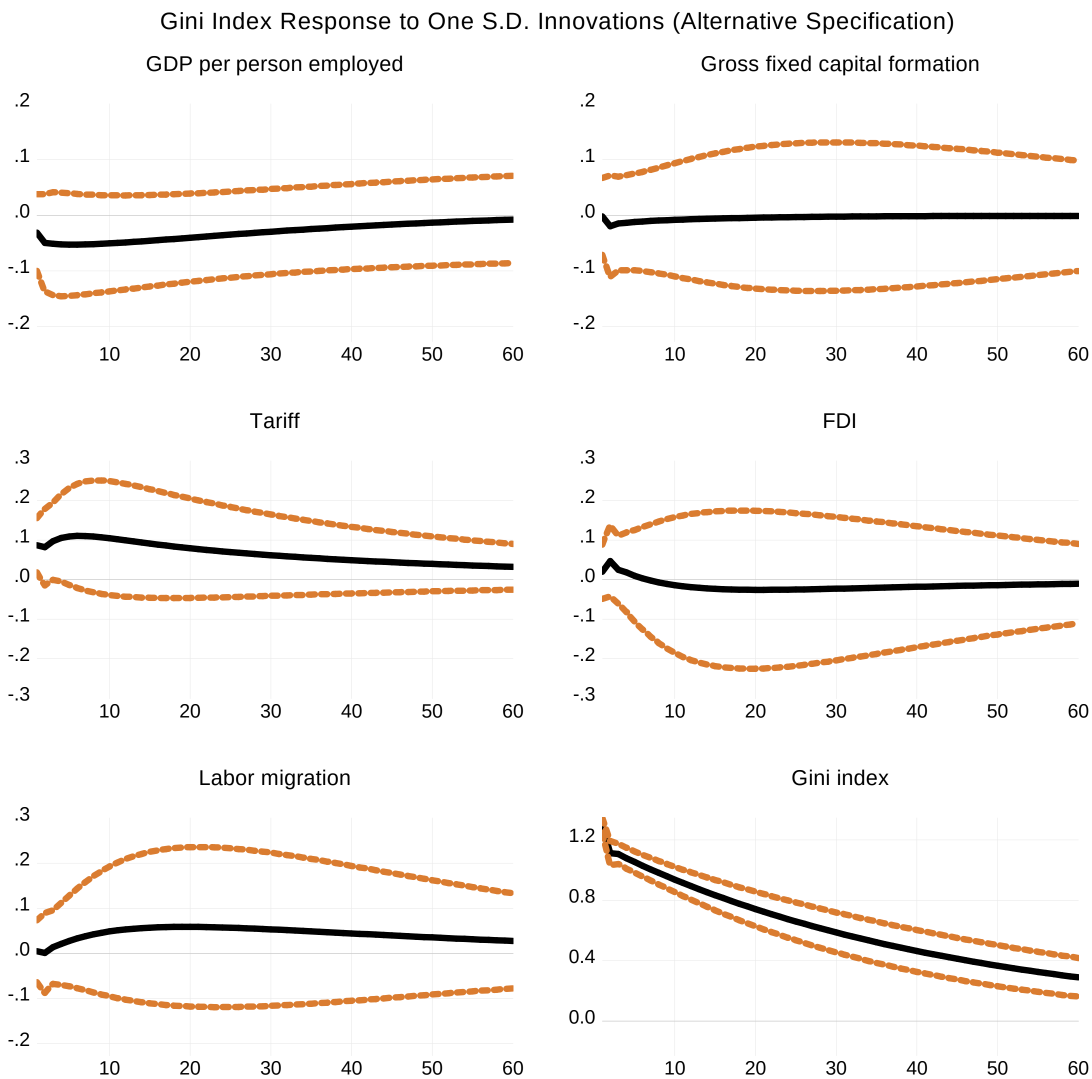

Figure C.8: Gini index response to one S.D. innovations of key variables under tariff specification

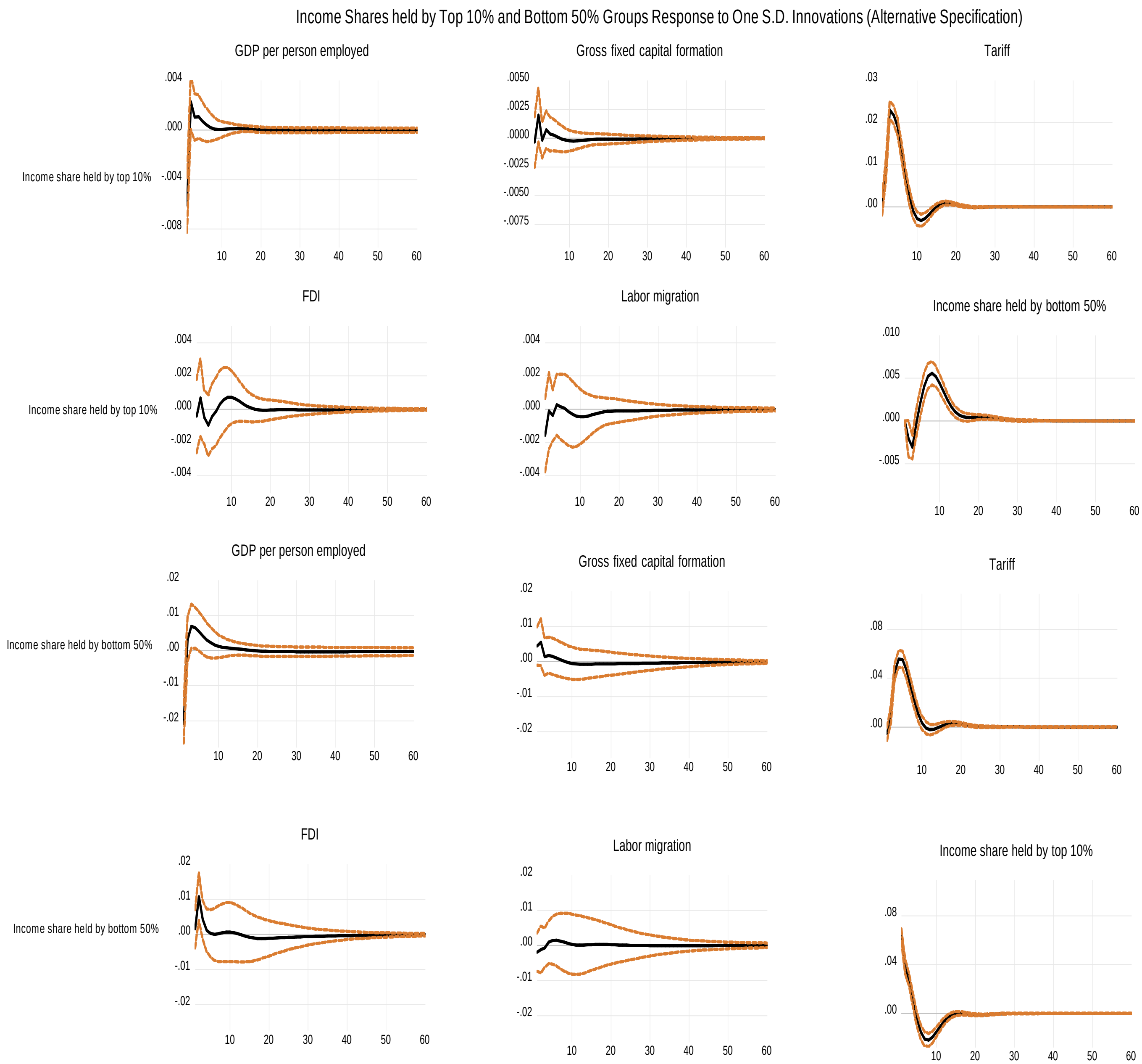

Figure C.9: Income shares response to one S.D. innovations of key variables under tariff specification

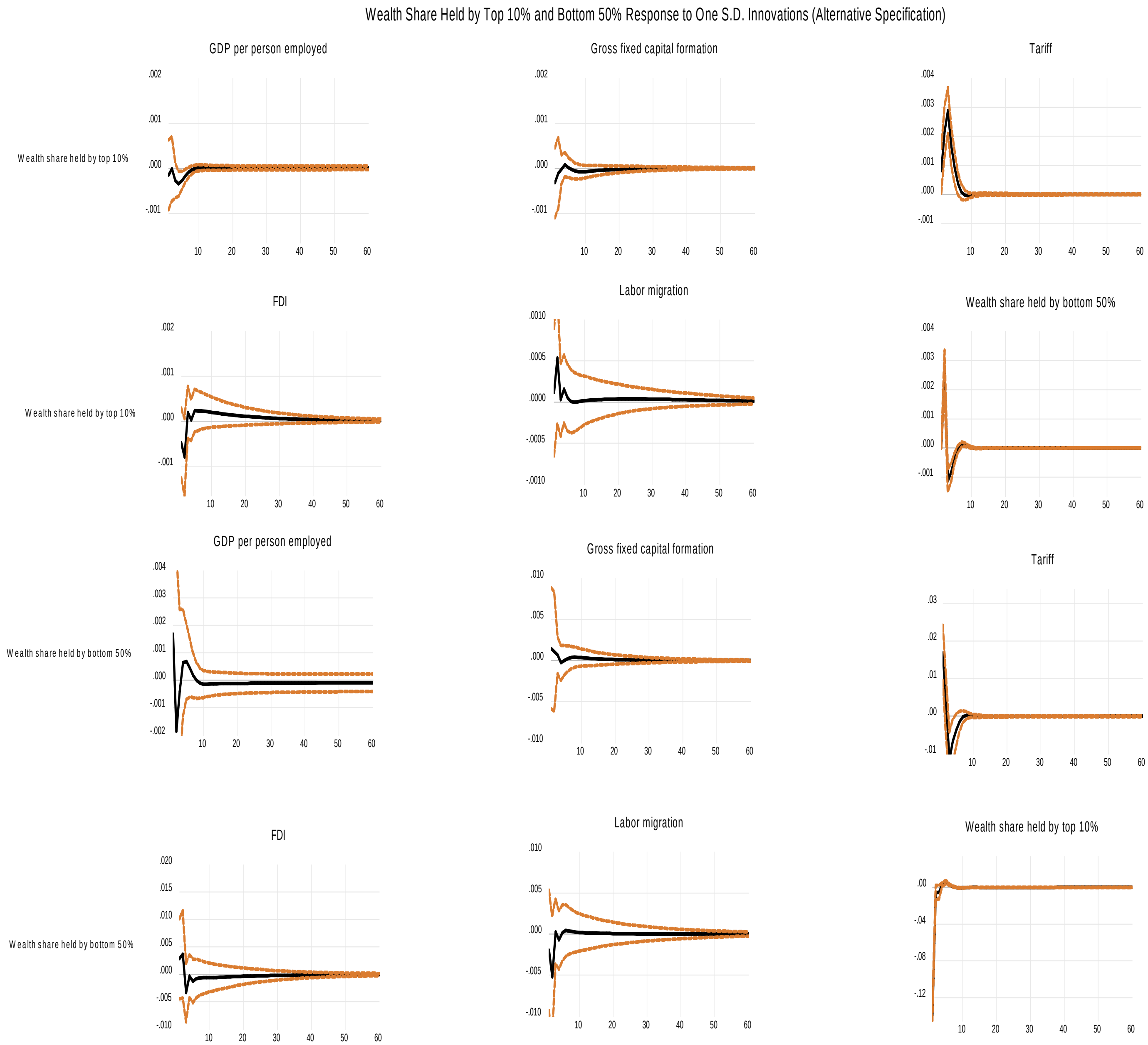

Figure C.10: Wealth shares response to one S.D. innovations of key variables under tariff specification

C.2 Data Description

Most time series data are collected from the World Bank's World Development Indicator and some of them are from the OECD statistics. Income and wealth shares held by top 10% and bottom 50% are from the World Inequality Database.

Table C.1: Data description

Variables	Description
Labor productivity	GDP per person employed (constant 2017 PPP $)
Investment	Gross fixed capital formation (constant 2015 US$)
Exports	Exports of goods and services (constant 2015 US$)
FDI	Foreign direct investment, net inflows (BoP, current US$)
Labor migration	Net migration
Unemployment rate	Unemployment, total (% of total labor force)
Labor force	Labor force participation rate, total (% of total population ages 15+)
Income inequality	Gini index
Income share held by top 10%	Pre-tax national income share held by the p90p100 group
Income share held by bottom 50%	Pre-tax national income share held by the p0p50 group
Wealth share held by top 10%	Net personal wealth share held by the p90p100 group
Wealth share held by bottom 50%	Net personal wealth share held by the p0p50 group
Tariff	Tariff rate, applied, weighted mean, all products (%)
Government spending on education	Government expenditure on education, total (% of GDP)
Researchers in R&D	Researchers in R&D (per million people)