Cross-Country Externalities of Trade and FDI liberalization

Qing Liu and Larry D Qiu*†

October 26, 2010

Abstract

We develop a three-country version of the Helpman, Melitz and Yeaple (2004) model with firm heterogeneity, industry heterogeneity and country heterogeneity to study firms' foreign market entry strategies. We show that (i) for any single host country, the export-FDI cutoff is higher in more skill-intensive industries than in less skill-intensive industries; and (ii) for any single industry, the cutoff is higher (lower) in the more developed country than in the less developed country if the industry's skill intensity is high (low). We also use this model to study how economic policy changes in one foreign country (F1) affect home firms' market entry decisions in another foreign country (F2). We predicts that FDI liberalization in F1 results in the following: (i) some firms from the home country switch from export to FDI in F1; (ii) skilled labor's wage rate drops in the home country; (iii) wage inequality between the skilled and unskilled labor decreases; and (iv) some firms from the home country switch from FDI to export to F2. The effects from trade liberalization are just the opposite, but the effects from education improvement are qualitatively the same as FDI liberalization. The cross-country externalities work through the domestic labor market, which is a new channel to understand cross-country effects of trade and FDI liberalization.

Keywords: Export, FDI, firm heterogeneity, industry heterogeneity, country heterogeneity, cross-country externalities, wage inequality, skill training, contractual friction.

JEL Code: F12, F14, F16, F23, L11, J24, J31

*Correspondence: School of Economics and Finance, The University of Hong Kong, Pokfulam Road, Hong Kong. Emails: qlecon@hku.hk and larryqiu@hku.hk.
†Acknowledgement: We greatly benefitted from our discussions with Pol Antras, Elhanan Helpman, Marc Melitz, and Stephen Yeaple.

1. Introduction

Foreign direct investment (FDI) is playing an increasingly more important role in globalization and the world economic development. In this paper, we investigate the global patterns of export and FDI from different industries in different countries. We also explore how FDI and trade liberalization in one host country affects the source country's labor market and FDI flows to another host country.

The above issues can be best studied using a modified Helpman, Melitz, and Yeaple (HMY) (2004) model with three countries and three types of heterogeneity: heterogenous firms, heterogenous industries, and heterogenous countries. In particular, we consider the case where firms from country H (the home country) produce differentiated goods and contemplate serving two segmented foreign markets, F_1 and F_2fi

Þ

by comparing the export-FDI sorting pattern between the two foreign countries when the two countries are different only in their market size, or education level. The results are simple and intuitive: The market with a smaller size or a lower education level is *tougher* in the sense that the export-FDI cutoff is higher. We then explore the cases where the two foreign countries are different in more than one dimension. The most interesting case is that one country (e.g., a more developed one) has a higher wage rate and a higher education level than the other (i.e., a less developed nality of FDI and export. With regard to the first contribution, none of the existing studies have all three dimensions in one model, except HMY (2004). We can regard the earlier knowledge-capital models as having country heterogeneity because they focus on the how host country's characteristics affect FDI.[3] Yeaple (2003) has two dimensions of heterogeneity, industry and country, in his regression model.[4] Chen and Moore (2009) also have two dimensions of heterogeneity in their model: firm and country.[5] Although HMY (2004) introduce firm heterogeneity into a multicountry (country heterogeneity) and multisector (industry heterogeneity) model, they only focus on two dimensions, firm heterogeneity and industry heterogeneity, in their analysis. They do allow country difference in size. However, they assume that countries are symmetric in all other aspects, and the size difference is so small that the export-FDI cutoffs are the same in all countries, which effectively eliminates country heterogeneity in their analysis and results. In contrast, the main results of our paper are based not only on firm and industry heterogeneities but also on country heterogeneity in a variety of aspects including market size, education level, and economic development.

Our second contribution is on cross-country externalities in export and FDI, which are important but have been neglected in the literature.[6] The commonly perceived cross-country linkage of FDI is implicitly based on the traditional market access models: when policies in one country make FDI in that country more attractive, they divert FDI from other countries. For example, Fung et al. (2010) find that a 10 percent increase in China's FDI causes the eastern and southeastern Asian countries' shares of FDI to Asia to drop by about 2-2.5 percent. This FDI diversion argument assumes resources constraints on the multinationals: When the multinationals undertake new FDI in a country, they have to reduce their FDI in other countries. Hence, there is direct competition for FDI between host countries. We show that competition for FDI can also be indirect: FDI in one country affects the source country's economic condition, which in turn affects FDI in another country. The issue of cross-country linkage of market entry has recently captured the attention of some researchers. Albornoz et al. (2010) find that when a firm exports to a foreign market and finds it profitable, it is more likely that it will export to another foreign market later if market demands across countries are positively correlated. Cherkashin et al. (2010) find that when EU lowers trade barriers, it does not divert Bangladeshi export away from the US but actually raises Bangladeshi exports to both EU and the US markets.[7] Although these two studies have the feature of cross-country externalities, the mechanism that links various foreign countries in our model is very different from theirs. Albornoz et al (2010) assume that demands in foreign markets are positively correlated, and a firm's successful export to one market leads to entry to another market. Cherkashin et al. (2010) find that trade liberalization in one market raises export profitability in that market,

[3] In addtion to the traditional focus on comparative advantages, some previous empirical works have also examined the effects of host countries' other attributes on FDI, e.g., Hartman (1985) on taxes, Head and Mayer (2004) on market potential, and Wei (2000) on quality of institutions. See Blonigen (2005) for an excellent survey of this literature.

[4] Although Yeaple (2003) also emphasizes the characteristics of country-industry pairs in affecting FDI, he does not have a theoretical model to analyze them.

[5] Cherkashin, et al. (2010) also have two dimensions of heterogeneity (firm and country) in their model, but they consider export only (no FDI).

[6] The public and policy makers have voiced concerns about FDI competition. In Asia, the emergence of China has caused the fear that China is adversely affecting FDI flows into their economies. For example, in November 2002, the then Singaporean Deputy Prime Minister, Lee Hsien Loong, commented that "Southeast Asian countries are under intense competitive pressure, as their former activities, especially labor-intensive manufacturing, migrate to China. One indicator of this massive shift is the fact that Southeast Asia used to attract twice as much foreign direct investment as Northeast Asia, but the ratio is reversed." (*China Online*, November 14, 2002).

[7] Other multicountry models (e.g., Chen and Moore, 2010; HMY, 2004) do not have cross-country linkage.

which induces more firms in the home country to enter the industries; these new entrants also export to other markets. In our paper, FDI liberalization in one foreign country induces some domestic firms to switch from export to FDI in that country. This reduction in export reduces labor demand and consequently wage rate drops in the home country. As a result, all firms use domestic labor for production benefit, which raises export profits; thus, some firms substitute exports for FDI in the other foreign country. While all three papers have cross-country externalities in market entry and the other two papers are about export externalities only, our paper is about externalities between foreign countries in both FDI and export. We have also derived the cross-country externality results based on trade liberalization and education improvement.

Our mechanism for cross-country externalities relies on the effect of FDI on the source country's employment or wage rate. Not only is this effect clear in our model but it is also consistent with some empirical findings. Two empirical studies are most relevant in this regard. The first is Harrison and McMillan (2006), which finds that horizontal outward FDI from the US reduces employment of the parent firms in the US. The second is Debarera et al. (2010), which finds that for South Korean firms having FDI in countries with lower per capita income than South Korea, their parent firms' employment in South Korea grows more slowly than those that do not invest abroad.[8] These employment effects of FDI can translate to wage decrease if the wage rate is flexible, and therefore lend support to our prediction that home wage rate drops when there is FDI liberalization in a foreign country.[9]

Our paper is also related to the labor economics literature. Although most papers in international trade take factor endowment as given, researchers in labor economics pay much attention to skill training, which results in changes in factor endowment. Relevant research questions include who (firms or workers) should finance the training and whether there is underprovision for training. The answers depend on whether the trained skills are general or firm specific. See Becker (1964) for the first analysis on skill training and Acemoglu (1999) for a survey of some related studies. In this paper, we consider firm-specific skill training, and firms pay the training costs. Incorporating skill training into our trade-FDI model alone is not very interesting because it simply increases the cost of FDI. Realize the incomplete contracting nature of labor training is important. In the presence of some labor market imperfections [e.g., information about the amount of training investment (Katz and Ziderman, 1990) or about the training level (Chang and Wang, 1996)], contractual friction is inevitable. As argued by Hart and Moore (1994) with regard to the inalienability of human capital, because human capital is associated with the trainees once they are trained, it is inevitable that the trained workers will renegotiate with the firms to split the surplus generated from the training. This contractual friction discourages investment in skill training. The degrees of this friction vary from country to country. It is larger in a country with a lower education level because in the case of a negotiation breakdown, the firm

[8]In fact, the empirical evidence on the employment effects of FDI based on country-level data is mixed. See a literature survey by Debaera et al. (2010). However, the effects become much clearer when the types of FDI are classified into different groups by industry nature, e.g., horizontal or vertical FDI (as in Harrison and McMillan, 2006) or host country's characteristics (as in Debaera et al., 2010). The two cases mentioned above are most closely related to our model.

[9]Our prediction with regard to wage gap is different from those by Markusen and Venables (1997). The models are very different. We emphasize the cross industry differences in skill intensity in production, whereas they focus on the skill-intensity differences in various phrases of the production chain: firm-level entry, plant setup, production stage, etc. Moreover, we consider a foreign country's FDI liberalization effects on the source country's labor market and wage gap, but they consider FDI liberalization in all countries and their impacts on wage gap. The empirical findings on trade and FDI's effects on income gap are mixed. For references, see Feenstra and Hanson (1997) and Slaughter (2000),

has to hire unskilled workers to perform the skilled labor's job in production, resulting in a larger loss if the unskilled workers' education level is lower. For a given degree of friction, the negative effects of contractual friction in more skill-intensive industries are larger than in less skill-intensive industries. Thus, our paper allows us to investigate how a change in one foreign country's education level, which influences contractual friction in that country, affects export and FDI in that country and in the other country as well (through cross-country externalities).

There is an increasing body of studies incorporating the imperfect labor market in models of trade with heterogeneous firms. Helpman and Itskhoki (2009) and Helpman, Itskhoki, and Redding (2010) introduce labor searching and bargaining between firms and workers in the Melitz (2003) model to study the effects of trade on unemployment and wage inequality. The feature of those models with regard to the labor market is searching and matching between firms and workers, but that of our model is labor training. Moreover, the objective of our paper is also very different from theirs: we study cross-country and cross-industry export and FDI patterns in the presence of imperfect labor market.

The paper is organized as follows. We describe the model in Section 2. We perform the equilibrium analysis of export and FDI by heterogeneous firms from the same industry in Section 3. In Section 4, we focus on industry heterogeneity to determine how foreign market entry varies across industries. In Section 5, we analyze how a host country's conditions affect the export-FDI pattern. In Section 6, we show the cross-country externalities of export and FDI. Concluding remarks are presented in Section 7.

is the product set of industry η, and α captures the elasticity of substitution across varieties in the same industry. For the sake of convenience, in what follows, we drop the industry index η whenever we do not need to distinguish the industries. Utility maximization results in the following demand for each variety in any given industry and country:

$$x = A_i p^{-\epsilon}, \qquad \text{where } / = \frac{1}{1-\alpha} > 1, \tag{1}$$

A_i is the industry's aggregate consumption index in the corresponding market, and p is the price. We use A_1 and A_2 to denote the demand level in F_1 and F_2, respectively, and A (without subscript) in H. They are assumed to be given exogenously.

Let us now describe entry and exit in each industry. Following Melitz (2003), we assume that in H, each of the differentiated varieties is produced by a single firm, and each firm produces only one variety. Although there is free entry to the industries, a fixed entry cost is required. A firm needs to hire some skilled labor and some unskilled labor to search for the basic technology required to enter an industry. For simplicity, we assume that the total number of labor required is f_E and half of it is skilled labor. Consequently, the entry cost is equal to $\frac{1}{2}(w+1)f_E$. Upon paying the fixed entry cost, each firm draws a productivity level θ (> 0) from a cumulative distribution, $G(\theta)$, and then decides whether to exit or stay in the industry. If a firm exits, then the game is over for it. If a firm decides to produce, it incurs a fixed plant set-up cost equal to $\frac{1}{2}(w+1)f_D$, where f_D is considered the number of workers, half skilled and half unskilled, hired to set up the production plant. The staying firms also need to decide how much to produce for the domestic market, and how to serve the foreign markets, which can be either export or FDI. Both export and FDI incur additional fixed costs. If the firm exports its product to F_i, it pays an additional overhead cost $w_i f_{Xi}$, where f_{Xi} is the number of workers hired in F_i to set up a distribution network in F_i, and bears an iceberg transport cost: only $\tau \in (0,1)$ unit of the good reaches the destination per unit of the good shipped. If the firm chooses FDI in F_i, it pays an additional overhead cost $w_i f_{Ii}$, where f_{Ii} is the number of workers hired in F_i to set up a plant and a distribution network in F_i. Thus, $w_i(f_{Ii} - f_{Xi})$ represents the extra fixed costs of producing in F_i (i.e., FDI) compared with exporting to F_i. It is reasonable to assume $f_{Ii} - f_{Xi} > 0$.[10]

We next describe the production technologies. Labor is the only factor used to produce the goods. Following the labor economics literature, we use the popular canonical model, which assumes that both skilled labor and unskilled labor are used in the production of a good. See Acemoglu and Autor (2010) for discussions about the popularity and limitation of this model.[11] Specifically, we assume that if firm θ (i.e., the firm with the drawn productivity θ) uses s skilled workers and u unskilled workers, its output becomes

[10]This basic setup is the same as in Melitz (2008), except that we have skilled and unskilled labor for fixed costs. It will become clear later that our specifications of skilled-versus-unskilled labor and domestic-versus-foreign labor in fixed costs have no consequence on the qualitative aspect of the results derived in this study. Only the result on wage gap may be altered in the extreme case, where the fixed FDI cost requires a very large amount of skilled labor from H.

[11]If one wants to analyze the separation of different tasks, which use different skills of labor and are components of the final goods, then the canonical model is not useful. A more general model is required. Acemoglu and Autor (2010) have a general discussion about this, whereas Grossman and Rossi-Hansberg (2008) have a specific analysis of the task model for offshoring. However, outsourcing and offshoring are not issues in our study; the canonical model is not only a simpler one but also a more appropriate one to use.

$$x = \theta \left(\frac{s}{\eta}\right)^{\eta} \left(\frac{u}{1-\eta}\right)^{1-\eta}, \qquad 0 < \eta < 1, \tag{2}$$

where η captures the skilled-labor intensity in production. Thus, industries are different in their skilled-labor intensities.

3. Analysis

All firms are identical ex ante. Hence, our analysis focuses on a firm's decision after entering an industry. As the fixed industry entry cost is sunk, we do not include it in the profit expressions in all the analyses below. In this section, we first analyze a firm's profit from each market, based on which we derive its optimal decision with regard to foreign market entry. For expositional convenience, we use $\Theta \equiv \theta^{\alpha\epsilon}$, which is proportional to the productivity variable θ. Thus, we also regard Θ as a productivity variable.

3.1. Domestic Market

Each firm faces the given market wage rates when it makes the hiring decision. Suppose that a firm hires s skilled workers and u unskilled workers to produce for the domestic market. The firm's profit from the domestic market is

$$\pi_D = A^{1-\alpha}\theta^{\alpha} \left(\frac{s}{\eta}\right)^{\alpha\eta} \left(\frac{u}{1-\eta}\right)^{\alpha(1-\eta)} - sw - u - \frac{1\square}{}$$

subject to the production constraint $x_D + x_1 + x_2 = \theta \left(\frac{s}{\eta}\right)^{\eta} \left(\frac{u}{1-\eta}\right)^{1-\eta}$.

■ *Export to One Country Only*. Suppose that a firm exports to only one foreign country, say F_i, in which case, $x_{j\neq i} = 0$, $e_i = 1$ and, $e_{j\neq i} = 0$. Profit maximization then implies that the marginal revenue in H and that in F_i must be equal, which leads to $A^{1-\alpha} x_D^{\alpha-1} = A_i^{1-\alpha} \tau^{\alpha} x_i{}^{\alpha-1}$ and $x_i = \frac{A_i}{A} \tau^{\alpha\epsilon} x_D$. The firm's optimization problem is reduced to

$$\max_{s,u} \pi_X = Q_i^{1-\alpha} \theta^{\alpha} \left(\frac{s}{\eta}\right)^{\alpha\eta} \left(\frac{u}{1-\eta}\right)^{\alpha(1-\eta)} - sw - u - \frac{1}{2}(w+1) f_D - w_i f_{Xi},$$

where $Q_i \equiv A + A_i \tau^{\alpha\epsilon}$.

We obtain the optimal solution as $s^* = Q_i \eta \alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta$ and $u^* = Q_i (1-\eta) \alpha^{\epsilon} w^{-\alpha\epsilon\eta} \Theta$. Consequently, the optimal profit is $Q_i(1-\alpha)\alpha^{\alpha\epsilon} w^{-\alpha\epsilon\eta} \Theta - \frac{1}{2}(w+1) f_D - w_i f_{Xi} = \pi_D^* + \pi_{Xi}^*$, where the optimal export profit is

$$\pi_{Xi}^* = A_i \tau^{\alpha\epsilon} (1-\alpha) \alpha^{\alpha\epsilon} w^{-\alpha\epsilon\eta} \Theta - w_i f_{Xi}. \tag{3}$$

Evidently, the firm's export activity does not affect its optimal domestic profit π_D^*.

■ *Export to Two Countries*. Suppose that a firm exports to both foreign markets, in which case, $e_1 = e_2 = 1$. Profit maximization implies that the marginal revenues from each of the three markets must be equal, which results in $A^{1-\alpha} x_D^{\alpha-1} = A_1^{1-\alpha} \tau^{\alpha} x_1{}^{\alpha-1} = A_2^{1-\alpha} \tau^{\alpha} x_2{}^{\alpha-1}$. Then, $x_1 = \frac{A_1}{A} \tau^{\alpha\epsilon} x_D$, $\;x_2 = \frac{A_2}{A} \tau^{\alpha\epsilon} x_D$. With this, the firm's optimization problem is reduced to

$$\max_{s,u} \pi_X = Q^{1-\alpha} \theta^{\alpha} \left(\frac{s}{\eta}\right)^{\alpha\eta} \left(\frac{u}{1-\eta}\right)^{\alpha(1-\eta)} - sw - u - \frac{1}{2}(w+1) f_D - w_1 f_{X1} - w_2 f_{X2},$$

where $Q \equiv A + (A_1 + A_2)\tau^{\alpha\epsilon}$.

The optimal solution is $s^* = Q \eta \alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta$ and $u^* = Q(1-\eta) \alpha^{\epsilon} w^{-\alpha\epsilon\eta} \Theta$, and the optimal profit is $Q(1-\alpha)\alpha^{\alpha\epsilon} w^{-\alpha\epsilon\eta} \Theta - \frac{1}{2}(w+1) f_D - w_1 f_{X1} - w_2 f_{X2} = \pi_D^* + \pi_{X1}^* + \pi_{X2}^*$. Hence, the firm's total profit is simply the sum of the optimal profits from each individual markets.

■ *Summary*. For a firm with $\Theta > \Theta_D$, if it does not take FDI, then its total profit is

$$\Pi_X^* = \pi_D^* + e_1 \pi_{X_1}^* + e_2 \pi_{X_2}^*,$$

where $e_i = 1$ if $\pi_{X_i}^* > 0$ and $e_i = 0$ otherwise. In particular, at the firm level, the decision on whether or not to export to one foreign market is not affected by its entry decision in the other foreign market. Define Θ_{Xi} from $\pi_{Xi}^*(\Theta_{Xi}) = 0$. Then,

$$\Theta_{Xi} \equiv \frac{w^{\alpha\epsilon\eta} w_i f_{Xi}}{A_i \tau^{\alpha\epsilon} (1-\alpha) \alpha^{\alpha\epsilon}}. \tag{4}$$

Given the other parameters, we have $\pi^*_{Xi} > 0$ if and only if $\Theta > \Theta_{Xi}$.

To obtain the case where some firms are pure domestic producers, we need to impose the condition $\Theta_D < \Theta_{Xi}$, which is $\frac{2A}{A_i\tau^{\alpha\epsilon}} > \frac{(w+1)f_D}{w_i f_{Xi}}$. This is typically true in a model like ours that considers a large developed country as the home country, that is, A is larger than A_i; assuming $f_{Xi} > \tau^{\alpha\epsilon} f_D$ is common in the literature. However, all the main results derived in this study remain unchanged if this condition is violated; thus, there are no pure domestic firms.

3.3. FDI and Labor Training

When a firm chooses FDI to enter a foreign country, it produces the good in the host country. We do not consider export-platform FDI and thus rule out the case where a firm undertakes FDI in F_i and sells the output from its subsidiary to the market in H or F_j.[12] There are three options for a firm's FDI decision: (i) a firm undertakes FDI in both F_1 and F_2, (ii) it undertakes FDI in F_1 only, and (iii) it undertakes FDI in F_2 only. As for any single firm, entry and production in one country does not affect entry and production in another country, we can investigate a firm's FDI in each country separately.

Suppose that a firm undertakes FDI in F_i. Then in F_i, the firm hires local workers to produce. However, because there is no skilled labor in F_i, the firm needs to provide training to some workers to acquire the skill.[13] For simplicity, we assume that the firm pays the training cost, which is t_i per worker, and workers need not to exert any effort in the learning. As a result, the firm pays both the unskilled workers and the trained workers the market wage rate, w_i. If the firm trains s_i workers and hires u_i unskilled workers in production, its output is given from the production function as in (2). However, anticipating that the firm can benefit from getting the trained-workers' services, the trained workers may bargain with the firm after the training but at the right beginning of the production.[14]

What is the outside option for the trained workers? Following the labor economics literature, assume that the (short-term, on-the-job) training is firm specific.[15] That is, the trained skill provided by the firm for producing a variety is no use for production of another variety. Thus, if the trained workers quit, theywould go back to the labor pool and receive the market wage w_i.

What is the outside option for the firm? Due to the inalienability of human capital, the firm and the skilled workers can not contract ex ante upon the trained-workers' future services.[16] As there would be no time to train new workers if the trained workers quit, the firm has to hire the unskilled workers to take the skilled jobs, which would

[12] Antras and Foley (2010) study the implications of a free trade agreement between two foreign countries on FDI in those countries in the presence of export-platform FDI.

[13] See Acemoglu and Pischke (1999) for a discussion and literature on skill training. With some labor market imperfections, which we implicitly assume, we can allow trained skill to be general (not firm specific).

[14] Contractual frictions exist in the presence of labor market imperfections, such as informational imferctions as analyzed by Acemoglu and Pischke (1999) and some studies cited in their paper. In order not to divert our attention, we do not explore the optimal labor contracts that might help mitigate or even eliminate contractual frictions (see Acemoglu and Pischke, 1999, for a discussion).

[15] An alternative theory based on adverse selection argues that the training could be general. However, due to the information asymmetricity on the employee's ability, if the employee quits the current firm, he/she will suffer a decrease in his/her earning because the new employer does not know his/her productivity; thus, the employee is also locked-in (see Acemoglu and Pischke, 1998 and 1999).

[16] Following Hart and Moore (1994), we also suppose that at the beginning they cannot contract upon the future output or revenue either. In the European Chamber's 2007 survey of European firms in China, 64 percent of the firms find it more difficult to retain engineers in China than in Europe, and the number is 74 percent for sales persons.

inevitably lower the productivity.[17] Suppose the productivity discount rate is $1 - \delta_i \in (0, 1)$, in the sense that if the firm hires u_i unskilled workers to take the unskilled jobs and s_i unskilled workers to take the skilled jobs, the output becomes

$$x_i = \delta_i \theta \left(\frac{s_i}{\eta}\right)^{\eta} \left(\frac{u_i}{1-\eta}\right)^{1-\eta}.$$

The degree of productivity loss is determined by the gap between the basic capability of the unskilled labor without training and their capability after training. This basic capability is affected by many factors, including general education. For convenience, we simply consider δ_i as labor's education level in F_i.

Let us now turn to the bargaining between the firm and the trained workers, assuming that the trained workers act as a union so that they quit or stay with one decision.[18] If the trained workers stay with the firm, the firm's profit from market F_i (excluding training cost and fixed cost $w_i f_{Ii}$, which are sunk) is $A_i^{1-\alpha} \theta^{\alpha} \left(\frac{s_i}{\eta}\right)^{\alpha\eta} \left(\frac{u_i}{1-\eta}\right)^{\alpha(1-\eta)} -$

a result, the firm's optimal profit from FDI in F_i is

$$\pi^*_{Ii} = \mathsf{A}_i \frac{(2-\alpha)}{2^{\epsilon}} \alpha^{\alpha\epsilon} \left(\frac{1+\delta_i^{\alpha}}{\mathsf{w}_i}\right)^{\alpha\epsilon} \left(\frac{\mathsf{w}_i}{\mathsf{w}_i+\mathsf{t}_i}\right)^{\alpha\epsilon\eta} \Theta - \mathsf{w}_i \mathsf{f}_{Ii}. \tag{5}$$

We define Θ_{Ii} from $\pi^*_{Ii}(\Theta_{Ii}) = 0$, which yields

$$\Theta_{Ii} \equiv \frac{(2\mathsf{w}_i)^{\epsilon} \mathsf{f}_{Ii}}{\mathsf{A}_i(2-\alpha)\alpha^{\alpha\epsilon}(1+\delta_i^{\alpha})^{\alpha\epsilon}} \left(\frac{\mathsf{w}_i+\mathsf{t}_i}{\mathsf{w}_i}\right)^{\alpha\epsilon\eta} \tag{6}$$

We have $\pi^*_{Ii} > 0$ if and only if $\Theta > \Theta_{Ii}$.

3.4. Optimal Foreign Market Entry Decisions by Heterogenous Firms from a Given Industry

As previously shown, a firm's entry decision in one foreign market (export or FDI) does not affect its optimal decision in the other markets. Hence, we can derive a firm's optimal decision in each market separately. The firm chooses export to F_i if and only if $\pi^*_{Xi} > \max\{0, \pi^*_{Ii}\}$. The firm chooses FDI to enter F_i if and only if $\pi^*_{Ii} > \max\{0, \pi^*_{Xi}\}$. Let us define Θ_i from $\pi^*_{Ii}(\Theta_i) - \pi^*_{Xi}(\Theta_i) = 0$, which yields

$$\Theta_i \equiv \frac{\mathsf{w}_i(\mathsf{f}_{Ii} - \mathsf{f}_{Xi})}{\mathsf{A}_i \alpha^{\alpha\epsilon} \Gamma}, \tag{7}$$

where

$$\Gamma \equiv \left(\frac{2-\alpha}{2}\right) \left(\frac{1+\delta_i^{\alpha}}{2\mathsf{w}_i}\right)^{\alpha\epsilon} \left(\frac{\mathsf{w}_i}{\mathsf{w}_i+\mathsf{t}_i}\right)^{\alpha\epsilon\eta} - \tau^{\alpha\epsilon}(1-\alpha)\mathsf{w}^{-\alpha\epsilon\eta}.$$

If we draw the firm's export profit and FDI profit lines against Θ, we obtain Figure 1. The two lines intersect (at Θ_i) if and only if the slope of π^*_{Ii} is steeper than that of π^*_{Xi}, which requires

$$\frac{\tau^{\alpha\epsilon}(1-\alpha)}{\left(\frac{2-\alpha}{2}\right) \mathsf{w}^{\alpha\epsilon\eta} \left(\frac{1+\delta_i^{\alpha}}{2w_i}\right)^{\alpha\epsilon} \left(\frac{w_i}{w_i+t_i}\right)^{\alpha\epsilon\eta}} < 1.$$

Note that if π^*_{Ii} is too steep, we will have $\Theta_{Xi} > \Theta_i$, resulting in no firm choosing export in F_i. To obtain the most interesting case, as shown in Figure 1, for all industries, we need to confine to the condition $\Theta_{Xi} < \Theta_{Ii}$, which is

$$\frac{\tau^{\alpha\epsilon}(1-\alpha)}{\left(\frac{2-\alpha}{2}\right) \mathsf{w}^{\alpha\epsilon\eta} \left(\frac{1+\delta_i^{\alpha}}{2w_i}\right)^{\alpha\epsilon} \left(\frac{w_i}{w_i+t_i}\right)^{\alpha\epsilon\eta}} > \frac{\mathsf{f}_{Xi}}{\mathsf{f}_{Ii}}$$

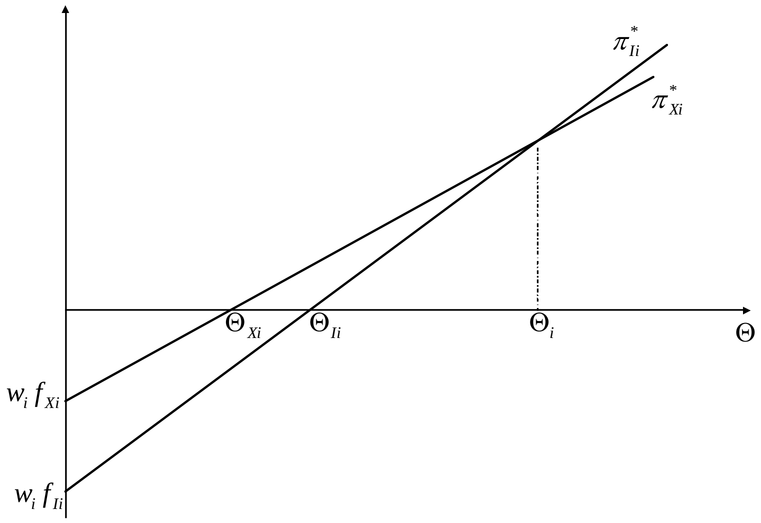

Figure 1: Sorting of Foreign Market Entry by Heterogenous Firms

Hence, to ensure the existence of Θ_i and $\Theta_{Xi} < \Theta_i$ in all industries, we assume

$$\frac{f_{Xi}}{f_{Ii}} < \frac{\tau^{\alpha\epsilon}(1-\alpha)}{\left(\frac{2-\alpha}{2}\right) w^{\alpha\epsilon\eta} \left(\frac{1+\delta_i^{\alpha}}{2w_i}\right)^{\alpha\epsilon} \left(\frac{w_i}{w_i+t_i}\right)^{\alpha\epsilon\eta}} < 1. \tag{C1}$$

With the above analysis, we can now characterize all firms' entry decisions in any given industry. The five cutoff points, Θ_D, Θ_{X1}, Θ_{X2}, Θ_1 and Θ_2, together partition the whole productivity space and the firms entry decisions are determined by their individual productivity positions. In turn, the cutoff points are determined by all parameters that characterize the home and foreign countries' economic conditions. Let

$$C = \{A, w, f_D; A_1, w_1, f_{I1}, f_{X1}, t_1, \delta_1; A_2, w_2, f_{I2}, f_{X2}, t_2, \delta_2\}$$

be the parameter space of economic conditions and $c \in C$ be a specific situation. Suppose that (C1) is satisfi the fixed entry costs and fixed plant setup costs. The home country's skilled labor market equilibrium is established by equating labor supply L and labor demand, which is given on the right-hand-side of the following equilibrium condition

$$L = \int_0^1 \left\{ \frac{1}{2} f_E + \int_{\Theta_D}^{\infty} \left[A\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta + \frac{1}{2} f_D \right] dG(\Theta) \right. \\ \left. + \int_{\Theta_{X1}}^{\Theta_1} A_1 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta dG(\Theta) + \int_{\Theta_{X2}}^{\Theta_2} A_2 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta dG(\Theta) \right\} d\eta. \tag{8}$$

Thus, skilled labor's wage rate, w, is determined by (8).

Two remarks are in order. First, if the skilled workers' wage is too high, firms may rather train unskilled labor instead of hire skilled labor directly. To avoid this unnecessary complication, we assume $w < 1 + t$, where t is the training cost per worker in H. This can be assumed directly because we suppose that skilled labor supply L is sufficiently high, which makes w sufficiently low. Second, w needs to be sufficiently small to satisfy (C1). The assumption of sufficiently high L can make this happen. Note that w is bounded from 1; thus, the second inequality of (C1) does not impose additional constraint on w.

4. Industry Heterogeneity and Foreign Market Entry

In Section 3, we have analyzed the sorting pattern of foreign market entry based on firms' productivity in any *given* industry, that is, given η. In this section, our focus is on the sorting pattern of foreign market entry based on different industries. Our specific question is as follows: for firms with the same productivity level, that is, given Θ, but from different industries, how are their foreign market entry decisions different?

From (5), π^*_{Ii} is a decreasing function of η. In industries where skilled labor is more important, FDI will incur a larger loss due to labor training in the foreign countries. From (3), we also note that π^*_{Xi} is decreasing in η because in H skilled labor is more expensive than unskilled labor; thus, the labor cost is higher in more skill-intensive industries. A firm in industry η prefers FDI to export if and only if $\pi^*_{Ii} > \pi^*_{Xi}$. There are many possible outcomes from such a comparison because both π^*_{Ii} and π^*_{Xi} curves have negative slopes. In what follows, we provide sufficient conditions to obtain one interesting and realistic outcome that we will focus on. First, assume

$$\frac{w_i}{w_i + t_i} < \frac{1}{w}. \tag{C2}$$

This condition implies that the training costs in the foreign countries are high, but the skilled-labor wage rate in H is not too high (which would be the case if the skilled-labor endowment in H is large). In this case, as an industry become more skill intensive, the FDI profit drops more rapidly than export profit. This can be confirmed from the following inequality

$$
\begin{aligned}
\frac{\partial \pi^*_{Ii}}{\partial \eta} - \frac{\partial \pi^*_{Xi}}{\partial \eta} &= A_i \frac{(2-\alpha)}{2^{\epsilon}} \alpha^{\alpha\epsilon} \left(\frac{1+\delta_i^{\alpha}}{w_i}\right)^{\alpha\epsilon} \left(\frac{w_i}{w_i+t_i}\right)^{\alpha\epsilon\eta} \Theta\alpha / \ln\left(\frac{w_i}{w_i+t_i}\right) \\
&\quad - A_i \tau^{\alpha\epsilon}(1-\alpha)\alpha^{\alpha\epsilon} w^{-\alpha\epsilon\eta} \Theta\alpha / \ln\left(\frac{1}{w}\right) \\
&< A_i \tau^{\alpha\epsilon}(1-\alpha)\alpha^{\alpha\epsilon} w^{-\alpha\epsilon\eta} \Theta\alpha / \left[\ln\left(\frac{w_i}{w_i+t_i}\right) - \ln\left(\frac{1}{w}\right)\right] \\
&< 0.
\end{aligned}
$$

Thus, when we draw the two profit curves (against η), as shown in Figure 2, π^*_{Ii} is steeper (negatively sloped) than π^*_{Xi}.

Second, suppose $\pi^*_{Ii}(\eta = 1) < \pi^*_{Xi}(\eta = 1)$, which holds for all Θ if and only if

$$
\left[\frac{(2-\alpha)}{2^{\epsilon}} \left(\frac{1+\delta_i^{\alpha}}{w_i+t_i}\right)^{\alpha\epsilon} - \tau^{\alpha\epsilon}(1-\alpha) w^{-\alpha\epsilon}\right] < \frac{w_i(f_{Ii} - f_{Xi})}{A_i \alpha^{\alpha\epsilon}}. \tag{C3}
$$

Third, let Θ_0 be the (unique) value such that $\pi^*_{Ii}(\eta = 0) = \pi^*_{Xi}(\eta = 0)$ holds, which implies

$$
\Theta_0 = w_i(f_{Ii} - f_{Xi}) / A_i \alpha^{\alpha\epsilon} \left[\frac{(2-\alpha)}{2^{\epsilon}} \left(\frac{1+\delta_i^{\alpha}}{w_i}\right)^{\alpha\epsilon} - \tau^{\alpha\epsilon}(1-\alpha)\right].
$$

Then, $\pi^*_{Ii}(\eta = 0) > \pi^*_{Xi}(\eta = 0)$ if and only if $\Theta > \Theta_0$. We can draw Figure 2 under (C2) and (C3) for any given $\Theta > \Theta_0$. The single-crossing point, η_i^*, is given from $\pi^*_{Ii}(\eta_i^*) = \pi^*_{Xi}(\eta_i^*)$, or $A_i \alpha^{\alpha\epsilon}\Gamma\Theta = w_i(f_{Ii} - f_{Xi})$, which is identical to (7). For any given $\Theta > \Theta_0$, FDI is preferred to export if $\eta < \eta_i^*$ and export is preferred to FDI if $\eta > \eta_i^*$. Thus, for skill-intensive industries, firms are more likely to choose export over FDI. That is, skill intensity discourages FDI.[20]

Note that if $\Theta < \Theta_0$, the two profit curves do not cross and $\pi^*_{Ii} < \pi^*_{Xi}$ in all industries.

We now combine the analysis on foreign market entry for heterogenous firms and that on heterogenous industries in Figure 3. The positive slope of the export-FDI division line is proven in Appendix A. Note obtaining $\Theta_D \geq \Theta_0$ is possible. However, our main results do not depend on the ranking of Θ_D and Θ_0.

The analysis above allows us to establish the following proposition.

Proposition 1. The export-FDI cutoff of productivity level is higher in more skill-intensive industries than less skill-intensive industries.

F2.8(r.8(stri408d)-54(opos(i)-6.ition)-253.8(a)-1(lsoon)-253.i(t)-.that9)-3.6(gets51.1(v)15.2oura2.8(r.8(e(a)-1(fs,)]TJ/TT71Tf)1

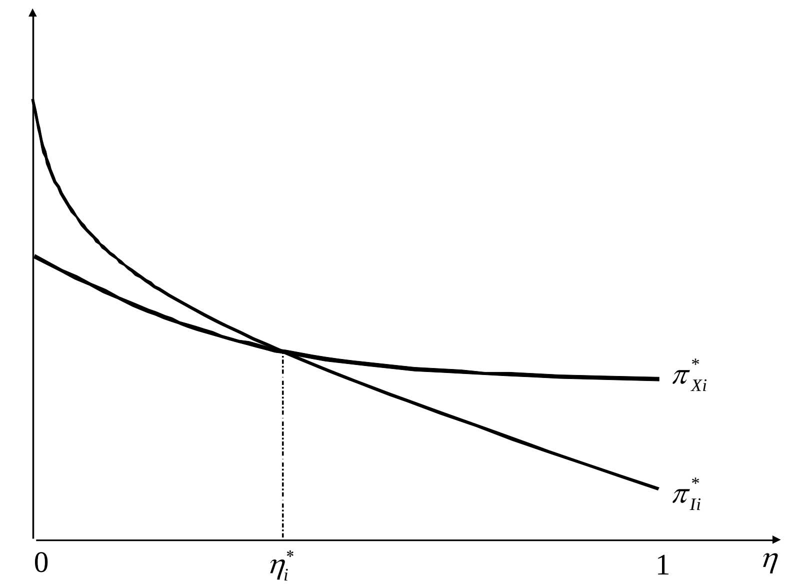

Figure 2: Sorting of Foreign Market Entry by Heterogenous Industries

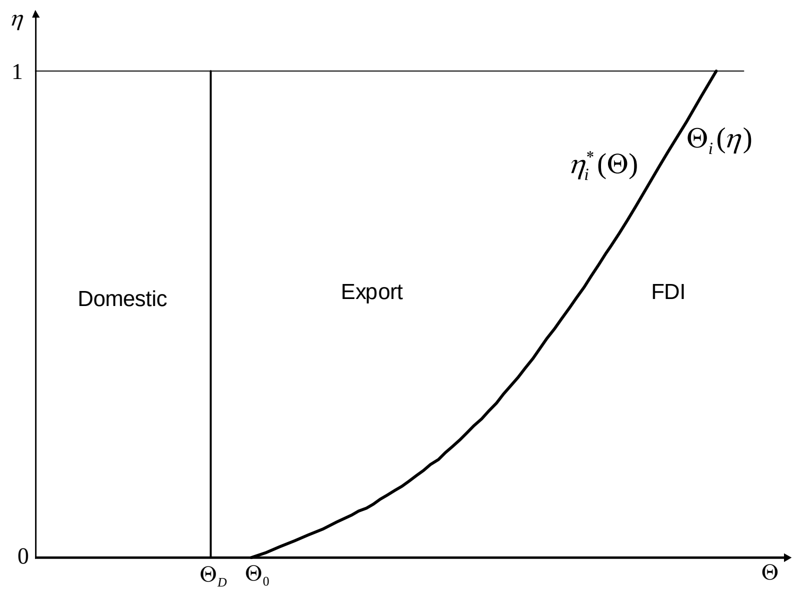

Figure 3: Sorting of Foreign Market Entry by Firms and Industries

5. Country Heterogeneity and Foreign Market Entry

In the previous sections, we have investigated foreign market entry by heterogenous firms in a given industry and by equally efficient firms from heterogenous industries, as summarized in Figure 3. In this section, we turn our attention to country heterogeneity. In this model, the two foreign countries can be different in many dimensions, that is, market size (A_i), wage rate (w_i), education level (δ_i), training cost (t_i), fixed entry costs (f_{Xi} and f_{Ii}); thus, our analysis focuses on some of them.

Aside from focusing on certain important dimensions, we also restrict the parameter space to avoid having too many cases to discuss. Recall that in the previous sections, we characterized the conditions for $\Theta_D < \Theta_{Xi} < \Theta_{Ii}$. In this section, we assume that all those conditions still hold. Then, the central issue is how the sorting patterns are different between the two foreign countries. That is, we are interested in the comparison between Θ_{X1} and Θ_{X2}, that between Θ_{I1} and Θ_{I2}, and that between η_1^* and η_2^*.

As one central question of this paper is how the presence of labor training and contract friction affects H firms' foreign market entry, we assume $t_1 + w_1 = t_2 + w_2$ to eliminate the cost difference between the two foreign countries.[21] Without loss of generality, let $t_1 + w_1 = t_2 + w_2 = 1$. For the same reason, we also assume $w_1 f_{X1} = w_2 f_{X2}$, and $w_1 f_{I1} = w_2 f_{I2}$.

5.1. Single-dimensional Heterogeneity

In this subsection, we explore two cases where the two foreign countries are different in one aspect only: market size or education level. Accordingly, we assume $w_1 = w_2$.

■ *Market Size Difference*

Suppose that the two foreign countries are different only in market size. In particular, suppose $A_1 > A_2$, but $w_1 = w_2$ and $\delta_1 = \delta_2$. Then, for any given firm, $\pi_{X1}^* - \pi_{X2}^* = (A_1 - A_2)(1-\alpha)\tau^{\alpha\epsilon}\alpha^{\alpha\epsilon}w^{-\alpha\epsilon\eta}\Theta > 0$, and $\pi_{I1}^* - \pi_{I2}^* = \frac{1}{2^\epsilon}(2-\alpha)\alpha^{\alpha\epsilon}(A_1 - A_2)\Theta\left(\frac{1+\delta_1^\alpha}{w_1}\right)^{\alpha\epsilon} w_1^{\alpha\epsilon\eta} > 0$. Hence, the country with a larger market (F_1) is more attractive than the other (F_2) in both export and FDI. Although some firms find it not profitable to export to F_2, they find it profitable to export to F_1. Although some firms find it not profitable to have FDI in F_2, they find it profitable to have FDI in F_1. This comparison is simple and intuitive, but it does not tell us anything about the difference in entry decision between the two foreign countries. The foreign market entry decision, between export and FDI, is affected by the relative attractiveness of FDI to export. In what follows, we show that the relative attractiveness of FDI to export in the country with a larger market (F_1) is greater than that in the other (F_2). The reason is that the firm has a lower marginal cost with FDI than with export; thus, it benefits more with FDI than with export in bigger market.

For firms from the same industry, a direct comparison based on the expression of Θ_i yields $\Theta_1 < \Theta_2$. *Hence, although some firms [$\Theta \in (\Theta_1, \Theta_2)$] find it profitable to have export and FDI in both countries, they choose FDI in F_1 but export to F_2.* The result that the larger market attracts more FDI is definitely not surprising, and it has

[21] Although the comparative advantage motive for FDI can be easily analyzed in this framework, we abstract from it to highlight the importance of labor training and general education level. This is achieved in our analysis by assuming that the labor costs (i.e., basic wage and training cost) are identical in the two foreign countries.

been empirically confirmed by many existing studies (e.g., Yeaple, 2003). Our analysis at the firm level provides a theoretical explanation for Yeaple's (2003) empirical finding at country level: the export/FDI ratio is lower in larger markets.[22]

We can also see how the industry sorting is different between the two countries. Based on (7) and with $\frac{\partial \Gamma}{\partial \eta} < 0$ (see Appendix A), total differentiation yields $\frac{\partial \eta_i^*}{\partial A_i} > 0$; thus, $\eta_1^* > \eta_2^*$ because $A_1 > A_2$. *Thus, for firms with the same productivity level, those in industries with* $\eta \leq \eta_2^*$ *choose FDI in both* F_1 *and* F_2*, those in industries with* $\eta \geq \eta_1^*$ *choose export to both countries, and those in industries with* $\eta \in (\eta_2^*, \eta_1^*)$ *choose FDI in* F_1 *but export to* F_2. Therefore, the larger country attracts more firms from skill-intensive industries to undertake FDI than the smaller country. This country-industry pairing has not been derived and tested in the literature. However, some other types of country-industry pairing can be found: for example, using industry level data, Yeaple (2003) finds that countries with abundant skilled labor will attract more FDI from skill-intensive industries.

■ *Education Level Difference*

Suppose that the two foreign countries differ only in education level. Specifically, assume $A_1 = A_2$, $w_1 = w_2$, but $\delta_1 > \delta_2$. A firm does not produce in country F_1 or F_2 if it chooses export; thus, the education level of the foreign workers does not affect the firm's export profit. However, in the case of FDI, the firm hires local workers in the host countries for production. In a host country with a higher education level, the firm's outside option is also higher, which results in a higher FDI profit. Hence, the country with the higher education level is always more attractive for FDI than the country with the lower education level. These two comparisons immediately lead to the following result: although some firms find it not profitable to have FDI in F_2, they find it profitable to have FDI in F_1. This is formally proved as follows.

If we fix the industry, then from (4) and (6), we have $\Theta_{X1} = \Theta_{X2}$ and $\Theta_{I1} < \Theta_{I2}$. Hence, $\Theta_1 < \Theta_2$. If we fix the level of productivity, then, because $\frac{\partial \Gamma}{\partial \delta_i} > 0$ and $\frac{\partial \Gamma}{\partial \eta} < 0$, we obtain $\frac{\partial \eta_i^*}{\partial \delta_i} > 0$ from (7). Hence, $\eta_1^* > \eta_2^*$. That is, for firms with the same given productivity level, those from industries with $\eta \in (\eta_2^*, \eta_1^*)$ will choose FDI in F_1 but export to F_2, although others have the same foreign market entry decisions in both F_1 and F_2. Both proofs show that *the country with the higher education level will attract more FDI than the country with the lower education level.*

5.2. Multidimensional Heterogeneity

In reality, countries are different in many dimensions. This subsection is devoted to examining how a firm's foreign market entry decisions are different in the two foreign countries, which are different in more than one dimension. As there are too many cases in which countries are different, let us focus on just one that we think is both realistic and interesting: $A_1 = A_2$, but $w_1 > w_2$ and $\delta_1 > \delta_2$. This captures the situation where a more developed country generally has a higher wage rate and a higher education level. Note that a more developed country may not have a larger market, which is affected not only by the development level but also the population size. Our specifications also imply $t_1 < t_2$, which is reasonable because training workers from a more developed country is generally easier than from a less developed country.

[22] According to Yeaple (2003), his finding indicates that firms tend to substitute FDI for export to larger markets. We show that the firms with median level productivity are the ones that make this substitution.

Let us first focus on any given industry η. As $A_1 = A_2$ and $w_1 f_{X1} = w_2 f_{X2}$, we can easily obtain $\pi^*_{X1} = \pi^*_{X2}$ from (3). This result of equal export profits is clear because export profit is not affected by the foreign country's wage rate and education level.

Utilizing $t_1 + w_1 = t_2 + w_2 = 1$ in (5), we can rewrite a firm's FDI profit in F_i to $\pi^*_{Ii} = A_i 2^{-\epsilon}(2-\alpha)\alpha^{\alpha\epsilon}\Theta(1+\delta_i^{\alpha})^{\alpha\epsilon} w_i^{\alpha\epsilon(\eta-1)} - w_i f_{Ii}$. Given any η, we can view π^*_{Ii} as a function of Θ, which is linear. Note that $\pi^*_{I1}(\Theta = 0) = -w_1 f_{I1} = -w_2 f_{I2} = \pi^*_{I2}(\Theta = 0)$, and that the profit line $\pi^*_{I1}(\Theta)$ is steeper than that of $\pi^*_{I2}(\Theta)$ if and only if

$$\left(\frac{w_1}{w_2}\right)^{1-\eta} < \frac{1+\delta_1^{\alpha}}{1+\delta_2^{\alpha}}. \tag{9}$$

The following result is straightforward.

Lemma 1. In any given industry, if (9) holds, then all firms' FDI profits in F_1 are larger than in F_2. The result is reversed if the inequality in (9) is reversed.

The above result is intuitive. There is also a tradeoff for a firm's FDI profit: a higher education level reduces the profit loss from contractual friction, but a higher wage rate raises the production cost. If (9) holds, the relative education advantage associated with F_1 is stronger than the relative cost disadvantage with it; thus, the FDI profit in F_1 is higher.

However, condition (9) is affected by the degree of skill intensity, and hence the FDI profit comparison can be different for different industries. Proposition 2 can be easily established.

Proposition 2. (i) If (9) holds at $\eta = 0$, we have $\Theta_1 < \Theta_2$ for all η;

(ii) If (9) is reversed at $\eta = 0$, then, there exists $\tilde{\eta} \in (0, 1]$ such that $\Theta_1 < \Theta_2$ for all $\eta \in (\tilde{\eta}, 1]$, and $\Theta_1 > \Theta_2$ for other η.

Proof. See Appendix B.

When (9) holds at $\eta = 0$, F_1's education advantage over F_2 is very strong relative to its production cost disadvantage. As a result, F_1 is more attractive for FDI than F_2 (in the sense that $\Theta_1 < \Theta_2$) in all industries. If the advantage is not so strong [i.e., (9) is reversed at $\eta = 0$], then the skill intensity matters. In high skill-intensive industries, education level matters more, and thus, F_1 is more attractive for FDI than F_2. However, but in low skill-intensive industries, education level matters less, and thus, F_1 is less attractive for FDI than F_2 because F_2 has a lower wage rate.

6. Wage Rate and Cross-country Externalities

After conducting the equilibrium analysis in the preceding sections, we are now ready to examine whether a change in economic condition in one foreign country affects H firms' entry decisions in the other foreign country. That is, we want to determine whether there exist cross-country externalities in market entry decisions. We will examine various cases of exogenous condition changes.[23] Note that we no longer need to maintain the many assumptions imposed for country comparisons in Section 5.

6.1. FDI Liberalization

Suppose that the government in F_1 lowers the fixed cost of FDI in its country (e.g., subsidization on plant building) so that f_{I1} decreases.

Based on our earlier analysis, f_{I1} affects Θ_1 directly and affects all other cutoffs indirectly through its effect on w. The question is whether the effects are positive or negative and how strong each effect is. Note that $\frac{\partial\Theta_1}{\partial f_{I1}} > 0$. This direct effect is clear: a reduction in F_1's fixed FDI cost encourages the marginal firms in all industries to switch from export to FDI in F_1. This switch affects the home country's labor demand, which will in turn generates the indirect effects on H firms' market entry decisions in both the home and foreign countries. These changes in entry decision once again affect labor demand in the domestic labor market. To obtain the equilibrium effects, we take the total differentiation in the home country's labor market equilibrium equation as given by (8). This allows us to obtain (see Appendix C for the detailed steps)

$$\Phi_1 \frac{dw}{df_{I1}} = \Phi_2, \tag{10}$$

where Φ_i are some complicated functions as given in the proof, and both are positive. Therefore, we have $\frac{dw}{df_{I1}} > 0$. Although the wage rate drops, we still have $\frac{d\Theta_1}{df_{I1}} > 0$ (see proof in Appendix D). That is, the reduction in wage rate will not offset or reverse the initial switch from export to FDI.

Note from (7), $\frac{d\Theta_2}{dw} < 0$. Hence, $\frac{d\Theta_2}{df_{I1}} = \frac{d\Theta_2}{dw}\frac{dw}{df_{I1}} < 0$.

Clearly we can also have $\frac{dw}{df_{I2}} > 0$ and $\frac{d\Theta_1}{df_{I2}} < 0$.

As FDI liberalization does not affect the domestic wage rate for unskilled workers, FDI liberalization (in either one of the foreign countries) clearly reduces H's wage inequality between skilled and unskilled labor.

We summarize the analysis above in the following proposition.

Proposition 3. FDI liberalization in one foreign country (i) induces more FDI and reduces export to this country; (ii) reduces FDI and increases export to the other foreign country; and (iii) lowers the skilled labor's wage rate and reduces the wage gap between the skilled and unskilled labor in the home country.

There are three important points in Proposition 3. First, it shows the existence of cross-country externalities in firms' foreign market entry decisions. Second, it emphasizes the channel through which one foreign country's FDI

[23] Antras and Foley (2010) include a multicountry feature in their model and also explore how economic policy changes in the host countries affect FDI. In particular, they examine how the formation of a free trade agreement between two foreign countries affects the home firms entry strategies. However, their focus is very diferent from ours: we consider one country's policy change and its effects on the other country, whereas they consider a joint policy change of the two foreign countries. Although they also predict FDI substitution, the reason is very different from that in this study.

firms choose export (Θ_{X1} drops) to this country, substituting FDI (Θ_1 increases). This raises the demand for labor in H. The wage rate for skilled labor increases, worsening the wage inequality. This wage hike reduces the profitability of domestic production; thus, increases the cutoffs Θ_D and Θ_{X2} but lowers Θ_2; that is, export to F_2 drops while FDI to F_2 increases.

6.3. Education Improvement

Suppose that one foreign country, say F_1, significantly improves its labor's education level. As a result, δ_1 increases. Note that $\frac{\partial \Theta_1}{\partial \delta_1} < 0$. Hence, the immediate effect of education improvement in F_1 is that more FDI is attracted to this country and less export is taken by H's firms to enter F_1. This reduces the labor demand in H, lowers wage rate for skilled labor, and reduces the wage gap. Finally, the decline in wage rate induces more export and less FDI to F_2. The equilibrium results of education improvement are the same as those of FDI liberalization. The formal proof is given in Appendix F.

7. Concluding Remarks

This paper extends the HMY (2004) model to include two factors of production and the three dimensions of heterogeneity: firm heterogeneity, industry heterogeneity, and country heterogeneity. In addition to the usual finding in the Melitz (2003) types of models where in a given industry the most efficient firms choose FDI, median efficient firms choose exports, and less efficient firms stay in the home market, we also find that for firms with the same efficiency level but from different industries, those from high skill-intensive industries choose export, whereas those from low skill-intensive industries choose FDI. Foreign countries have different attractiveness to FDI and export depending on their market size, education level, and economic development level, which are all conducive to FDI. Policy changes in one foreign country affect not only FDI and export in that country, but also FDI and export in the other foreign country, and thus policy exhibits cross-country externalities. The mechanism of such cross-country externalities works through the indirect effects of the policy changes on the source country's labor market. For example, FDI liberalization on one foreign country induces some firms from the source country in all industries to switch from export to FDI, which reduces the demand for labor and hence wage rate in the source country. As a result, some firms switch from FDI to export to another foreign country. This FDI liberalization reduces the source country's wage for skilled labor and narrows the wage gap.

To focus on the cross-country externalities, we simplified the domestic labor market by assuming that the unskilled labor's wage rate is fixed due to a large supply of unskilled labor or the use of unskilled labor in the production of numeraire goods. This is perfectly legitimate, and relaxing this restriction will not affect the main results of the paper. However, one (and only one) of the results need to be reexamined: the FDI liberalization's effect on wage gap. With FDI liberalization in one foreign country, the demand for both skilled and unskilled labor drops due to the switch from export to FDI by some firms. In equilibrium, the wage rate for skilled and that for unskilled labor both drop. The question is which drops more. We hypothesize that the wage gap drops, that is, the result obtained when we fix the unskilled labor's wage rate still holds. This is the logic. Recall that the cutoff Θ_1 is larger in more skill-intensive industries than in less skill-intensive industries. That is, the switch from export to FDI in more skill-intensive industries is made by firms with a higher productivity level, and they produce more output than those that make the switch in less skill-intensive industries. Thus, the reduction in demand for skilled labor is larger than the reduction in demand for unskilled labor; thus, the wage rate drops for skilled labor is more drastic than that for unskilled labor.

Our paper has produced a number of testable predictions, such as the relationship between industry skill intensity and firm productivity with regard to firms' choice between FDI and export and the effects of foreign country's FDI liberalization, trade liberalization, and education improvement on domestic wage rates and wage inequality. Although some of these findings are indirectly consistent with those from some existing empirical studies, it would be ideal to conduct an empirical analysis using firm-level data to test all our hypotheses directly. The most interesting hypothesis is the linkage between the changes in FDI (and exports) in two foreign countries via the domestic labor market. This is left for future work.

Appendix

A. Slope of the export-FDI division line.

Note that under (C2), we have

$$\begin{aligned}
\frac{\partial \Gamma}{\partial \eta} &= \left(\frac{2-\alpha}{2}\right)\left(\frac{1+\delta_i^{\alpha}}{2w_i}\right)^{\alpha\epsilon}\left(\frac{w_i}{w_i+t_i}\right)^{\alpha\epsilon\eta}\alpha/\ln\left(\frac{w_i}{w_i+t_i}\right) - \tau^{\alpha\epsilon}(1-\alpha)w^{-\alpha\epsilon\eta}\alpha/\ln\left(\frac{1}{w}\right) \\
&< \tau^{\alpha\epsilon}(1-\alpha)w^{-\alpha\epsilon\eta}\alpha/\left[\ln\left(\frac{w_i}{w_i+t_i}\right) - \ln\left(\frac{1}{w}\right)\right] \\
&< 0.
\end{aligned}$$

As $\eta_i^*(\Theta)$ is also defined by (7); thus, differentiating the condition with respect to Θ yields

$$\frac{\partial \Gamma}{\partial \eta}\frac{\partial \eta_i^*}{\partial \Theta}\Theta + \Gamma = 0.$$

Hence, $\frac{\partial \eta_i^*}{\partial \Theta} > 0$. Similarly, we can have $\frac{\partial \Theta^*}{\partial \eta} > 0$. *Q.E.D.*

B. Proof of Proposition 2.

After simplification, we have $\Theta_1 < \Theta_2$ if and only if (9) holds. As $w_1 > w_2$, the LHS of the inequality is decreasing in η, but the RHS is constant with regard to η. Therefore, if (9) holds at $\eta = 0$, it holds for all η. If (9) is reversed at $\eta = 0$, then $\frac{1+\delta_1^{\alpha}}{1+\delta_2^{\alpha}} > 1$ as $\delta_1 > \delta_2$, and $\left(\frac{w_1}{w_2}\right)^{(1-\eta)} = 1$ when $\eta = 1$. Thus, we must have a cutoff $\tilde{\eta} \in (0, 1]$ such that when $\eta \in (0, \tilde{\eta})$, we have $\frac{1+\delta_1^{\alpha}}{1+\delta_2^{\alpha}} < \left(\frac{w_1}{w_2}\right)^{(1-\eta)}$; when $\eta \in (\tilde{\eta}, 1]$, we have $\frac{1+\delta_1^{\alpha}}{1+\delta_2^{\alpha}} > \left(\frac{w_1}{w_2}\right)^{(1-\eta)}$. *Q.E.D.*

C. Proof of (10)

Differentiating (8) with respect to f_{I1} yields

$$\begin{aligned}
0 \quad = \quad & \int_0^1 \left\{ \int_{\Theta_D}^{\infty} -A\eta\alpha^{\epsilon} w_S^{-2-\alpha\epsilon\eta} (\alpha/\eta+1) \frac{dw}{df_{I1}} \Theta dG(\Theta) - \left(A\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta_D + \frac{1}{2} f_D \right) g(\Theta_D) \frac{\partial \Theta_D}{\partial w} \frac{dw}{df_{I1}} \right. \\
& - \int_{\Theta_{X1}}^{\Theta_1} A_1 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-2-\alpha\epsilon\eta} (\alpha/\eta+1) \frac{dw}{df_{I1}} \Theta dG(\Theta) + A_1 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta_1 g(\Theta_1) \left(\frac{\partial \Theta_1}{\partial w} \frac{dw}{df_{I1}} + \frac{\partial \Theta_1}{\partial f_{I1}} \right) \\
& - A_1 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta_{X1} g(\Theta_{X1}) \frac{\partial \Theta_{X1}}{\partial w} \frac{dw}{df_{I1}} - \int_{\Theta_{X2}}^{\Theta_2} A_2 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-2-\alpha\epsilon\eta} (\alpha/\eta+1) \frac{dw}{df_{I1}} \Theta dG(\Theta) \\
& \left. + A_2 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta_2 g(\Theta_2) \frac{\partial \Theta_2}{\partial w} \frac{dw}{df_{I1}} - A_2 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta_{X2} g(\Theta_{X2}) \frac{\partial \Theta_{X2}}{\partial w} \frac{dw}{df_{I1}} \right\} d\eta.
\end{aligned}$$

As w is independent of η, $\frac{dw}{df_{I1}}$ is not a function of η, and we can take $\frac{dw}{df_{I1}}$ out of the integrations and reorganize the above equation as (10), where

$$\begin{aligned}
\Phi_1 \quad \equiv \quad & - \int_0^1 \left\{ -\eta (\alpha/\eta+1) \alpha^{\epsilon} w^{-2-\alpha\epsilon\eta} \left[\int_{\Theta_D}^{\infty} A\Theta dG(\Theta) + \int_{\Theta_{X1}}^{\Theta_1} A_1 \tau^{\alpha\epsilon} \Theta dG(\Theta) + \int_{\Theta_{X2}}^{\Theta_2} A_2 \tau^{\alpha\epsilon} \Theta dG(\Theta) \right] \right. \\
& - \left(A\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta_D + \frac{1}{2} f_D \right) g(\Theta_D) \frac{\partial \Theta_D}{\partial w} + A_1 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \left(\Theta_1 g(\Theta_1) \frac{\partial \Theta_1}{\partial w} - \Theta_{X1} g(\Theta_{X1}) \frac{\partial \Theta_{X1}}{\partial w} \right) \\
& \left. + A_2 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \left(\Theta_2 g(\Theta_2) \frac{\partial \Theta_2}{\partial w} - \Theta_{X2} g(\Theta_{X2}) \frac{\partial \Theta_{X2}}{\partial w} \right) \right\} d\eta, \\
\Phi_2 \quad \equiv \quad & \int_0^1 A_1 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta_1 g(\Theta_1) \frac{\partial \Theta_1}{\partial f_{I1}} d\eta
\end{aligned}$$

Clearly, $\frac{\partial \Theta_D}{\partial w} > 0$, $\frac{\partial \Theta_{Xi}}{\partial w} > 0$, $\frac{\partial \Theta_i}{\partial w} < 0$, and $\frac{\partial \Theta_1}{\partial f_{I1}} > 0$. Hence, $\Phi_i > 0$, for both $i = 1, 2$, and from (10), we must have $\frac{dw}{df_{I1}} > 0$. *Q.E.D.*

D. Proof of $\frac{d\Theta_1}{df_{I1}} > 0$.

We prove $\frac{d\Theta_1}{df_{I1}} > 0$ by contradiction. Clearly, $\frac{d\Theta_D}{df_{I1}} = \frac{d\Theta_D}{dw}\frac{dw}{df_{I1}} > 0$ and $\frac{d\Theta_{Xi}}{df_{I1}} = \frac{d\Theta_{Xi}}{dw}\frac{dw}{df_{I1}} > 0$. Suppose $\frac{d\Theta_1}{df_{I1}} \leq 0$, then from the effects of f_{I1} on Θ_D, Θ_{Xi}, Θ_2 and w, we know that an increase in f_{I1} will always decrease the domestic labor demand for skilled workers [i.e., the RHS of (8)]; thus, the labor market equilibrium condition (8) can never hold after FDI policy changes. However, as (8) always holds in equilibrium, we know that $\frac{d\Theta_1}{df_{I1}} \leq 0$ cannot be true, and we must have $\frac{d\Theta_1}{df_{I1}} > 0$. *Q.E.D.*

E. The Case of Trade Liberalization

■ We first analyze the change in f_{X1}. Differentiating (8) with respect to f_{X1} yields

$$\begin{aligned}
0 \;=\; & \int_0^1 \left\{ \int_{\Theta_D}^{\infty} -A\eta\alpha^{\epsilon} w^{-2-\alpha\epsilon\eta} (\alpha/\eta+1) \frac{dw}{df_{X1}} \Theta dG(\Theta) - \left(A\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_D + \frac{1}{2} f_D \right) g(\Theta_D) \frac{\partial \Theta_D}{\partial w} \frac{dw}{df_{X1}} \right. \\
& - \int_{\Theta_{X1}}^{\Theta_1} A_1 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-2-\alpha\epsilon\eta} (\alpha/\eta+1) \frac{dw}{df_{X1}} \Theta dG(\Theta) + A_1 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_1 g(\Theta_1) \left(\frac{\partial \Theta_1}{\partial w}\frac{dw}{df_{X1}} + \frac{\partial \Theta_1}{\partial f_{X1}} \right) \\
& - A_1 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_{X1} g(\Theta_{X1}) \left(\frac{\partial \Theta_{X1}}{\partial w}\frac{dw}{df_{X1}} + \frac{\partial \Theta_{X1}}{\partial f_{X1}} \right) - \int_{\Theta_{X2}}^{\Theta_2} A_2 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-2-\alpha\epsilon\eta} (\alpha/\eta+1) \frac{dw}{df_{X1}} \Theta dG(\Theta) \\
& \left. + A_2 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_2 g(\Theta_2) \frac{\partial \Theta_2}{\partial w}\frac{dw}{df_{X1}} - A_2 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_{X2} g(\Theta_{X2}) \frac{\partial \Theta_{X2}}{\partial w}\frac{dw}{df_{X1}} \right\} d\eta.
\end{aligned}$$

w is independent of η; thus, $\frac{dw}{df_{X1}}$ is not a function of η, and we can take $\frac{dw}{df_{X1}}$ out of the integrations and reorganize to have $\Delta_1 \frac{dw}{df_{X1}} = \Delta_2$, where

$$\begin{aligned}
\Delta_1 \;\equiv\; & \int_0^1 \left\{ -\eta (\alpha/\eta+1) \alpha^{\epsilon} w^{-2-\alpha\epsilon\eta} \left[\int_{\Theta_D}^{\infty} A\Theta dG(\Theta) + \int_{\Theta_{X1}}^{\Theta_1} A_1 \tau^{\alpha\epsilon}\Theta dG(\Theta) + \int_{\Theta_{X2}}^{\Theta_2} A_2 \tau^{\alpha\epsilon}\Theta dG(\Theta) \right] \right. \\
& - \left(A\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_D + \frac{1}{2} f_D \right) g(\Theta_D) \frac{\partial \Theta_D}{\partial w} + A_1 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \left(\Theta_1 g(\Theta_1) \frac{\partial \Theta_1}{\partial w} - \Theta_{X1} g(\Theta_{X1}) \frac{\partial \Theta_{X1}}{\partial w} \right) \\
& \left. + A_2 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \left(\Theta_2 g(\Theta_2) \frac{\partial \Theta_2}{\partial w} - \Theta_{X2} g(\Theta_{X2}) \frac{\partial \Theta_{X2}}{\partial w} \right) \right\} d\eta, \\
\Delta_2 \;\equiv\; & A_1 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \int_0^1 \left(\Theta_{X1} g(\Theta_{X1}) \frac{\partial \Theta_{X1}}{\partial f_{X1}} - \Theta_1 g(\Theta_1) \frac{\partial \Theta_1}{\partial f_{X1}} \right) d\eta.
\end{aligned}$$

Clearly, $\frac{\partial \Theta_D}{\partial w} > 0$, $\frac{\partial \Theta_{Xi}}{\partial w} > 0$, $\frac{\partial \Theta_i}{\partial w} < 0$, $\frac{\partial \Theta_{X1}}{\partial f_{X1}} > 0$, and $\frac{\partial \Theta_1}{\partial f_{X1}} < 0$. Hence, $\Delta_1 < 0$ and $\Delta_2 > 0$, and thus $\frac{dw}{df_{X1}} < 0$.

From the expressions of the cutoffs, wee immediately have

$$\frac{d\Theta_D}{df_{X1}} = \frac{d\Theta_D}{dw}\frac{dw}{df_{X1}} < 0, \quad \frac{d\Theta_{X2}}{df_{X1}} = \frac{d\Theta_{X2}}{dw}\frac{dw}{df_{X1}} < 0, \quad \text{and} \quad \frac{d\Theta_2}{df_{X1}} = \frac{d\Theta_2}{dw}\frac{dw}{df_{X1}} > 0.$$

As for the other two cutoffs, we have

$$\frac{d\Theta_{X1}}{df_{X1}} = \frac{\partial \Theta_{X1}}{\partial w}\frac{dw}{df_{X1}} + \frac{\partial \Theta_{X1}}{\partial f_{X1}} \quad \text{and} \quad \frac{d\Theta_1}{df_{X1}} = \frac{\partial \Theta_1}{\partial w}\frac{dw}{df_{X1}} + \frac{\partial \Theta_1}{\partial f_{X1}}.$$

We show $\frac{d\Theta_{X1}}{df_{X1}} > 0$ by contradiction. Suppose this is not true, that is, $\frac{d\Theta_{X1}}{df_{X1}} < 0$ (for clearer proof, we drop the case with equality). From the profit function π^*_{X1} and the corresponding profit line in Figure 1, we note that an increase in f_{X1} shifts down the intercept of the the profit line π^*_{X1}; if $\frac{d\Theta_{X1}}{df_{X1}} < 0$, the cutoff Θ_{X1} shifts to the left, and the new profit line, say π'_{X1}, must have a much steeper slope than π^*_{X1}. It is clear that the two profit lines, π^*_{I1} (which does not move as a result of changes in f_{X1} and w) and π'_{X1} must intersect at a point to the right of Θ_1, which implies

$\frac{d\Theta_1}{df_{X1}} > 0$. Hence, the move of the two cutoff points ($\frac{d\Theta_{X1}}{df_{X1}} < 0$ and $\frac{d\Theta_1}{df_{X1}} > 0$) implies an increase in demand for labor associated with an increase in f_{X1}. Moreover, the move of all other cutoffs ($\frac{d\Theta_D}{df_{X1}} < 0$, $\frac{d\Theta_{X2}}{df_{X1}} < 0$, and $\frac{d\Theta_2}{df_{X1}} > 0$) also implies an increase in demand for labor. Thus, labor demand increases and labor market is not in equilibrium. This is a contradiction. Therefore, $\frac{d\Theta_{X1}}{df_{X1}} > 0$, which implies $\frac{d\Theta_1}{df_{X1}} < 0$ following the analysis we just had.

■ We now turn to the change in τ_1. We first modify (8) using τ_1 and τ_2 to substitute the respective τ. We then differentiate (8) with respect to τ_1 to obtain

$$\begin{aligned} 0 \;=\; & \int_0^1 \left\{ \int_{\Theta_D}^{\infty} -A\eta\alpha^{\epsilon} w^{-2-\alpha\epsilon\eta} (\alpha/\eta + 1) \frac{dw}{d\tau_1} \Theta dG(\Theta) - \left(A\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta_D + \frac{1}{2} f_D \right) g(\Theta_D) \frac{\partial \Theta_D}{\partial w} \frac{dw}{d\tau_1} \right. \\ & - \int_{\Theta_{X1}}^{\Theta_1} A_1 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-2-\alpha\epsilon\eta} (\alpha/\eta + 1) \frac{dw}{d\tau_1} \Theta dG(\Theta) + \int_{\Theta_{X1}}^{\Theta_1} A_1 \tau^{\alpha\epsilon - 1} / \eta\alpha^{1+\epsilon} w^{-1-\alpha\epsilon\eta} \Theta dG(\Theta) \\ & + A_1 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta_1 g(\Theta_1) \left(\frac{\partial \Theta_1}{\partial w} \frac{dw}{d\tau_1} + \frac{\partial \Theta_1}{\partial \tau_1} \right) - A_1 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta_{X1} g(\Theta_{X1}) \left(\frac{\partial \Theta_{X1}}{\partial w} \frac{dw}{d\tau_1} + \frac{\partial \Theta_{X1}}{\partial \tau_1} \right) \\ & \left. - \int_{\Theta_{X2}}^{\Theta_2} A_2 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-2-\alpha\epsilon\eta} (\alpha/\eta + 1) \frac{dw}{d\tau_1} \Theta dG(\Theta) \right\} d\eta. \end{aligned}$$

Take $\frac{dw}{d\tau_1}$ out of the integrations and reorganize it to obtain $\Psi_1 \frac{dw}{df_{X1}} = \Psi_2$, where

$$\begin{aligned} \Psi_1 \;\equiv\; & \int_0^1 \left\{ -\eta (\alpha/\eta + 1) \alpha^{\epsilon} w^{-2-\alpha\epsilon\eta} \left[\int_{\Theta_D}^{\infty} A\Theta dG(\Theta) + \int_{\Theta_{X1}}^{\Theta_1} A_1 \tau^{\alpha\epsilon} \Theta dG(\Theta) + \int_{\Theta_{X2}}^{\Theta_2} A_2 \tau^{\alpha\epsilon} \Theta dG(\Theta) \right] \right. \\ & \left. - \left(A\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \Theta_D + \frac{1}{2} f_D \right) g(\Theta_D) \frac{\partial \Theta_D}{\partial w} + A_1 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \left(\Theta_1 g(\Theta_1) \frac{\partial \Theta_1}{\partial w} - \Theta_{X1} g(\Theta_{X1}) \frac{\partial \Theta_{X1}}{\partial w} \right) \right\} d\eta, \\ \Psi_2 \;\equiv\; & \int_0^1 \left[A_1 \tau^{\alpha\epsilon} \eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta} \left(\Theta_{X1} g(\Theta_{X1}) \frac{\partial \Theta_{X1}}{\partial \tau_1} - \Theta_1 g(\Theta_1) \frac{\partial \Theta_1}{\partial \tau_1} \right) - \int_{\Theta_{X1}}^{\Theta_1} A_1 \tau^{\alpha\epsilon - 1} / \eta\alpha^{1+\epsilon} w^{-1-\alpha\epsilon\eta} \Theta dG(\Theta) \right] d\eta \end{aligned}$$

As $\frac{\partial \Theta_D}{\partial w} > 0$, $\frac{\partial \Theta_{Xi}}{\partial w} > 0$, and $\frac{\partial \Theta_i}{\partial w} < 0$, and it is easy to show $\frac{\partial \Theta_{X1}}{\partial \tau_1} < 0$ and $\frac{\partial \Theta_1}{\partial \tau_1} > 0$, we have $\Psi_1 < 0$ and $\Psi_2 < 0$, and thus $\frac{dw}{d\tau_1} > 0$.

From the expressions of the cutoffs, wee immediately have

$$\frac{d\Theta_D}{d\tau_1} = \frac{d\Theta_D}{dw} \frac{dw}{d\tau_1} > 0, \quad \frac{d\Theta_{X2}}{d\tau_1} = \frac{d\Theta_{X2}}{dw} \frac{dw}{d\tau_1} > 0, \quad \text{and} \quad \frac{d\Theta_2}{d\tau_1} = \frac{d\Theta_2}{dw} \frac{dw}{d\tau_1} < 0.$$

We can also prove the following (the proof is similar to that in the case of f_{X1})

$$\frac{d\Theta_{X1}}{d\tau_1} = \frac{\partial \Theta_{X1}}{\partial w} \frac{dw}{d\tau_1} + \frac{\partial \Theta_{X1}}{\partial \tau_1} < 0 \quad \text{and} \quad \frac{d\Theta_1}{d\tau_1} = \frac{\partial \Theta_1}{\partial w} \frac{dw}{d\tau_1} + \frac{\partial \Theta_1}{\partial \tau_1} > 0.$$

Q.E.D.

F. Education

Differentiating (8) with respect to δ_1 yields

$$
\begin{aligned}
0 \;=\; & \int_0^1 \Big\{ -\left(A\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_D + \frac{1}{2} f_D \right) g(\Theta_D) \frac{\partial \Theta_D}{\partial w}\frac{dw}{d\delta_1} \\
& + A_1 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_1 g(\Theta_1)\left(\frac{\partial \Theta_1}{\partial w}\frac{dw}{d\delta_1} + \frac{\partial \Theta_1}{\partial \delta_1}\right) - A_1 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_{X1} g(\Theta_{X1})\frac{\partial \Theta_{X1}}{\partial w}\frac{dw}{d\delta_1} \\
& + A_2 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_2 g(\Theta_2)\frac{\partial \Theta_2}{\partial w}\frac{dw}{d\delta_1} - A_2 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_{X2} g(\Theta_{X2})\frac{\partial \Theta_{X2}}{\partial w}\frac{dw}{d\delta_1} \Big\} d\eta.
\end{aligned}
$$

From that we have $\Lambda_1 \frac{dw}{df_{X1}} = \Lambda_2$, where

$$
\begin{aligned}
\Lambda_1 \;\equiv\; & \int_0^1 \Big\{ -\left(A\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_D + \frac{1}{2} f_D \right) g(\Theta_D) \frac{\partial \Theta_D}{\partial w} \\
& + A_1 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\left(\Theta_1 g(\Theta_1)\frac{\partial \Theta_1}{\partial w} - \Theta_{X1} g(\Theta_{X1})\frac{\partial \Theta_{X1}}{\partial w}\right) \\
& + A_2 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\left(\Theta_2 g(\Theta_2)\frac{\partial \Theta_2}{\partial w} - \Theta_{X2} g(\Theta_{X2})\frac{\partial \Theta_{X2}}{\partial w}\right) \Big\} d\eta, \text{ and} \\
\Lambda_2 \;\equiv\; & -\int_0^1 A_1 \tau^{\alpha\epsilon}\eta\alpha^{\epsilon} w^{-1-\alpha\epsilon\eta}\Theta_1 g(\Theta_1)\frac{\partial \Theta_1}{\partial \delta_1} d\eta
\end{aligned}
$$

As $\frac{\partial\Theta_D}{\partial w} > 0$, $\frac{\partial\Theta_{Xi}}{\partial w} > 0$, $\frac{\partial\Theta_i}{\partial w} < 0$ and $\frac{\partial\Theta_1}{\partial\delta_1} < 0$, we have $\Lambda_1 < 0$, $\Lambda_2 > 0$ and thus $\frac{dw}{d\delta_1} < 0$. Moreover, the effects of δ_1 on the following cutoff productivities are easily obtained:

$$
\begin{aligned}
\frac{d\Theta_D}{d\delta_1} &= \frac{d\Theta_D}{dw}\frac{dw}{d\delta_1} < 0, & \frac{d\Theta_{X1}}{d\delta_1} &= \frac{d\Theta_{X1}}{dw}\frac{dw}{d\delta_1} < 0, \\
\frac{d\Theta_{X2}}{d\delta_1} &= \frac{d\Theta_{X2}}{dw}\frac{dw}{d\delta_1} < 0, & \frac{d\Theta_2}{d\delta_1} &= \frac{d\Theta_2}{dw}\frac{dw}{d\delta_1} > 0.
\end{aligned}
$$

We further prove $\frac{d\Theta_1}{d\delta_1} < 0$ by contradiction. Suppose $\frac{d\Theta_1}{d\delta_1} \geq 0$.From the above effects of δ_1 on $\Theta_D, \Theta_{Xi}, \Theta_2$, and w, we know that an increase in δ_1 will always increase the domestic labor demand for skilled workers [i.e., the RHS of (8)]. Thus, the labor market equilibrium condition (8) can never hold after the education level changes. This is the contradiction. *Q.E.D.*

References

Acemoglu, Daron and Jorn-Steffen Pischke, 1998, "Why do firms train? Theory and evidence", *Quarterly Journal of Economics*, 113(1), 79-118.

Acemoglu, Daron and Jorn-Steffen Pischke, 1999, "Beyond Becker: Training in imperfect labor markets", *Economic Journal*, 109, 112-142.

Albornoz, F., H Pardo, G. Corcos and E. Ornelas, 2010, "Sequential exporting", CEP Discussion Paper No. 974.

Antras, Pol and C. Fritz Foley, 2010, "Regional trade integration and multinational firm strategies," forthcoming in Barro, R. and J-W. Lee (eds.), *Costs and Benefits of Regional Economic Integration*, Oxford University Press.

Antras, Pol and Elhanan Helpman, 2004, "Global sourcing", *Journal of Political Economy*, 112(3), 552-580.

Bao, Xiaohua and Larry D. Qiu, 2010, "The impacts of technical barriers to trade on extensive margin, intensive margin, and Total Trade Flow", Working Paper, the University of Hong Kong.

Becker, Gary, 1964, *Human Capital*, Chicago: University of Chicago Press.

Brainard, S. Lael, 1997, "An empirical assessment of proximity-concentration trade-off between multinational sales and trade", *American Economic Review*, 87(4), 520–544.

Blonigen, Burce, 2005, "A review of the empirical literature on FDI determinants", *Atlantic Economic Journal*, 33, 383-403.

Chang, Chun, and Yijiang Wang, 1996, "Human capital investment under asymmetric information: The Pigovian conjecture revisited", *Journal of Labor Economics*, XVI, 505–519

Chen, Maggie and Michael Moore, 2010, "Location decision of heterogeneous multinational firms", *Journal of International Economics*, 80(2), 188-199

Cherkashin, I., S. Demidova, H.L. Kee and K. Krishna, 2010, "Firm heterogeneity and costly trade: A new estimation strategy and policy experiments", Working Paper.

Debaere, Peter, Hongshik Lee and Joonhyung Lee, 2010, "It matters where you go: Outward foreign direct investment and multinational employment growth at home", *Journal of Development Economics*, 91, 301-309.

Chantasasawat, Musakorn, KC Fung, Hitomi Iizakda, and Alan Siu, 2010, "FDI flows to Latin America, East and Southeast Asia, and China: Substitutes or complements?", *Review of Development Economics*, 14(3), 533-546.

Feenstra, Robert and Gordon Hanson, 1996, "Globalization, outsourcing, and wage inequality", *American Economic Review*, 86(2), 240–245.

Feenstra, Robert and Gordon Hanson, 1997, "Foreign direct investment and relative wages: evidence from Mexico's Maquiladoras", *Journal of International Economics*, 42, 371–393.

Harrison, Ann and Margaret McMillan, 2006, "Outsourcing jobs? Multinationals and US employment", NBER Working Papers 12372.

Grossman, Gene M. and Esteban Rossi-Hansberg, 2008, "Trading tasks: A simple theory of offshoring", *American Economic Review*, 98(5), 1978-1997.

Hart, Oliver D. and John Moore, 1994, "A theory of debt based on the inalienability of human capital", *Quarterly Journal of Economics*, 109(4), 841-879.

Hartman, David, 1985, "Tax policy and foreign direct investment", *Journal of Public Economics*, 26, 107-21.

Head, K. and T. Mayer, 2004, "Market potential and the location of Japanese investment in the European Union", *Review of Economics and Statistics*, 86, 959-72.

Helpman, Elhanan, 1984, "A simple model of trade with multinational corporations", *Journal of Political Economy*, 92, 452–471.

Helpman, Elhanan and Oleg Itskholi, 2010, "Labor market rigidities, trade and unemployment", *Review of Economic Studies*, 77, 1100-1137.

Helpman, Elhanan, Oleg Itskholi and Stephen Redding, 2010, "Inequality and unemployment in a global economy", *Econometrica*, 78(4), 1239-1283.

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

Katz, Eliakim, and Adrian Ziderman, 1990, "Investment in general training: The role of information and labour mobility", *Economic Journal*, 1147–1158.

Markusen, James R. and Keith Maskus, 2003, "General-equilibrium approaches to the multinational firm: A review of theory and evidence". In James Harrigan and Kwan Choi (Eds.), *Handbook of Empirical International Trade*. London, Blackwell.

Markusen, James R. and Anthony J. Venables, 1997, "The role of multinational firms in the wage-gap debate", *Review of International Economics*, 5(4), 435-451.

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

Mincer, Jacob, 1974, *Schooling, Experience, and Earnings.* New York, Columbia University Press.

Parsons, Donald O., 1986. "The employment relationship: Job attachment, work effort, and the nature of contracts", In O. Ashenfelter and R. Layard (Eds.), *Handbook of Labor Economics*, vol. 2. New York, Elsevier.

Slaughter, Matthew, 2000, "Production transfer within multinational enterprises and American wages", Journal of International Economics, 50, 449-472

Yeaple, Stephen R., 2003. "The role of skill endowments in the structure of U.S. outward foreign direct investment", *Review of Economic and Statistics* 85(3), 726-734.

Wei, Shang-Jin, 2000, "How taxing is corruption on international investors?" *Review of Economics and Statistics*, 82, 1-11.

Weiss, Yoram, 1986, "The determination of life cycle earnings: A survey". In O. Ashenfelter and R. Layard (Eds.), *Handbook of Labor Economics*, vol. 1. New York, Elsevier.