Learning by Exposure:
Evidence from Foreign Direct Investment in Viet Nam

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Abstract

This paper studies the potential productivity spillover and aggregate welfare gain when low-productivity firms are in close proximity to higher-productivity firms. Using foreign directly-invested (FDI) firms in Viet Nam as a proxy for high-productivity type, as well as a comprehensive Vietnamese firm census from 2000-2015, I found a strong positive correlation between a domestic firm's current productivity with their past exposure with high-productivity firms. Building on the Hopenhayn (1992) model of firm entry and exit, I model different firm types with log-normal distributions where low-productivity type learns from the highest type by exposure. The model yields a unique equilibrium and predicts the revenue distribution well; however, it underestimates the improvement in productivity for domestic firms.

1 Introduction

Firms improve their productivity through various learning mechanisms, one of which is by exposure to firms with more advanced technologies. The miracle economic growth of Asian countries like Japan and South Korea during the nineteenth and twentieth centuries exemplifies this process. Their development is frequently attributed to knowledge gained from interactions with more productive Western enterprises, whose influence typically occurred through foreign investment and direct technology transfers, significantly accelerating the development of domestic firms (Cai, 2008). During those periods, growth rate in these countries exceeded 7%, even reaching 10% for Japan in some years (World Bank, n.d.-a, n.d.-b).

Such direct technology transfers is hardly achievable nowadays, due to the fiercer global economic competition and perhaps weaker political incentives for direct technology transfer. Nonetheless, developing countries in Asia still attempt to mimic such growth in a somewhat similar way: attracting foreign direct investment (FDI). Specifically, these countries administered favoring conditions for foreign firms (especially in higher technology fields) to either invest in incumbent domestic firms or set up new plants. By doing this, developing government hope that the existence of foreign firms would raise local labor's stock of knowledge, induce some forms of within-firm technology transfer, raise domestic firms' awareness of new technologies, or increase demand for domestic inputs, which in turn could incentivize domestic providers to upgrade (Blomström and Persson, 1983). All these channels are often referred to as "technology spillover," potentially affecting the productivity of domestic firms and new entrants.

However, after decades of FDI attraction, it is still unclear whether the benefits outweigh the costs. Besides the possible benefits, the penetration of foreign firms also create more competition, which in turn can force domestic firms to exit instead of upgrading themselves. Empirical evidence for technology spillover is also inconsistent, as reported by Demena and van Bergeijk, 2017, in a literature review of 69 FDI-spillover studies covering 31 developing countries during the 1986–2013 period. They examined a total of 1450 spillover estimates, which show a mixture of positive, negative, as well as inconclusive results in similar shares.

Although it is challenging to identify an exogenous change in FDI to get an accurate causal effect, this literature review suggests that FDI might not be as helpful as many developing countries have hoped for. In fact, an increase in foreign presence might even hinders the birth and growth of domestic firms as competition increases. It is also possible that there is no learning for high-skilled labor, as foreign firms might just take advantage of the cheap labor force for low-skilled work. Even with positive technology spillover, domestic and foreign firms might not incorporate it to their profit-maximization problem, leading to an economy smaller than optimal. To address these problems and trade-offs, this paper shows a one-country general equilibrium multiple entrants facing different fixed costs.

The model is built based on the firm dynamic model of Hopenhayn, 1992 with some simplifications used in Melitz, 2003 for firm production function. There are several modifications such as technology spillover and different distributions for different firm types. The model is calibrated using the Viet Nam Enterprise Census. Details on data are characterized in Appendix A.

Why Viet Nam?

Several factors support the choice of Viet Nam for calibration. First, it is a very young country in terms of economic development, with consistent firm census covering the period before and after its first big wave of FDI in 2005. In particular, Viet Nam started a total liberalization in 1994 after decades of centralized economy, wars, and highly limited trade opportunities due to the US sanction. In 2005, its government formalized laws to attract foreign direct investments (FDI), enforcing income tax cut, import tariff exemptions, internalization exemption, and rent reduction for foreign investors, especially those investing in low-income areas and within innovative sectors. Its firm census is carried out annually from 2000 until now, covering almost the entire period of liberalization and foreign direct investment.

Secondly, not all countries attract FDI the same way – a country might limit foreign ownership, fix some ratio of internalization (requiring foreign firms to use some level of domestic inputs), or put a ceiling on tax exemptions. Viet Nam is a country where there is not much limit on foreign operation: foreign entrepreneurs are allowed to open companies which has 100% foreign ownership, tax and tariff cuts are unlimited, and there is no internalization quota. This has led to a high volume of FDI over the years, concentrated in several economic zones, making it relatively easier to measure statistically significant FDI exposure.

Third, the timing and composition of Viet Nam's growth coincide with the direction of FDI exposure, suggesting some positive spillover. For the past 20 years, Viet Nam's GDP has steadily grown at around 7 percent annually, and FDI inflow has also been keeping up at around 20 percent of total investment and is equivalent to 6 percent of GDP (General Statistics Office of Vietnam, n.d., World Bank, n.d.-b). Most foreign projects focused on the manufacturing sector, especially in the production of textile and electronic components assembly, which takes advantage of the abundance of low-cost labor. During the same period, Viet Nam's share of manufacturing in total value-added increased from 19 to 24 percent, while employment share increased from 17 to 33 percent (General Statistics Office of Vietnam, n.d.).

Previous empirical results in Viet Nam show that there is negative horizontal spillover, positive backward spillover, and negative forward spillover from FDI (Huynh et al., 2021, Thang et al., 2016, Le and Pomfret, 2011). The negative horizontal spillover can be explained by (1) a lack of knowledge sharing as firms are in direct competition within the same sector, and (2) the presence of foreign firms bidding up input prices and taking up market share. The positive backward spillover can be explained by higher input demand from foreign firms, which then motivates domestic suppliers to upgrade. The negative forward spillover, on the other hand, can be a result of (1) a high quality of FDI products that can only be exported and not supplied to domestic firms, and (2) a higher wage of low-skilled labor. There are also other results showing positive horizontal spillover effects (Hoang and Pham, 2010), yet the dataset used is from the early 2000s when FDI only started coming into Viet Nam. This potentially captured the reverse causality part of the regression where FDI only enters a sector if such sector has a high value-added.

The structure of this paper is as followed: Section 2 summarizes the empirical findings, which motivate the set up of the model. Section 3 describe the model that integrates learning with exposure. Section 4 describes the method of calibration, as well as calibration results. Finally, the last section summarizes the paper.

2 Empirical observations

Although the data used for calibration is from 2000 to 2018, the data used in this section is only from 2009 to 2015. This is because the following empirical observations needs specific variables for input-output table and for the productivity calculation, which only the 2009-2015 dataset provide consistently. Detailed explanations are included in Appendix A.3.

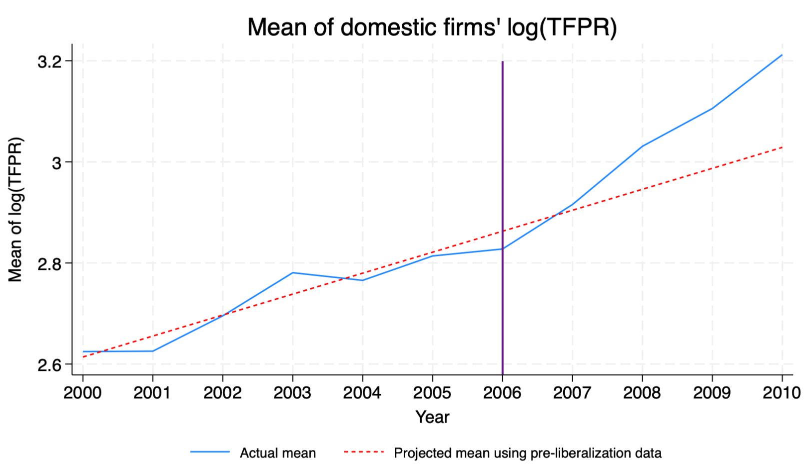
An important metric used in this section is the measure of productivity, TFPR. To calculate this, I mainly used the method by Olley and Pakes, 1996, with the correction in Ackerberg et al., 2015. For robustness check, I used the OLS estimation, which keeps in more observations than the Olley-Pakes method. The production function of firm i in sector s at time t is assumed to be Cobb-Douglas:

$$log(\text{valueadded}_{ist}) = log(\text{TFPR}_{ist}) + \alpha_{ks}k_{ist} + \alpha_{ls}l_{ist}$$

in which the coefficient α_{ls} for log labor (l) and coefficient α_{ks} for log fixed capital (k) are by sector. All values except number of labor are normalized to 2010 price using the consumer price index.

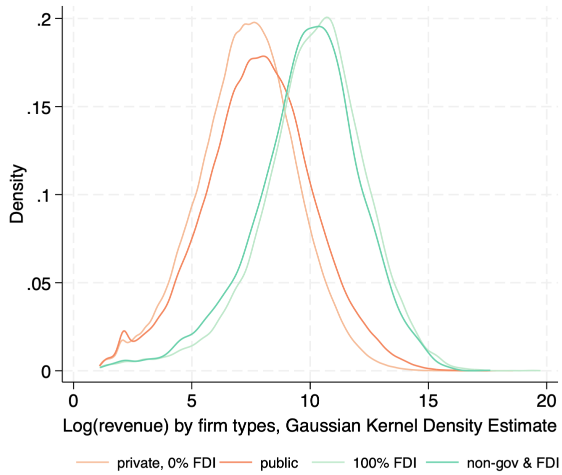
2.1 Domestic firms' average TFPR improves at greater rate following the 2006 FDI liberalization

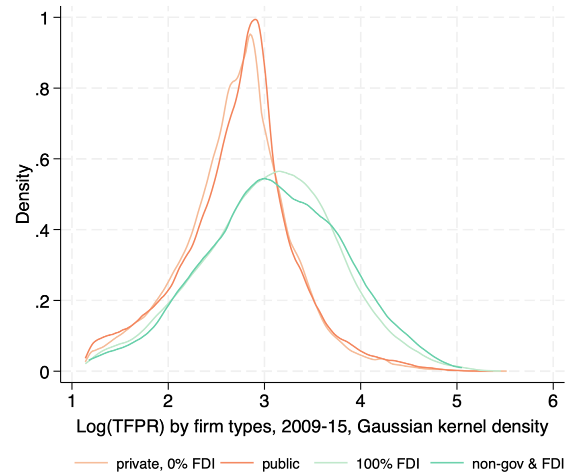
In the graph below, the blue line shows the average of domestic firms' TFPR (in log) for each year from 2000 to 2010. The red dotted line shows the projected growth post 2006, which is the year of FDI liberalization. We can see that before 2006, the overall trend is linear. However, post 2006, the real growth is higher than the projected growth, suggesting some benefits from the liberalization on domestic firms alone.



2.2 Foreign firms have a denser right-tail productivity distribution

The distribution of revenue and productivity for different firm types is





In this plot, the observations are firms in manufacturing and service sectors; government-dominated firms are dropped. We can see that FDI-related firms (green lines) has a higher productivity and revenue distribution than domestic firms (orange lines). For revenue, the shape of the distributions are almost the same, while for TFPR, FDI firms has a higher variance. This is due to the higher variance in value-added.

2.3 There is a positive correlation between domestic firms' productivity and FDI exposure.

The FDI exposure is measured by how far and how productive surrounding FDI firms are. In the dataset, each firm's area, sub area, and sub-sub areas are reported, which I used as a proxy of distance between firms and checked for robustness by varying proxy weights. Following the recent literature that firms' knowledge are substitutable [], I assumed the CES weight of firms exposure with elasticity of substitution be γ. Here, firm size is not accounted for, as in our model later on, higher productivity firms tend to hire more labors, and thus including size will only be double accounting. Finally, FDI exposure of domestic firm i at time t is measured as

$$\text{FDI\_exposure}_{i,t} = \left(\sum_{i' \text{ is FDI}} (\text{distance from } i \text{ to } i')^{\frac{1}{\gamma}} \times \text{TFPR}_{i',t}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}$$

Since I do not have firm's specific location, distances are approximated by whether two firms share the same region or sub region. In particular, each firm is located by ward, district, and province. Here, I used weight of (1, 0.9, 0.6) if two firms share the same (ward, district, province). [1].

FDI exposure is also decomposed into horizontal, forward, and backward exposures. The exact input-ouput linkage data is not available; therefore, I used a modified FDI exposure for forward linkage of firm i in sector s^* is:

$$\begin{aligned}
\text{Foward_FDI_exposure}_{i,t} &\approx \sum_{s \neq s^*} \text{FDI_exposure}_{is,t} * Pr[\text{firm } i \text{ supplies to sector } s \text{ at time } t] \\
&\approx \sum_{s \neq s^*} \text{FDI_exposure}_{is,t} * \text{Sector } s^*\text{'s supply share to sector } s \text{ at } t
\end{aligned}$$

Backward linkage is defined similarly. Supply share is extracted from the Input-Output table, with details in Appendix A.2. Finally, to measure potential spillover, I used the following identification for domestic firm i in sector s, location l, and time t

$$\text{TFPR}_{is,t} = \beta_0 + \beta_1 \times \text{FDI\_exposure}_{is,t-1} + \boldsymbol{\beta}_2 \times \boldsymbol{X}_{is,t} + \boldsymbol{\beta}_3 \times \boldsymbol{FE}_{is,t}$$

with $\boldsymbol{X}$ as firm's characteristics such as firm size; $\boldsymbol{FE}$ are the province, year, and sector fixed effect. Results are as followed: Columns (1) and (2) of Table 1 show that all effects are

Dependent var: Log(TFPR)	(1) (full panel)	(2) (full panel)	(3) (balanced panel)	(4) (balanced panel)
Log(FDI exposure)	0.0326***		0.0314***	
	(0.00492)		(0.00629)	
Log(horizontal FDI exposure)		0.0291***		0.0339***
		(0.00652)		(0.00510)
Log(forward FDI exposure)		-0.00362		-0.000611
		(0.00525)		(0.00455)
Log(backward FDI exposure)		0.0214**		0.0169**
		(0.00874)		(0.00800)
R-squared	0.245	0.249	0.266	0.295
Observations	540320	365948	127387	70571

Standard errors in parentheses
$^* p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$
Note: Other parameters include firm size, province fixed effect, year fixed effect, and sector fixed effect.

Table 1: Correlation between domestic firms' productivity with past exposure to FDI

positive when using the full dataset. Regressions (3) and (4) shows that when using a balanced panel, the effects become either smaller or insignificant. This means that the entry and exit

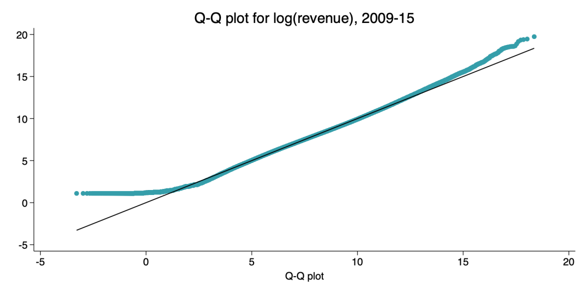
[1] Table 1. The result is robust for other weights such as (1, 1, 1) and (1, 0.95, 0.8)

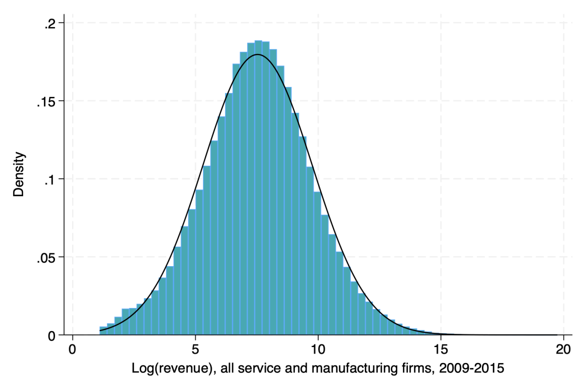
of firms biased FDI exposure, in which new entrance are likely to positively contributing to the average productivity.

Robustness and alternative specifications

2.4 Firm revenue distribution is approximately log-normal

Below is the histogram of all firms' log revenue from the 2009-2015 period as well as their Q-Q plot. Note that for each year, the distribution is similar compared to this aggregated data. Here, we can see that firm revenue is log-normally distributed at the center. There is a high deviation at the lower end, which are most likely due to some cutoffs and exit behaviors of firms.





3 Model

The setup is similar to Melitz, 2003, but with multiple types of entrances that face in different exit rates and fixed costs. There is one representative household with an inelastic labor supply. The market is at stationary equilibrium.

3.1 Household

A representative household has a C.E.S utility function over a continuum of goods indexed by ω:

$$Q = \left[\int_{\omega \in \Omega} q(\omega)^{\frac{\epsilon-1}{\epsilon}} d\omega \right]^{\frac{\epsilon}{\epsilon-1}}$$

Here, Ω is the set of all differentiated goods ω; $\epsilon > 1$ is the elasticity of substitution; and $q(\omega)$ is the quantity of good ω purchased.

Assume further that there are subgroups of goods $\{\Omega_i\}_{i=1,2,...,I}$ belonging to different firm types i (for example, goods produced by foreign firms and goods produced by domestic firms) such that $\{\Omega_i\}_{i=1,2,...,I}$ form a partition of Ω and

$$Q_i \equiv \left[\int_{\omega \in \Omega_i} q(\omega)^{\frac{\epsilon-1}{\epsilon}} d\omega \right]^{\frac{\epsilon}{\epsilon-1}}, \forall i = 1, 2, ..., I$$

This means

$$Q = \left(\sum_{i=1}^{I} Q_i^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}} \tag{1}$$

Given prices $\{p(\omega)\}_\Omega$, household maximizes their utility Q and set the aggregate price indexes as

$$P_i = \left[\int_{\omega \in \Omega_i} p(\omega)^{1-\epsilon} d\omega \right]^{\frac{1}{1-\epsilon}}, \forall i = 1, 2, ..., I$$

$$P = \left(\sum_{i=1}^{I} P_i^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}} \tag{2}$$

Denoting spending on good ω as $r(\omega) = p(\omega)q(\omega)$, we also have

$$R_i \equiv \int_{\omega \in \Omega_i} r(\omega) d\omega = P_i Q_i$$

$$R \equiv \sum_{i=1}^{I} R_i = \sum_{i=1}^{I} P_i Q_i \tag{3}$$

Labor income is derived from its labor L, supplied inelastically, and wage w, determined competitively. Total labor income is wL.

3.2 Incumbent firms

There are I types of firms operating. Each type i has a mass M_i and productivity distribution $\gamma_i(\varphi)$. Each firm produces using only labor $q(\varphi) = \varphi l$, given a fixed operating cost f_i (in unit of labor and is unique to each type i), and labor unit cost w. Each firm's productivity φ is constant overtime.

In this economy, each firm takes quantity demanded as given and set price to maximize profit. Using the variable cost $\frac{w}{\varphi}$ from the production function, as well as the C.E.S. demand structure with elasticity of substitution ϵ, optimal pricing for firms with productivity φ is:

$$p(\varphi) = \frac{\epsilon}{\epsilon - 1}\frac{w}{\varphi} \tag{4}$$

Denote $\pi_i(\varphi), \Pi_i, \Pi$ as profit for firm with productivity φ, total profit for all firms type i, and total profit in economy. Optimal pricing (2) means

$$\pi_i(\varphi) = \frac{1}{\epsilon} r(\varphi) - w f_i \tag{5}$$

Let firm type i's exogenous exit rate be δ_i, then a firm type i and productivity φ has the value function:

$$v_i(\varphi) = \max\{\sum_{t=0}^{+\infty} (1-\delta_i)^t \pi_i(\varphi), 0\} = \max\{\frac{1}{\delta_i}\pi_i(\varphi), 0\}$$

This value function means that a firm exits if their profit falls below 0. In fact, we can identify a cutoff φ_i^* for productivity such that firm type i will exit if their productivity falls below φ_i^*. From the C.E.S. demand, it must be true that

$$q(\varphi) = QP^{\epsilon} p(\varphi)^{-\epsilon} \tag{6}$$

which means

$$\frac{q(\varphi)}{q(\varphi')} = \left(\frac{\varphi}{\varphi'}\right)^{\epsilon} \text{ and } \frac{r(\varphi)}{r(\varphi')} = \left(\frac{\varphi}{\varphi'}\right)^{\epsilon - 1} \tag{7}$$

for any two firms $\varphi, \varphi' \in \Omega$. This and (5) mean $\lim_{\varphi \to 0^+} \pi_i(\varphi) = -f_i < 0$ and $\lim_{\varphi \to \infty} \pi_i(\varphi) = \infty$. We also have π_i is continuous and strictly increasing on $(0, \infty)$ if all firm produces. These conditions ensure that there is a unique cutoff φ_i^* of productivity for each firm type i to be profitable, such that

$$\pi_i(\varphi_i^*) = 0 \Leftrightarrow \frac{1}{\epsilon} r(\varphi_i^*) - wf_i = 0, \forall i = 1, 2, ..., I \tag{8}$$

This is the zero-profit cutoff condition (ZPC).

3.3 Simplifying the expressions

Similar to Melitz, 2003, the economy can be characterized by representative productivities instead of the whole distributions. In particular, define the average productivity of each firm type as

$$\tilde{\varphi}_i = \left[\int_{\varphi_i^*}^{\infty} \varphi^{\epsilon-1} \gamma_i(\varphi) d\varphi\right]^{\frac{1}{\epsilon-1}} \tag{9}$$

Then, we have

$$P_i = M_i^{\frac{1}{1-\epsilon}} p(\tilde{\varphi}_i) \tag{10}$$

$$Q_i = M_i^{\frac{\epsilon}{\epsilon-1}} q(\tilde{\varphi}_i) \tag{11}$$

$$R_i = M_i r(\tilde{\varphi}_i) \tag{12}$$

$$L_{pi} \equiv M_i l_i(\tilde{\varphi}_i)$$

with L_{pi} being the productive labor use to pay variable cost and fixed production costs for all firms in type i, and

$$l_i(\varphi) = \frac{q(\varphi)}{\varphi} + f_i \tag{13}$$

for all φ, i.

3.4 Firm entrance

Each potential firm knows their type i but only draw a productivity φ_i after paying a fixed entrance cost f_{ei} (in unit of labor). Each firm type i draws from productivity distribution with pdf $g_i(\varphi)$ and cdf $G_i(\varphi)$ with domain $(0, \infty)$. The mass of entrance for each type is M_{ei}, which is zero if no firm of type i enters.

In a stationary equilibrium, entry equals exit

$$\delta_i M_i = (1 - G_i(\varphi_i^*))M_{ei}, \forall i = 1, 2, ..., I \tag{14}$$

as firms type i drawing below φ_i^* will immediately exit. The stationary distribution for firms type i is

$$\gamma_i(\varphi) = \begin{cases} \frac{g_i(\varphi)}{1-G_i(\varphi_i^*)}, & \varphi \geq \varphi_i^* \\ 0, & \text{otherwise} \end{cases} \tag{15}$$

Firms type i tries to enter if and only if fixed entrance cost does not exceed the lifetime expected profit of its type. Taking into account the life-time multiplier $\frac{1}{\delta_i}$, the chance of immediate survival $1 - G_i(\varphi_i^*)$, and the current mass M_i of firms, we can characterize the expected lifetime profit of firm type i prior to productivity draw as

$$\frac{1}{\delta_i}\frac{1}{M_i}\Pi_i[1 - G_i(\varphi_i^*)] = \frac{1}{\delta_i}[\frac{1}{\epsilon}r_i(\tilde{\varphi}_i) - wf_i)][1 - G_i(\varphi_i^*)]$$

In a zero expected profit model, the free-entry (FE) condition is

$$M_{ei} \begin{cases} > 0, & \frac{1}{\delta_i}[\frac{1}{\epsilon}r(\tilde{\varphi}_i) - wf_i)][1 - G_i(\varphi_i^*)] = wf_{ei} \\ = 0, & \frac{1}{\delta_i}[\frac{1}{\epsilon}r(\tilde{\varphi}_i) - wf_i)][1 - G_i(\varphi_i^*)] < wf_{ei} \end{cases} \tag{16}$$

3.5 Market clearing

Labor market clearing means

$$L = \sum_{i=1}^{I} [M_i l_i(\tilde{\varphi}_i) + M_{ei} f_{ei}]$$

Household spends all income, which means

$$R = wL \tag{17}$$

The final market-clearing condition can be proved using the stationary equilibrium condition, firm's revenue decomposition, and free-entry condition[2] .

3.6 Learning

The problem is only meaningful if there are higher productivity types with higher fixed costs (if the higher productivity type is also facing lower fixed costs, then they will be the only survivor, which leads us back to the Melitz case of one-type firm economy).

Assumption 1. (Firm distribution) Type i has a log-normal distribution g_i parameterized by μ_i and σ_i such that

$$g_i(\varphi) = \frac{1}{\varphi \sigma_i \sqrt{2\pi}} exp\left[-\frac{(\ln \varphi - \mu_i)^2}{2\sigma_i^2} \right]$$

for each $\varphi \in (0, \infty)$.

Definition 1. (Higher productivity distribution) Type i is defined as *more productive* than type i' if $\mu_i \geq \mu_{i'}$ and

$$1 - G_i(x) \geq 1 - G_{i'}(x)$$

for all $x \geq e^{\mu_{i'}}$.

Intuitively, this definition states that for any φ above the median of the lower productivity type, the higher productivity type always have a higher accumulated weight $1 - G_i(\varphi)$. Also this does not fully rationalize the left tail of each distribution, it works with the symmetry of $\log(\varphi)$ and matches real-life observation where higher-productivity type has higher variation.

Assumption 2. (Order of distribution) Firm types are ordered such that $\mu_i \geq \mu_{i'}$ and $\sigma_i \geq \sigma_{i'}$ for all $i \leq i'$.

Intuitively, this definition means two things. First, types with higher median also have a higher variation. Secondly, type 1 has a higher productivity distribution than type 2, type 2 higher than type 3, and so on. The second result follows from the characteristic of log-normal distribution where $G_i = \Phi\left(\frac{\ln \varphi - \mu_i}{\sigma_i}\right)$ and from Definition 1.

[2]Total revenue of the economy is $R = \sum_i R_i = \sum_i (\Pi_i + wL_i) = \sum_i (\frac{1}{\epsilon} R_i - wM_i f_i + wL_i) = \sum_i \left(\frac{M_i \delta_i f_{ei}}{1 - G_i(\varphi_i^*)} + wL_i \right) = \sum_i (wM_i f_{ei} + wL_i) = wL$,with the third equality from competitive monopolistic mark-up, fourth equality from (16), fifth equality follows from (14). This proof is similar to Melitz, 2003, page 1704

Assumption 3. (Learning) Let $M = \sum_{i=1,...} M_i$ be the total mass of firms. If type 1 is the best type, then all other types learn from the existence of type 1 such that for all $i \neq 1$,

$$\mu_i = \underline{\mu}_i + h_{\mu,i}(\frac{M_1}{M})$$

$$\sigma_i = \underline{\sigma}_i + h_{\sigma,i}(\frac{M_1}{M})$$

such that $\underline{\sigma}_1 \leq \sigma_i \leq \sigma_1$, $\underline{\mu_i} \leq \mu_i \leq \mu_1$, $\lim_{x \to 1} \mu_i = \mu_1$, $\lim_{x \to 1} \sigma_i = \sigma_1$, $h'_\mu(x) > 0$, and $h'_\sigma(x) > 0$.

Intuitively, these assumptions mean two things

(i) The more type 1 penetrates the economy ($d(M_1/M) > 0$), the more low-productivity types learn.

(ii) When type 1 expands to fully penetrate the market ($M_1/M \to 1$), all other types fully learn and are able to identically mimic type 1.

Assumption 4. (Fixed costs) The highest-productivity type (type 1) faces the highest fixed production cost

$$f_1 \geq f_i \text{ for all } i = 2, 3, ..., I$$

and the highest fixed entrance cost normalized by the exit rate

$$\delta_1 f_{e1} > \delta_i f_{ei} \text{ for all } i = 2, 3, ..., I \tag{18}$$

Here, fixed entry cost is normalized by the exogenous exit rate because a potential firm looks at not only the cost to enter but also how risky the market is. I want to impose a condition where type 1 not only faces high fixed cost, but also a market risky enough that prevent them from monopolizing. For example, when fixed cost f_{e1} is high but type 1 does not have any risk ($\delta_1 \to 0$), while other types have very high risk, then type 1 will be the only player in the market. More information about this follows in Proposition 1's proof.

3.7 Competitive equilibrium and solution

Definition 2. (Stationary Competitive Equilibrium) Given the exogenous parameters L, ϵ, $\{\delta_i, f_i, f_{ei}\}_I$, and the distributional characteristics $\{\mu_i(M_1/M), \sigma_i(M_1/M)\}_I$, a competitive equilibrium is defined by

$\{P, Q, R, \{P_i, Q_i, R_i, M_i, M_{ei}, \gamma_i(.), \varphi_i^*, \tilde{\varphi}_i\}_I,\ \{p(\varphi), q(\varphi), \{l_i(\varphi)\}_I\}_{(0,\infty)}$ such that:

(i) Household take prices $\{p(\varphi)\}_{(0,\infty)}$ and characteristic of firms $\{\tilde{\varphi}_i, M_i\}_I$ as given, and choose quantities to maximizes their utility such that (1), (3), (6), (11), (10), (12) are satisfied.

(ii) Incumbent firm of type i with productivity φ take demand $\{q(\varphi)\}_{0,\infty}$ and fixed cost $\{f_i\}_I$ as given, choose price $p(\varphi)$, labor use $l_i(\varphi)$, and exit rule φ_i^* to maximize profit such that (4), (8), (13) are satisfied.

(iii) Potential firms take fixed cost and profitability of incumbent firms as given, and choose whether to enter or exit such that (16) is satisfied.

(iv) Market is cleared such that (17) is satisfied.

(v) The economy is at static equilibrium such that (14) and (15) are satisfied given (9).

The solution for this stationary competitive equilibrium satisfies the following properties:

Proposition 1. *If $\sum_{i=1}^{I} M_i > 0$, $\{g_i, f_i, f_{ei}\}_I$ satisfy the conditions in Section 3.6, $f_1 = f_i$ for all i, and $M_1 > 0$, then there exists $i > 0$ such that $M_i > 0$.*

Proof. Appendix C.1. □

Intuitively, this proposition states that the most productive type cannot be the only type existing in the market. This is because, as type 1 gets closer to fully penetrate the market, other types gets closer and closer to perfectly mimic type 1's productivity distribution. And since lower-productivity types face weakly lower fixed costs, they will enter and prevent type 1 to be the only player in the market.

Proposition 2. *Given $\{f_i\}_I$ and $\{f_{ei}\}_{i\neq 1}$, is a unique $\{f_{e1}\}$ such that $M_1 > 0$.*

Proof. Appendix C.2. □

Intuitively, this means that once fixed entrance cost for the most productive type is large enough, they will not enter at all.

Proposition 3. *There is a unique solution for the stationary competitive equilibrium.*

Proof. Appendix C.4. □

Proposition 4. *The relative cutoff for different types ($\varphi_i^*/\varphi_{i'}^*$) does not depend on the technological differences between types, but only the fixed production cost ($f_i/f_{i'}$).*

Proof. Appendix C.4. □

Proposition 5. *Average revenue $r(\tilde{\varphi}_1)$ of type 1 does not depend on $\{\mu_i\}_{i=1,2,...}$ distribution, but only on exit rate δ_1, fixed costs f_{e1}, f_1, and σ_1.*

This is an interesting result, which says changing μ_1 does not change $r(\tilde{\varphi}_1)$. In our context, it does not matter who the host country opens door to (either lower μ foreign country or higher μ foreign country), the average revenue of each foreign firm stays constant. This is a nice characteristic whose proof depends heavily on the log-normality of the firm distributions. Intuitively, increasing μ_1 means higher competition within foreign firms. And since the entry decision for type 1 only depends on expected profit of its own type, only foreign firms with better productivity draw choose to stay upon arrival.

Proposition 6. *Average revenue $r(\tilde{\varphi}_2)$ of type 2 does not depend on the fixed cost to enter f_{e1} for type 1.*

Proof. Appendix □

4 Model calibration and counterfactuals

In the calibration, we will use a two-type model with log-normal productivity, where the mean and variance of the low type's growth depends on the penetration of the high type. I used 2001-2006 data to reverse-engineer the parameter of the model, then project the parameters and solve for post-2006 domestic productivity. The parameters used are included the below table, with more details in the next section (parameter estimation strategy).

4.1 Parameters estimation strategy

I treated each year in the train dataset as a competitive general equilibrium and used structural accounting to characterize the values and movement overtime of the exogenous parameters. In particular, each year's data observes the entry and exit over time of each firm, the distribution

Parameters		Method
Elasticity of substitution	$\epsilon = 4$	Calculate upperbound from aggregate data 2000-05
Fixed costs	$f_{i,t}$	Reverse-calculation from 2000-08 data
Fixed entrance costs, foreign	$f_{e1,t}$	Reverse-calculation from 2000-05 data to estimate range. Final values are chosen within such range to match the real μ_{r_f}, t.
Fixed entrance costs, domestic	$f_{e2,t}$	Reverse-calculation from 2000-05 data to estimate range. Final values are chosen within such range to match the real μ_{r_d}, t.
Productivity, foreign	$\mu_{f,t}, \sigma_{f,t}$	Reverse-calculation from 2000-05, project trend for 2006-08
Baseline productivity, domestic	$\underline{\mu}_{i,t}, \underline{\sigma}_{i,t}$	Matching for joint moments of domestic firm revenue distribution, zero-profit cutoff, and free-entry condition for 2000-05. Project trend for 2006-2009.
Exit rate	δ_i	Real exit rate, 2000-08

Table 2: Parameter calibration strategy

of revenue and labor use $\{r_i, l_i\}_i$ for all firms in the manufacturing and service sectors, number of firms M_i for each firm type, and total labor pay $wL = \sum_i w_i l_i$. From these, I estimated the elasticity of substitution ϵ, exit rate δ_{it}, and distribution of productivity (μ_{it}, σ_{it}). I then checked the model's accuracy using 2005 data, and ran counterfactual using 2006-2008 data.

In the counterfactual exercise, there will be three relative paths of growth. First, I used the above results from train data to characterize a hypothetical growth path as if there were no 2005 liberalization. Second, I used the learning parameters at firm level (shape of h functions) extracted from 2009-2015 dataset in Section 2 to estimate the growth with the 2005 liberalization. Third, I compare them with actual growth of domestic productivity.

Below are the specifications used to identify the parameters in 2000-2005 from observed variables, including number of firms, revenue (in this case, valueadded to labor), number of labors used, labor pay, and firm type for each firm.

Elasticity of substitution ϵ for all years

Using 2000-2005 data, I identified the upperbound of ϵ using the following relationship:

$$r(\varphi) = p(\varphi)q(\varphi) = \frac{\epsilon}{\epsilon - 1} w(l_i(\varphi) - f_i) \leq \frac{\epsilon}{\epsilon - 1} w l_i(\varphi) \tag{19}$$

$$\Rightarrow \frac{\epsilon}{\epsilon - 1} \geq \frac{r(\varphi)}{w l_i(\varphi)}$$

Since r (in our case, it is valueadded to labor) is known and l is known for each firm, I took the median of $\frac{r(\varphi)}{wl(\varphi)}$ (valueadded over total labor pay) over all firms and used it as the upperbound for $\frac{\epsilon}{\epsilon-1}$. The median was used because it is more stable than mean in the data, and in the normal distribution, mean and median are the same. In our dataset, the mean of lowerbound over 2001-2005 period for $\frac{\epsilon}{\epsilon-1}$ is 1.2952744, which means the upperbound for ϵ is approximately 4.39. We used $\epsilon = 4$ for our calibration.

Wage w

At equilibrium, $R = wL$, which means we can get $w = R/L$ directly from observed data.

Revenue at special points $r(\varphi_i^*), r(\tilde{\varphi}_i)$

Using the zero-profit condition, we have

$$r(\varphi_i^*) = \epsilon w f_i$$

with f_i already identified above. Furthermore, (12) means

$$r(\tilde{\varphi}_i) = R_i/M_i$$

with R_i, M_i observed.

Fixed production cost f_i

By integrating the expression in (19) over all firms of each type i, we get:

$$R_i = \frac{\epsilon}{\epsilon - 1} w(L_i - M_i f_i) \Rightarrow f_i = (wL_i - \frac{\epsilon - 1}{\epsilon} R_i)(wM_i)^{-1}$$

with R_i, L_i, M_i observed, w calculated above, and ϵ imposed above.

Exit rate δ_{it} **for each years**

For all years, exit rate δ_{it} is detemined by number of firms that exist in year t but not $t+1$, divided by number of firms in t, the current year[3]. I calibrated this using firms' unique tax-code[4]. Intuitively, potential firm looks at the most recent year's exit rate to predict their

[3] An alternative calculation used a lag of exit rate, but the no-lag method offers a more stable path of fixed costs change over time.

[4] Although taxcodes are not available for all firms, missing and duplicated taxcodes account for less than 1 percent of total number of firms each year during 2001-2005. Meanwhile, exit rates range from 15 to 40

future exit rate.

Productivity distribution (μ_i, σ_i)

We will use the distribution of $\log(r(\varphi))$ to estimate the productivity of $\log(\varphi)$. Since φ follows a log-normal distribution, (7) indicates that for all $\varphi > \varphi_i^*$,

$$\sigma_i = \frac{\sigma_{r_i}}{\epsilon - 1} \text{ for } i = 1, 2$$

$$\mu_i = \frac{\mu_{r_i} - \ln(r(\varphi_i^*)) + (\epsilon - 1)\ln(\varphi_i^*)}{\epsilon - 1}$$

with μ_{r_i}, σ_{r_i} as the index for the log-normal distribution of r_i. Proof is in Appendix C.2.

Fixed entrance cost f_{ei}

Using results from the previous part and the zero-profit condition:

$$\begin{aligned} \mu_i &= [\mu_{r_i} - \ln(r(\varphi_i^*))]/(\epsilon - 1) + \ln(\varphi_i^*) \\ &= [\mu_{r_i} - \ln(\epsilon w f_i)]/(\epsilon - 1) + \ln(\varphi_i^*) \end{aligned}$$

which means

$$1 - G_i(\varphi_i^*) = 1 - \Phi\left(\frac{\ln(\varphi_i^*) - \mu_i}{\sigma_i}\right) = 1 - \Phi\left(\frac{\ln(\epsilon w f_i) - \mu_{r_i}}{\sigma_{r_i}}\right)$$

Finally, using the free-entry condition, we get f_{ei} satisfying

$$f_{ei} = \frac{1}{w\delta_i}[\frac{1}{\epsilon}r(\tilde{\varphi}_i) - wf_i)][1 - G_i(\varphi_i^*)]$$

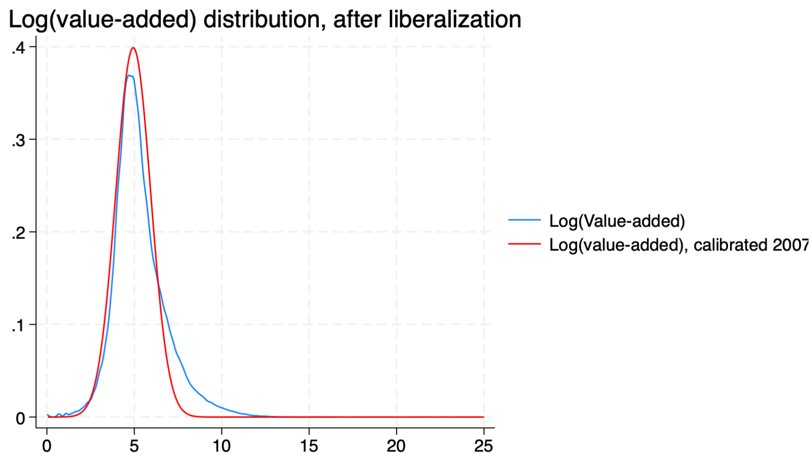
4.2 Calibration results

Matching of revenue distribution

By construction (table 2), the values of μ_{r_i} and σ_{r_i} with match well with the real values, since I chose the best values from the previous section's range to match revenue distribution. For each year, the deviation of μ_{r_i}, σ_{r_i} from the real values is less than 1%. Below is an example comparison between actual revenue distribution (blue line) and the calibrated revenue

percent.

distribution (red line) if there were no exit.



While the log-normal parameters $(\mu_{r_i}, \sigma_{r_i})$ matches well, the cutoff of productivity does not. This is a common problem with model on firm entry and exit. In the calibrated model, domestic entrants' survival rate is only 10-25%, while it is 22-52% for foreign firms. This means that the revenue distribution for domestic firms should be cutoff at the far right-hand side; while in real life, there is no observed cutoff point.

Matching of growth in domestic productivity following the 2006 FDI shock

The calibrated model predicts an increase in productivity on top of projected growth (third column of Table 3). This shows the same trend as of real additional growth on top of projected growth (third column of Table 3); however, calibrated variable is more stable and does not explain fully the real growth.

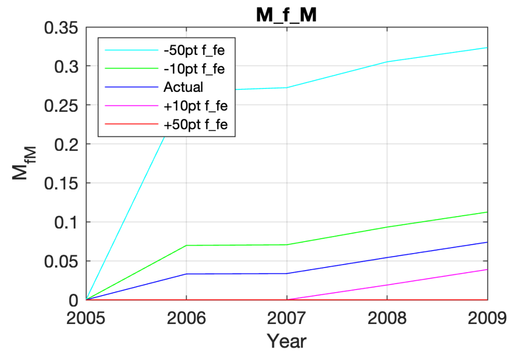
Year	Actual increase in μ_d	Calibrated increase in μ_d
2006	-1.035%	0.093%
2007	0.296%	0.244%
2008	2.766%	1.095%
2009	3.703%	2.354%

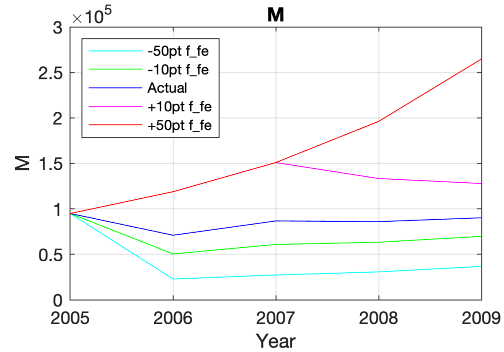
Table 3: Calibrated growth of domestic firms

4.3 Counterfactuals

For this section, I ran alternative scenarios where fixed cost for foreign firm to enter (f_{e1}) changes by 10 percentage point and 50 percentage point in each direction. I also assumed linear learning, with rates depend on the gap between foreign and domestic parameters.

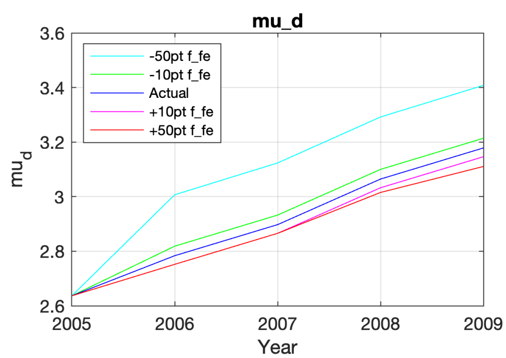
Number of firms

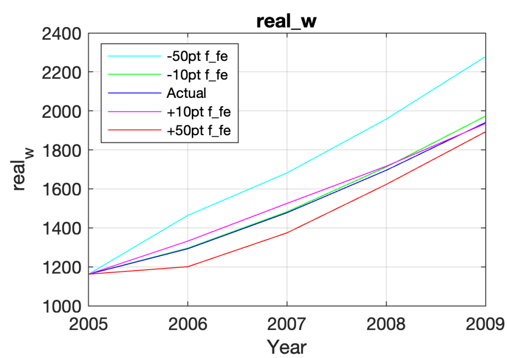




The left graph shows share of foreign firms, while the right graph show the total number of firms. As fixed costs to enter drop, there is a higher share of foreign firms. However, the total number of firms decreases, which can be explained by the increase in overall productivity of firms within the country that increases competition.

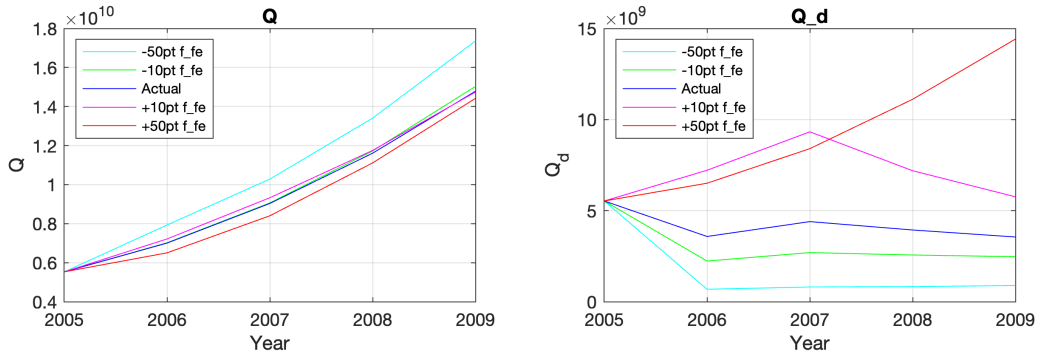
Domestic productivity and real wage





On the left-hand side, we can see that domestic productivity has a higher μ_d. As fixed costs to foreign firms drop, there is a higher share of foreign firms, which then increases μ_d. Welfare also increases, as it is the inverse of price aggregate P which drops due to higher share of high-productivity foreign firms.

Total quantity and domestic quantity



Total quantity of production Q (left graph) increases with lower costs, which can be explained by a higher share of labor moving into productive production. However, total domestic quantity Q_d drops. This happens despite the increase in μ_d that we have seen above. This is because while on average, domestic firms are more productive, fiercer competition makes the number of domestic firms drop, leading to a lower aggregate Q_d.

5 Welfare

There are multiple ways to define welfare in this context. From the consumer point-of-view, welfare only concerns the country's purchasing power (or real wage), which is improved with more variety of goods, as proved in Melitz, 2003. But, domestic government oftentimes care more about the productivity of domestic firms and their share of the market (Q_d). Each of these are analyzed in the counterfactual section; however, it is not a comprehensive analysis as it depends on only a single set of parameters.

In this section, we will talk about a more comprehensive welfare analysis for both real wage w and domestic production Q_d. The change in policy will be change in fixed costs. In real life, the Vietnamese government often change fixed entry cost f_{e1} by changing real estate policy, such as establishing foreign economic zones and government offices aiming at reducing knowledge barrier with potential investors, or raising and strengthening favorable land leasing terms. They also change fixed cost to operate f_1 with income tax relief and import tax cut. However, in our analysis, the focus is on fixed entrance cost.

Proposition 7. *In the stationary competitive equilibrium, the solution for* $\max_{f_{e1}} \sum_{i=2}^{I} Q_i$ *is unique.*

Intuitively, there is an optimal fixed entrance cost to foreign firms that maximizes domestic production. This might not maximize domestic consumption, but will protect domestic firms sufficiently so that they both learn and grow.

Proposition 8. *(Guess, not yet proved) Let f_{e1}^* be the optimal choice in the above maximization problem. Then, $\sum_{i=2}^{I} Q_i(f_{e1}^*) \geq \sum_{i=2}^{I} Q_i(\infty)$*

This proposition is claiming that having some foreign firms is still better for domestic production than having no foreign firms.

6 Critics and Conclusion

While the calibrated value-added distribution has a similar shape to the real one, the cutoff (not shown) is very high and unrealistic. This might be because of the backward calibration that identify an incorrect range for fixed costs. It is possible to scale down the fixed costs to reduce the cutoff to match better with reality; however, there is not a concrete justification for doing so yet.

Overall, this paper provided empirical evidences for some positive spillover of productivity from foreign to domestic firms, alongside with the lognormal distribution of firms in Viet Nam. I have constructed a model with CES demand and log-normal productivity distribution. The model is calibrated using the 2006 FDI shock in Viet Nam when it formally recognized FDI firms and provided multiple benefits to foreign investors. The calibrated model explains the growth in domestic productivity in addition to the projected growth path, although it does not fully explain the entire additional growth compared to real data. In addition, the counterfactuals show that while decreasing barrier further for foreign firms lead to the country's higher total production and real wage, it would decrease the share of domestic firms and their total production quantity.

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