Three Essays on International Trade and Monetary Economics

By

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ABSTRACT

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This dissertation consists of three studies in international trade and monetary economics. The first and third chapters study the impact of labor market rigidities on multinational firms' choice between FDI and outsourcing. The second chapter proposes a model that explores one of the motivations for using Bitcoin.

In the first chapter, I propose a two-country, two-sector model, where a firm's decision on offshoring depends on labor market rigidities, due to which firms need to bear not only wages, but also additional costs from the labor market. In this model, firms endogenously choose their organizational form, considering their productivity level and fixed organizational costs. The labor market cost generated by search frictions plays a key role in changing the variable benefits of each choice, and thus works as a key determinant in the process of selecting the organizational form for offshoring. The model has four different types of equilibria, depending on relative levels of two labor market costs (domestic and foreign) and the price of the intermediate input. In all equilibria, a relative rise in the domestic labor market cost increases the share of offshoring firms, while decreasing domestic integration. Furthermore, an economy with offshoring has a higher welfare level and a lower unemployment rate than autarky.

The second chapter offers an explanation for how Bitcoin gained its success, by focusing on the anonymity of the Bitcoin transactions based on the Bitcoin system's peer-to-peer nature, among several other features that distinguish it from previous digital currency systems. In the model that I propose, there exist two currency markets, Bitcoin and Debit, and agents are heterogeneous in their anonymity concerns. This heterogeneity drives some agents to choose the Bitcoin market and others to choose the Debit market

in the benchmark model. When I introduce the intermediaries, which accept Bitcoin for legal goods, the number of agents who choose the Bitcoin market increases, while the share of Bitcoin users engaged in illegal activities decreases.

Finally, in the third chapter, I examine the key prediction that I make in the first chapter: the difference in labor market flexibility across countries can be a key determinant in a firm's offshoring decision. I use the data set for 2006 through 2012 from U.S. related-party trade data of 453 6-digit North American Industry Classification System (NAICS6) level goods from 137 countries. For the labor market flexibility index, I use the Global Competitiveness Report (GCR) by the World Economic Forum. The data yields supporting results for the first chapter: the U.S. intrafirm imports share is positively correlated with the industry productivity dispersion only in countries that have the most flexible labor market. The supporting results stand out more with the data on developing countries only, which are mostly host countries trading with U.S. multinationals.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
Labor Market Structure and Offshoring

1.1 Introduction

Rapidly increasing international disintegration in production has gained attention in many studies. When a firm decides to move part of its production process or tasks abroad, it has two choices. It can forge an arm's-length relationship with other intermediate goods suppliers; or it can opt for vertical integration by setting up affiliates overseas. The former is called 'Outsourcing' and the latter, 'Foreign Direct Investment (FDI)'.

As some firms choose to outsource tasks while others choose FDI, a question naturally arises about the key determinants in each decision. Although many studies have attempted to answer this question, the labor market structure has received little attention, as most studies in the literature have assumed a frictionless labor market. Considering the fact that saving variable costs is the fundamental motivation of firms choosing to offshore, models with a frictionless labor market may be missing an important factor that affects a firm's decision.

In this paper, I consider the labor market structure to be a key determinant in a firm's decision to offshore. In the model I propose, two sectors exist, in one of which the labor market is under search and matching frictions. Specifically, the labor market structure is based on Helpman and Itskhoki (2010), where homogeneous workers search firms for jobs, while firms are heterogeneous across their skill levels. In this setting, it is costly for a firm to hire or fire workers, and thus firms consider not only the wage level, but also the labor market cost generated by the frictions. I show that a country with a relatively high labor market cost will have more firms choosing to offshore; and firms with a high productivity level will choose offshoring, while less productive firms remain in the domestic market.

When I analyze the impact of allowing offshoring on the economy, I find that the equilibrium with offshoring gives a weakly higher welfare level. Firms facing a higher labor market cost in the domestic labor market in autarky try to reduce the production to keep the profit level unchanged. Allowing offshoring, however, offsets the decrease in the quantity level by structural changes in the economy, as more firms choose to offshore. In an analysis of the total hiring and unemployment rate, I find that even though the total hiring in autarky is higher, the unemployment rate is also higher. These seemingly contradictory results have originated from the fact that the unemployment rate depends on not only the total jobs available, but also the number of job seekers in the labor market. When offshoring is available, workers realize that the number of jobs decreases; and choose the other sector, where labor market frictions do not exist.

The proposed model lies in an intersection of two strands of literatures. One of them focuses on the role of the labor market structure on issues in the international trade. Since the seminal work of Davidson et al. (1999), there have been many studies on this topic and now there exists well-developed literature on search-induced unemployment in different trade environments. Among this literature, two studies from Mitra and Ranjan (2010, 2012) are closely related to the model. In both studies, the labor market is under search and matching frictions. Mitra and Ranjan (2010) analyze the impact of offshoring on the unemployment rate. Interestingly, they find the impact of offshoring on the unemployment rate depends on inter-sectoral labor mobility. Under imperfect inter-sectoral labor mobility, unemployment may increase in the offshoring sector, while it may decrease in the non-offshoring sector. When the economy is under perfect inter-sectoral labor mobility, however, the economy-wide unemployment decreases unambiguously. Mitra and Ranjan (2013) analyze the role of offshoring in a model with fair wage consideration. In their model, workers are heterogeneous in terms of skill level, while firms are homogeneous. When the fair wage constraint is binding and a firm hires two types of labor, a distortion can arise in the production process. Mitra and Ranjan (2010) show that fairness consideration can motivate offshoring, as it could be a way of resolving the distortion. But neither study distinguishes FDI from Outsourcing as they do not focus on the firms' choice between the two.

Davidson et al. (2008) also introduce search and matching frictions into the labor market and analyze the impact of Outsourcing in high-tech jobs on low-skilled workers' wages. In their model, there exist two types of labor, high-skilled and low-skilled, and firms endogenously choose their technology level. Interestingly, Davidson et al. (2008) find that under certain conditions, Outsourcing can increase the wage level of low-skilled labor in the long run. In the long run equilibrium, there will be more entry of firms and if the new firms select the low-level technology, it will become easier for low-skilled labor to find employment and their wage level can increase. In the short run, however, both types of labor are worse off, as high-skilled labor now faces fewer job opportunities and lowered wages, while low-skilled labor encounters greater competition for jobs.

Although many papers in the literature on trade issues related to labor market rigidities use novel models, several recent papers have attempted to introduce search-induced unemployment into standard trade models.[1] In particular, Helpman and Itskhoki (2010) introduce Diamond-Mortensen-Pissarides-type search and matching frictions into the labor market. They use a two-sector model where one sector is monopolistically competitive. Firms become heterogeneous when they enter the market, and some choose to export, while others decide whether to exit or remain in the domestic market. Helpman and Itskhoki (2010) show that labor market flexibility can be a source of comparative advantage in trade, i.e., a country with lowered labor market inefficiencies can get welfare improvement, while its trade partner becomes worse off.

Another strand of literature this paper relies on tries to answer the question of why

[1] See Cuñat and Melitz (2010), Cuñat and Melitz (2012), Davidson and Matusz (2012), and Felbermayr et al. (2011).

some firms choose to outsource, while others choose FDI. In some studies, incomplete contracts play a central role. Antràs (2003) focuses on the incomplete contract between a firm and a supplier. With Outsourcing, a firm can have efficiency gains from having a specialized supplier. However, due to incomplete contracts, hold-up problems occur, and both sides tend to underinvest compared to the optimal level. Similarly, Grossman and Helpman (2002) and Grossman and Helpman (2003) have modeled an economy where firms are placed in a trade-off between extra governance costs in FDI and the incomplete contract problem in Outsourcing.

In other studies, the heterogeneity of firms' productivity level induces different sorting across firms. In Antràs and Helpman (2004), firms are heterogeneous in terms of productivity. In this model, they make two choices. In choosing location between North and South, they face a trade-off between the low fixed cost at home and low variable costs in a foreign country. On the other hand, in the choice between vertical integration and arm's-length relationship, firms face a trade-off between an ownership advantage in vertical integration and better incentives in Outsourcing. These trade-offs, together with the incomplete contract problem in Outsourcing, drive firms to choose certain organizational forms depending on their realized productivity levels. In Antràs and Helpman (2004) model, firms with high productivity level choose FDI, while less productive firms choose Outsourcing.

While many studies focus on the role of incomplete contracts and productivity levels, Chen (2011) places informational asymmetry at the center of the analysis. In this model, firms face an adverse selection problem in choosing an intermediate goods supplier, while they face an inefficient monitoring problem when they choose FDI. This model is helpful in explaining why FDI is heavily concentrated in capital-intensive industries, in which monitoring costs are significantly lower than in other industries, which alleviates the inefficient monitoring problem in FDI.

In this paper, I extend the model in Helpman and Itskhoki (2010). While following the basic setup of their model, I allow firms to have offshoring choices, which include both FDI and Outsourcing. Compared to previous studies, firms have a different source of trade-off in choosing offshoring. They can lower their production costs by selecting a foreign country with a low labor market cost, even though it would incur an additional fixed organizational cost. Thus, the labor market cost directly affects a firm's decision to offshore.

The remainder of this paper is organized as follows. In Section 1.2, I develop the model and in Section 1.3, I calculate the profit levels of the three different choices. In Section 1.4, I derive four different types of equilibria and analyze them in Section 1.5. Finally, in Section 1.6, I offer a summary of the analysis with concluding remarks. The proof of the main results are in Appendices.

1.2 Model

In this model, there exist two sectors. One sector produces a homogeneous good, while the other produces differentiated goods. In the homogeneous-good sector, there are no labor market frictions and all firms produce domestically. The price of the homogeneous good is normalized to one and it serves as a numeraire. In the differentiated-goods sector, search and matching frictions exist in the labor market. Firms in this sector can produce domestically by using domestic labor, but they can also choose to offshore by paying the fixed organizational cost of FDI or Outsourcing. As in many previous studies, I assume that the fixed organizational cost of FDI is higher than that of Outsourcing.

1.2.1 Preferences

A representative household gets utility from consuming q_0 homogeneous goods and a continuum of differentiated goods,

$$Q = \left[\int_{i\in I} q(i)^{\beta} di\right]^{\frac{1}{\beta}}, \quad 0 < \beta < 1, \tag{1.1}$$

where $q(i)$ denotes consumption of variety i, I denotes the set of varieties, and β is a measure of the elasticity of substitution between varieties. The total utility from consuming them is defined as

$$U = q_0 + \frac{1}{\varsigma} Q^{\varsigma}, \quad 0 < \varsigma < \beta.$$

The restriction $\varsigma < \beta$ implies that differentiated goods are better complements to each other than the homogeneous good.

It is well known that CES preferences yield the following constant elasticity demands:

$$q(i) = Q\left(\frac{p(i)}{P}\right)^{-\frac{1}{1-\beta}}. \tag{1.2}$$

And the price index for Q is defined as

$$P = \left[\int_i p(i)^{-\frac{\beta}{1-\beta}} di\right]^{-\frac{1-\beta}{\beta}}.$$

With total spending E, the representative household maximizes its utility by choosing

$$Q = P^{-\frac{1}{1-\varsigma}}, \tag{1.3}$$

$$q_0 = E - P^{-\frac{\varsigma}{1-\varsigma}}. \tag{1.4}$$

1.2.2 Technology

In the homogeneous-good sector, firms make one unit of good by using one unit of labor. As the market is competitive, the wage is equal to the price of the homogeneous good, one.

Following Melitz (2003), the market in the differentiated-goods sector is monopolistically competitive, and each firm needs to pay the entry cost, f_e, to enter the market. After paying the entry cost, firms realize their productivity level, θ, which is from a known common distribution. The production function of a firm with θ is given by

$$q(\theta) = \theta h, \tag{1.5}$$

where h is the number of workers the firm hires. Firms can choose to offshore by hiring foreign labor (FDI) or buying intermediate inputs from intermediate-goods suppliers (Outsourcing) to substitute h. In order to produce, firms also have to pay a fixed production cost, f_d.

Using Equation (1.2) and Equation (1.5), we can calculate the price and revenue of a firm with productivity level θ as a function of Q and h:

$$\begin{aligned} p(\theta) &= (\theta h)^{-(1-\beta)} Q^{-(\beta-\varsigma)}, \\ R(\theta) &= (\theta h)^{\beta} Q^{-(\beta-\varsigma)}. \end{aligned} \tag{1.6}$$

1.2.3 The Labor Market

In this economy, there is a continuum of identical households of measure one. As each household has L units of workers, the total labor endowment of this economy is L. Workers can choose to work either in the homogeneous-good sector or in the differentiated-goods sector. A household allocates its labor into two sectors. Out of L workers, it allocates N to the differentiated-good sector and $L - N$ to the homogeneous-good sector. As the wage in the homogeneous-good sector is equal to one, the average wage from working in the differentiated-goods sector should be one.

In the differentiated-goods sector, labor market frictions exist, and as a result of which, firms face a labor market cost, b, whenever it hires a worker. In this setting, firms consider not only the wage level, but also the labor market cost when they make a decision on the size of their labor.

The labor market cost can be decomposed into hiring and firing costs. When firms hire workers, they have to pay costs in opening vacancies. As it is not possible to have immediate matchings with potential workers, an inefficiency in the matching process also incurs costs.

When a vacancy is filled, firms have to fire a fraction of workers they hired, as they are assumed to realize whether workers are suitable or not for the jobs they are matched, once they are hired. Thus, firms need to hire more than an optimal number of employees, and they have to bear other costs related to the firing process.

Following the approach that is proposed in Helpman and Itskhoki (2010), I assume that the hiring cost b_h is a function of labor market tightness,

$$x = \frac{H}{(1-\sigma)\,N},$$

where H is the total hiring in the differentiated-goods sector and σ is the fraction of job openings which need to be fired. As firms anticipate to fire a fraction σ of total matches, they hire $\frac{H}{1-\sigma}$ to have H workers.

Hiring costs in this economy are defined as

$$b_h = ax^{\delta}, \quad a > 1 \, and \ \delta > 0,$$

where a represents frictions in the labor market during the hiring process. Higher costs of opening a vacancy or lower efficiency of matching technology will give us a higher a.

When firms fire a worker, they bear firing costs, ψ. Under the assumption that I made regarding the firing process, the total labor market cost becomes

$$b = \frac{1}{1-\sigma}\left(b_h + \sigma\psi\right) \tag{1.7}$$

and the economy-wide unemployment rate is defined as

$$u = \frac{N-H}{L}.$$

Following Stole and Zwiebel (1996a) and Stole and Zwiebel (1996b), firms engage in a generalized Nash Bargaining procedure over the revenue they create with matches. For simplicity, I assume equal bargaining power for a firm and a worker. As a result, the equilibrium wage as a function of employment is the solution of the following equation:

$$\frac{\partial}{\partial h}\left(R\left(h\right) - w\left(h\right)h\right) = w\left(h\right), \tag{1.8}$$

where $R\left(h\right)$ is the revenue and h is the number of workers. As an additional worker affects the overall wage level, Equation (1.8) yields a differential equation of w. With zero outside option for a worker,[2] the bargaining procedure makes the marginal gains from the additional worker equal to the marginal gains to the worker.

[2]Once a worker enters the differentiated-goods sector, she cannot go back to the homogeneous-good sector.

1.3 Choices of Firms

1.3.1 Domestic Integration (DI)

Firms in the differentiated-goods sector must pay a fixed cost, f_d, regardless of their organizational choices when they decide to produce. This fixed cost may include costs associated with headquarter services, such as accounting, finance operations, and R&D.

By using Equation (1.8), we can calculate equilibrium wages, $w(\theta)$, as a function of employment:

$$\frac{\partial}{\partial h}\left[R(\theta) - w(\theta)h\right] = w(\theta). \tag{1.9}$$

By solving this, we get

$$w(\theta) = \frac{\beta}{1+\beta}\frac{R(\theta)}{h}. \tag{1.10}$$

Thus, a firm loses $\frac{\beta}{1+\beta}R(\theta)$ after the wage bargaining and faces

$$\max \frac{1}{1+\beta}R(\theta) - bh - f_d, \tag{1.11}$$

and the optimal level of hiring becomes

$$h_d^*(\theta) = \left[\frac{\beta}{b(1+\beta)}\right]^{\frac{1}{1-\beta}} Q^{-\frac{\beta-\varsigma}{1-\beta}}\theta^{\frac{\beta}{1-\beta}}. \tag{1.12}$$

By plugging this into the wage equation, we get the wage and profit level from choosing DI:[3]

$$w(\theta) = b, \quad \forall\theta,$$

[3]In more general settings where the bargaining power of two parties are not equal, the wage level is proportional to the labor market cost. Specifically, with a relative bargaining power of firms μ, we get $w(\theta) = b/\mu$.

$$
\begin{aligned}
\pi_d^*(\theta) &= (1-\beta)\left(\frac{1}{1+\beta}\right)^{\frac{1}{1-\beta}}\left(\frac{\beta}{b}\right)^{\frac{\beta}{1-\beta}} Q^{-\frac{\beta-\varsigma}{1-\beta}}\theta^{\frac{\beta}{1-\beta}} - f_d \\
&\equiv A_d\Theta - f_d, \qquad (1.13)
\end{aligned}
$$

where $A_d = (1-\beta)\left(\frac{1}{1+\beta}\right)^{\frac{1}{1-\beta}}\left(\frac{\beta}{b}\right)^{\frac{\beta}{1-\beta}} Q^{-\frac{\beta-\varsigma}{1-\beta}}$ and $\Theta\left(=\theta^{\frac{\beta}{1-\beta}}\right)$ is a different measure of productivity.

1.3.2 FDI

Instead of hiring domestic labor, a firm can hire foreign labor by engaging in FDI. Similar to the domestic labor market, there also exist labor market frictions in the foreign labor market, and firms have to bear b_f whenever they hire workers.[4]

I assume that a firm engaging in FDI faces the same bargaining procedure as in Equation (1.9),

$$\frac{\partial}{\partial h}\left[R(\theta) - w_f(\theta)h\right] = w_f(\theta),$$

and the resulting wage level becomes

$$w_f(\theta) = \frac{\beta}{1+\beta}\frac{R(\theta)}{h}.$$

Therefore, the result of the wage bargaining is the same: a firm pays $\frac{\beta}{1+\beta}R(\theta)$ for the total wage. A firm solves the same problem as in DI with the foreign labor market cost, b_f, but with an additional fixed organizational cost of FDI, f_f, which is assumed to be greater than that of Outsourcing, f_u. Thus, a firm faces

$$\max \frac{1}{1+\beta}R(\theta) - b_f h - f_d - f_f$$

[4]Same as in the domestic labor market, b_f is generated from search and matching frictions in the foreign labor market. For example, we can think of a labor market structure in a foreign country to be the same as a domestic labor market with different parameters, $b_f = \frac{1}{1-\sigma_f}\left(a_f x_f^{\delta} + \sigma_f \psi_f\right)$.

and by solving this, we can derive the optimal hiring level,

$$h_f^*(\theta) = \left[\frac{\beta}{b_f(1+\beta)}\right]^{\frac{1}{1-\beta}} Q^{-\frac{\beta-\varsigma}{1-\beta}}\theta^{\frac{\beta}{1-\beta}}.$$

With the optimal hiring level, we can derive the following wage and profit level from choosing FDI:

$$w_f(\theta) = b_f, \quad \forall\theta,$$

$$\begin{aligned}
\pi_f^*(\theta) &= (1-\beta)\left(\frac{1}{1+\beta}\right)^{\frac{1}{1-\beta}}\left(\frac{\beta}{b_f}\right)^{\frac{\beta}{1-\beta}} Q^{-\frac{\beta-\varsigma}{1-\beta}}\theta^{\frac{\beta}{1-\beta}} - f_d - f_f \\
&\equiv A_f\Theta - f_d - f_f. \qquad (1.14)
\end{aligned}$$

1.3.3 Outsourcing

Now suppose that a firm can buy intermediate goods from foreign suppliers to substitute for labor.[5] The intermediate goods market is assumed to be perfectly competitive, and suppliers in the foreign country are assumed to have relative strength in dealing with the foreign labor market compared to firms from the home country, as they have more information about the labor market structure. Thus, they face a lower labor market cost compared to firms engaging in FDI, i.e.,

$$b_u < b_f,$$

where b_u denotes the labor market cost that suppliers face.

With the competitive price of an intermediate good, $p_u^{'}$, suppliers also has to bargain

[5]For simplicity, domestic Outsourcing is assumed to be dominated by domestic integration. Under an assumption that domestic firms are exposed to the same information about the domestic labor market, this is satisfied with the condition, $p^*/b>(1+\beta)^{1/\beta}$, where p^* denotes the unit price of a domestic intermediate good.

with theirs labor forces,

$$\frac{\partial}{\partial h}\left[p_u^{'}h - w_u h\right] = w_u,$$

and by solving this equation, we get

$$w_u = \frac{1}{2}p_u^{'}.$$

Thus, after the wage bargaining, a supplier maximizes the following problem:

$$\max \frac{1}{2}p_u^{'}h - b_u h.$$

And as the market is perfectly competitive, the price of an intermediate good should be at a level where the supplier gets zero profit, i.e.,

$$p_u^{'} = 2b_u.$$

By choosing Outsourcing, a firm can keep all of its revenue, as it does not have to deal with the labor market anymore. However, it is assumed that it needs to pay the adjustment cost, c, for every intermediate good to make it fit into its production process. Thus, the unit price of the intermediate good, p_u, becomes $p_u^{'} + c$. So the problem that a firm with Outsourcing faces is

$$\max R(\theta) - p_u h - f_d - f_u$$

and the resulting level of hiring and profit becomes

$$\begin{aligned}
h_u^*(\theta) &= \left(\frac{\beta}{p_u}\right)^{\frac{1}{1-\beta}} Q^{-\frac{\beta-\varsigma}{1-\beta}} \theta^{\frac{\beta}{1-\beta}}, \\
\pi_u^*(\theta) &= (1-\beta)\left(\frac{\beta}{p_u}\right)^{\frac{\beta}{1-\beta}} Q^{-\frac{\beta-\varsigma}{1-\beta}} \theta^{\frac{\beta}{1-\beta}} - f_d - f_u \\
&\equiv A_u \Theta - f_d - f_u. \qquad (1.15)
\end{aligned}$$

1.4 Equilibrium

As firms are different in terms of productivity and three choices come with different levels of fixed costs, we can observe different organizational types across firms in equilibrium. With three choices, we could have seven different cases. Although it is theoretically possible to have equilibrium with only FDI or only Outsourcing, I consider them as extreme cases and will discuss four other equilibria, which include at least Domestic Integration. From here on, I refer to these equilibria as Type 1, Type 2, Type 3, or Type 4 equilibrium: Type 1 has only DI and Type 2 has DI and Outsourcing. Type 3 is with DI and FDI and Type 4 includes all three choices.

1.4.1 Two Possible Paths

As a thought experiment, we now consider what would happen if the home labor market cost starts to increase from a very low level. When it is very low compared to p_u and b_f, firms located at home have no incentive to engage in offshoring. Thus, we would have Type 1 equilibrium, where only DI exists. As b increases, while p_u and b_f remain fixed, the relative benefits from choosing offshoring increase. When the gains from offshoring are sufficient to cover its fixed organizational cost, firms would change their organizational form into Outsourcing or FDI.

At this point, it is unclear which type of offshoring would be selected in the new equilibrium without further analysis. But that choice depends on the relative size of p_u and b_f. If the price of the intermediate good is relatively low compared to the foreign labor market cost, it is reasonable to expect that the equilibrium will change to Type 2 because Outsourcing involves lower fixed organizational cost. If that is not the case, the equilibrium will change to Type 3. This naturally gives rise to the following questions: what would be the possible equilibrium paths as b changes? And what are the conditions for each path? It turns out that two different paths exist in this model, depending on certain parameter values.

The first path is from Type 1 to Type 2. This happens when the gains from FDI are not sufficient to cover the additional fixed cost, $f_f - f_u$. In this path, as b increases, firms choose Outsourcing and then it becomes impossible to have FDI in equilibrium. This is because the relative variable benefits from having Outsourcing over FDI do not rely on the domestic labor market cost. If we derive the relative ratio between two coefficients, we get

$$\frac{A_f}{A_u} = (1+\beta)^{-\frac{1}{1-\beta}} \left(\frac{p_u}{b_f}\right)^{\frac{\beta}{1-\beta}},$$

which is independent of b. This means that the relative gains from having Outsourcing over FDI do not change as b increases. If A_f/A_u is smaller or equal to one, the gains from FDI would never become larger than that of Outsourcing due to higher fixed organizational cost, and the equilibrium would stay in Type 2 as b increases.

Instead, if A_f/A_u is big enough, we would have another path which includes FDI. In this path, FDI comes in first; and later we can see both choices in the equilibrium. In other words, the equilibrium changes from Type 1 to Type 3 and then moves on to Type 4. As b increases, FDI becomes more attractive for the most productive firms, while other firms stick to DI due to their inability to cover the fixed organizational cost of FDI. When b further increases, some firms begin to change to Outsourcing as the relative variable benefits from DI further shrink. In this equilibrium, firms with a high-productivity level choose FDI and firms with a modest-productivity level choose Outsourcing, while firms with a low-productivity level stay with DI. And as the condition of two paths cannot be satisfied at the same time, we can derive the following results.

Lemma 1. *In any path, Type 2 equilibrium cannot coexist with Type 3 or Type 4 equilibrium.*

Proof. This is clear if we compare the equilibrium conditions of each type.[6] To have Type 2 equilibrium, we need the condition, $(1+\beta)^{-\frac{1}{1-\beta}}\left(\frac{p_u}{b_f}\right)^{\frac{\beta}{1-\beta}} \leq 1$. But to have Type 3 or Type 4 equilibrium, we must have the condition, $(1+\beta)^{-\frac{1}{1-\beta}}\left(\frac{p_u}{b_f}\right)^{\frac{\beta}{1-\beta}} > 1$. These two conditions cannot be satisfied at the same time. □

Proposition 1. *If the domestic labor market cost keeps increasing from a very low level, while keeping p_u and b_f fixed, the equilibrium would change as*

1. *Type 1 → Type 2, if* $(1+\beta)^{-\frac{1}{1-\beta}}\left(\frac{p_u}{b_f}\right)^{\frac{\beta}{1-\beta}} \leq 1$
2. *Type 1 → Type 3 → Type 4, if* $(1+\beta)^{-\frac{1}{1-\beta}}\left(\frac{p_u}{b_f}\right)^{\frac{\beta}{1-\beta}} > 1$

1.4.2 Equilibrium Conditions

To characterize the equilibrium in this model, let's find the equilibrium conditions. For each type of the equilibrium, there exists a zero profit cutoff productivity, Θ_d, and (possibly) other productivity cutoffs that are defined by the intersections of different profit equations:

$$A_d\Theta_d = f_d, \tag{1.16a}$$

$$A_d\Theta_i - f_d = A_i\Theta_i - f_d - f_i, \quad i \in \{u, f\}, \tag{1.16b}$$

$$A_f\Theta_f - f_d - f_f = A_u\Theta_f - f_d - f_u. \tag{1.16c}$$

Equation (1.16a) set the zero-profit cutoff and Equation (1.16b) pin down the productivity level which gives us the same profit from DI and FDI (or Outsourcing). Equation (1.16c)

[6] In Appendices, I list the sufficient conditions for each type.

only appears in Type 4 equilibrium, where profit equations of FDI and Outsourcing intersect each other.

As firms draw their productivity level after they pay the fixed entry cost, the free entry condition equalizes the expected profit to the fixed entry cost:

$$f_e = E[\pi(\Theta)].$$

The total output in the differentiated-goods sector is derived as

$$Q = M^{\frac{1}{\beta}} \left[\int q(\Theta)^{\beta} dG(\Theta) \right]^{\frac{1}{\beta}},$$

where M is the measure of firms in the sector and $q(\Theta)$ is the output of a firm with productivity level Θ.

In the labor market, each household divides its labor endowment into two sectors, and this process equalizes expected wages in both sectors, i.e.,

$$x(1-\sigma)\bar{w} = 1.$$

The LHS simply indicates an expected wage from choosing the differentiated-goods sector. A worker expects to receive an average wage, $\bar{w}$, when she is hired, x, and is not fired, $1-\sigma$. And the RHS is the wage level that a worker could get from the homogeneous-good sector.

Total hiring in the differentiated-goods sector is defined as

$$H = M \times E[h(\Theta)]$$

and the average wage in the sector can be calculated by

$$\bar{w} = \frac{M \times E[w(\Theta)h(\Theta)]}{H}.$$

Without an additional assumption on the distribution of Θ, these conditions will implicitly determine M, N, H, Q, and cutoff productivity levels.

1.4.3 Equilibrium with DI, Outsourcing, and FDI (Type 4)

In this section, I will characterize equilibrium conditions and firms' decision under Type 4 equilibrium. As the equilibrium conditions depend on the distribution of Θ, I assume that Θ follows the Pareto distribution with shape parameter α and minimum value Θ_m for the rest of the discussion. I list the equilibrium conditions of the other three types in Appendices.

To have Type 4 equilibrium, we should have sufficiently low foreign labor market costs so that firms can cover the high fixed organizational cost in FDI. The unit price of an intermediate good should also be low enough to cover the fixed organizational cost of Outsourcing, but it should not be too low, as it would drive FDI out of the equilibrium.

Lemma 2. *Sufficient conditions to have Type 4 equilibrium are*

1. $(1+\beta)^{\frac{1}{1-\beta}}\left(\frac{b}{p_u}\right)^{\frac{\beta}{1-\beta}} > 1$ *&* $(1+\beta)^{-\frac{1}{1-\beta}}\left(\frac{p_u}{b_f}\right)^{\frac{\beta}{1-\beta}} > 1$,

2. $(1+\beta)^{\frac{1}{1-\beta}}\left(\frac{b}{p_u}\right)^{\frac{\beta}{1-\beta}} - 1 < \frac{f_u}{f_d}$ *&*
$\left(\frac{b}{b_f}\right)^{\frac{\beta}{1-\beta}} - (1+\beta)^{\frac{1}{1-\beta}}\left(\frac{b}{p_u}\right)^{\frac{\beta}{1-\beta}} < \left(\frac{f_f - f_u}{f_u}\right)\left[(1+\beta)^{\frac{1}{1-\beta}}\left(\frac{b}{p_u}\right)^{\frac{\beta}{1-\beta}} - 1\right]$.

Proof. As $f_f > f_u > 0$, we should have $A_f > A_u > A_d$ to have Type 4 equilibrium. The first condition comes from $A_d < A_u < A_f$. The second condition is derived from $\Theta_d < \Theta_u < \Theta_f$, where Θ_d, Θ_u, and Θ_f are defined by

$$\begin{cases} A_d\Theta_d - f_d \equiv 0 \\ A_u\Theta_u - f_u \equiv A_d\Theta_u \\ A_f\Theta_f - f_f \equiv A_u\Theta_f - f_u. \end{cases}$$ □

The first condition of this Lemma states that the variable benefits from FDI should be greatest, while the second condition restricts the variable gains from FDI, so that we can have both Outsourcing and DI in the equilibrium. If conditions in Lemma 2 are satisfied, we can find the following decision rule for firms in Type 4 equilibrium.

Proposition 2. *A firm with Θ will*

$$\begin{cases} exit & if\, \Theta < \Theta_d \\ choose\, DI & if\, \Theta_d < \Theta < \Theta_u \\ choose\, Outsourcing & if\, \Theta_u < \Theta < \Theta_f \\ choose\, FDI & if\, \Theta_f < \Theta. \end{cases}$$

This proposition tells us that a firm makes a decision over its structure by comparing its realized productivity level with three productivity cutoffs. It is interesting to note that this is similar to the segregation result of the headquarter intensive sector in Antràs and Helpman (2004). Although both papers share the same assumption on the relative sizes of fixed organizational costs, the fundamental source of the result is different. In Antràs and Helpman (2004), a trade-off between the ownership advantages in FDI and better incentive in Outsourcing, and the incomplete contracts in Outsourcing drive the results. In this model, however, the labor market condition, along with the price of intermediate goods, is the basis of the result as they determine three productivity cutoffs.

Using the equilibrium conditions that we discussed in the previous section, we can get analytical solutions of Θ_d, Θ_u, and Θ_f. Before proceeding further, it will be helpful to express Θ_u and Θ_f in terms of Θ_d by using three cutoff conditions:

$$\Theta_u = \frac{f_u}{f_d}\left[(1+\beta)^{\frac{1}{1-\beta}}\left(\frac{b}{p_u}\right)^{\frac{\beta}{1-\beta}} - 1\right]^{-1}\Theta_d \equiv k_1\Theta_d, \tag{1.17}$$

$$\Theta_f = \frac{f_f - f_u}{f_d}\left[\left(\frac{b}{b_f}\right)^{\frac{\beta}{1-\beta}} - (1+\beta)^{\frac{1}{1-\beta}}\left(\frac{b}{p_u}\right)^{\frac{\beta}{1-\beta}}\right]^{-1}\Theta_d \equiv k_2\Theta_d. \tag{1.18}$$

With these, we can express three profit equations in terms of three productivity cutoffs:

$$\begin{aligned}
\pi_d(\Theta) &= f_d \frac{\Theta}{\Theta_d} - f_d, \\
\pi_u(\Theta) &= (f_u + k_1 f_d) \frac{\Theta}{k_1 \Theta_d} - f_d - f_u, \\
\pi_f(\Theta) &= \left[k_2 f_d + \left(\frac{k_2 - k_1}{k_1} \right) f_u + f_f \right] \frac{\Theta}{k_2 \Theta_d} - f_d - f_f.
\end{aligned}$$

If we plug these into the free entry condition and apply the Pareto distribution assumption, we get

$$\begin{aligned}
f_e &= \int_{\Theta_d}^{\Theta_u} \left[f_d \frac{\Theta}{\Theta_d} - f_d \right] dG(\Theta) + \int_{\Theta_u}^{\Theta_f} \left[(f_u + k_1 f_d) \frac{\Theta}{k_1 \Theta_d} - f_d - fu \right] dG(\Theta) \\
&\quad + \int_{\Theta_f}^{\infty} \left[\left(k_2 f_d + \left(\frac{k_2 - k_1}{k_1} \right) f_u + f_f \right) \frac{\Theta}{k_2 \Theta_d} - f_d - f_f \right] dG(\Theta) \qquad (1.19) \\
&= \frac{(k_1 k_2)^{-\alpha} \left[\left(f_f - f_u \right) k_1^{\alpha} + \left(f_u + f_d k_1^{\alpha} \right) k_2^{\alpha} \right]}{\alpha - 1} \left(\frac{\Theta_m}{\Theta_d} \right)^{\alpha},
\end{aligned}$$

where the last expression, which relates Θ_d in terms of k_1 and k_2, is decreasing in Θ_d.

The labor market condition and the average wage condition are calculated as

$$x(1 - \sigma)\bar{w} = 1 \qquad (1.20)$$

and as

$$\overline{w} = \frac{M}{H} \int_{\Theta_d}^{\Theta_u} w(\Theta) h_d(\Theta) dG(\Theta) = \frac{bM}{H} \int_{\Theta_d}^{\Theta_u} h_d(\Theta) dG(\Theta). \qquad (1.21)$$

The second equality of the average wage condition holds because all domestic labor receives the same wage, b.

The total hiring, H, and the total output in the differentiated-goods sector, Q, are defined as

$$H = M \int_{\Theta_d}^{\Theta_u} h_d(\Theta) dG(\Theta) \qquad (1.22)$$

and

$$Q = M^{\frac{1}{\beta}} \left[\int_{\Theta_d}^{\Theta_u} q_d\left(\Theta\right)^{\beta} dG\left(\Theta\right) + \int_{\Theta_u}^{\Theta_f} q_u\left(\Theta\right)^{\beta} dG\left(\Theta\right) + \int_{\Theta_f}^{\infty} q_f\left(\Theta\right)^{\beta} dG\left(\Theta\right) \right]^{\frac{1}{\beta}}, \quad (1.23)$$

where

$$\begin{aligned} q_d\left(\Theta\right) &= \Theta^{\frac{1-\beta}{\beta}} h_d, \\ q_u\left(\Theta\right) &= \Theta^{\frac{1-\beta}{\beta}} h_u, \\ q_f\left(\Theta\right) &= \Theta^{\frac{1-\beta}{\beta}} h_f. \end{aligned}$$

Combining (1.20), (1.21), and (1.22), we get

$$\frac{H}{N} = \frac{1}{b}. \quad (1.24)$$

Using this result and Equation (1.7), we get the following equation that determines the labor market cost:

$$b = \frac{1}{1-\sigma}\left(ax^{\delta} + \sigma\psi\right) = \frac{1}{1-\sigma}\left\{a\left[\frac{1}{b\left(1-\sigma\right)}\right]^{\delta} + \sigma\psi\right\}. \quad (1.25)$$

Note that we can calculate b from Equation (1.25) as a function of labor market parameters. In other words, b does not depend on other fixed costs, nor the distribution of productivity. This result is consistent with the result of the closed economy model in Helpman and Itskhoki (2010).[7]

As the labor market cost is determined solely by exogenous labor market parameters, we can calculate Θ_d from Equation (1.19). As the right hand side of Equation (1.19) is decreasing in Θ_d, under the conditions of Proposition 2, there exists Θ_d, which is unique

[7] Note that this model focuses on not a horizontal FDI, but a vertical FDI. As discussed in Antras and Yeaple (2013), it is useful to assume zero transportation costs to shut down the horizontal incentive in FDI. Thus, if I introduce exports into this model, it will create unnecessary complications, while keeping the main results the same, as it would only increase the market size that firms face.

at a given level of b. Then, we can calculate the total output in the differentiated-goods sector using the zero profit condition:

$$\frac{1-\beta}{1+\beta}\left[\frac{\beta}{b(1+\beta)}\right]^{\frac{\beta}{1-\beta}} Q^{-\frac{\beta-\zeta}{1-\beta}}\Theta_d = f_d.$$

With Θ_d and Q, we can solve for M, N, and H using, (1.22), (1.23), and (1.24), while Θ_u and Θ_f can be solved from (1.17) and (1.18).

1.5 Analysis

1.5.1 FDI vs. Outsourcing

In this section, I attempt to analyze the trade-off between FDI and Outsourcing. To do this, let me list three different profit equations in three different choices:

$$\pi_d(\Theta) = A_d\Theta - f_d, \tag{1.26a}$$

$$\pi_f(\Theta) = A_f\Theta - f_d - f_f, \tag{1.26b}$$

$$\pi_u(\Theta) = A_u\Theta - f_d - f_u, \tag{1.26c}$$

where

$$\begin{aligned}
A_d &= (1-\beta)\left(\frac{1}{1+\beta}\right)^{\frac{1}{1-\beta}}\left(\frac{\beta}{b}\right)^{\frac{\beta}{1-\beta}} Q^{-\frac{\beta-\varsigma}{1-\beta}},\\
A_f &= (1-\beta)\left(\frac{1}{1+\beta}\right)^{\frac{1}{1-\beta}}\left(\frac{\beta}{b_f}\right)^{\frac{\beta}{1-\beta}} Q^{-\frac{\beta-\varsigma}{1-\beta}},\\
A_u &= (1-\beta)\left(\frac{\beta}{p_u}\right)^{\frac{\beta}{1-\beta}} Q^{-\frac{\beta-\varsigma}{1-\beta}}.
\end{aligned}$$

By comparing three different expressions, we can see that all three choices have a simple linear relationship with the productivity level and the three coefficients of Θ take similar forms. If we calculate ratios between them, we get $\frac{A_u}{A_d} = (1+\beta)^{\frac{1}{1-\beta}} \left(\frac{b}{p_u}\right)^{\frac{\beta}{1-\beta}}$, $\frac{A_f}{A_d} = \left(\frac{b}{b_f}\right)^{\frac{\beta}{1-\beta}}$, and $\frac{A_f}{A_u} = (1+\beta)^{-\frac{1}{1-\beta}} \left(\frac{p_u}{b_f}\right)^{\frac{\beta}{1-\beta}}$. From here, we can see that the relative levels of p_u and b_f along with b determine the relative variable benefits of each choice.

As $\frac{A_f}{A_u} = (1+\beta)^{-\frac{1}{1-\beta}} \left(\frac{p_u}{b_f}\right)^{\frac{\beta}{1-\beta}} = (1+\beta)^{-\frac{1}{1-\beta}} \left(\frac{2b_u+c}{b_f}\right)^{\frac{\beta}{1-\beta}}$, β and c affect the relative attractiveness of two choices at a given level of b_u and b_f. The term with β originates from the fact that in Outsourcing, firms do not have to bargain over their revenue with their labor, as they can replace workers with intermediate goods. Thus, we can interpret this term as an additional benefit of choosing Outsourcing over FDI.

Proposition 3. *By choosing Outsourcing, a firm can avoid the labor market and this gives a secondary benefit to the firm, which in turn increases as workers have more shares in the wage bargaining process.*

Proof. The term $(1+\beta)^{\frac{1}{1-\beta}}$, which can be interpreted as a secondary relative benefit of choosing Outsourcing over FDI, is an increasing function of β. It has a value of one when β is zero, and it goes to infinity as β goes to one. As the worker's share in the wage bargaining, $\frac{\beta}{1+\beta}$, increases in β, the secondary benefit of having Outsourcing increases in the workers' share. □

The intuition of this proposition is quite simple. The larger the share that workers receive in wage bargaining, the more the gains that firms have as a result of avoiding it.

The other parameter that affects the trade off between two choices is c. If we have very low c, Outsourcing will dominate FDI as it also has lower organizational cost. On the contrary, if c is too high, Outsourcing would not be chosen by any firms, as the variable benefits of choosing it would be lower than FDI and DI.

To be more specific, let's rewrite the first sufficient condition of Type 4 equilibrium:

$$b_f (1+\beta)^{\frac{1}{\beta}} - 2b_u < c < b (1+\beta)^{\frac{1}{\beta}} - 2b_u.$$

This condition tells us that, in Type 4 equilibrium, c has to be low enough to make Outsourcing a profitable option for some firms ($c < b(1+\beta)^{\frac{1}{\beta}} - 2b_u$), while it should not be too low, as it would drive FDI out of the equilibrium ($b_f(1+\beta)^{\frac{1}{\beta}} - 2b_u < c$). If c is larger than $b(1+\beta)^{\frac{1}{\beta}} - 2b_u$, we will have Type 3 equilibrium and if c is smaller than $b_f(1+\beta)^{\frac{1}{\beta}} - 2b_u$, it will become Type 2 equilibrium.

We can interpret c as a generality of a skill that a firm uses. If a firm uses unique technology, it will be very costly for it to buy an intermediate good and adjust it to fit into its production process. In this case, the firm would be better-off by choosing integration, instead of an arm's-length relationship. On the contrary, if the technology is a general one, it will be profitable to choose Outsourcing. We can also think of c as a fixed cost of producing an intermediate input as in Antràs (2003); but in my model firms have to bear all of the cost as suppliers get zero profit.

1.5.2 Effect of the Domestic Labor Market Cost on Firms' Decision

One benefit of using the proposed model is that we can derive analytic solutions of Θ_d, Θ_u, and Θ_f in all types of equilibria. With these, we can analyze the effect of the domestic labor market cost on individual firms' decision.

Equilibrium values of the zero profit cutoff in all types are summarized in Table 1.1. Note that unlike all the other equilibria, in Type 1, Θ_d does not depend on the domestic labor market cost. This means that as long as b lies in a range which supports Type 1 equilibrium, changes in b do not change the zero profit cutoff. It turns out that changes in b are completely offset by changes in the quantity index in the differentiated-goods sector, Q, so that the profit level of an individual firm remains the same. For three other types of equilibria, we can do comparative statics to determine the effect of changes in b on Θ_d and it turns out that Θ_d decreases in b in all of them.

Table 1.1: Three Productivity Cutoffs

	Θ_d	Θ_u	Θ_f
Type 1	$\left[\frac{f_d}{f_e(\alpha-1)}\right]^{1/\alpha}\Theta_m$	-	-
Type 2	$\left[\frac{f_d+k_1^{-\alpha}f_u}{f_e(\alpha-1)}\right]^{1/\alpha}\Theta_m$	$k_1\Theta_d$[1]	-
Type 3	$\left[\frac{f_d+k_3^{-\alpha}f_f}{f_e(\alpha-1)}\right]^{1/\alpha}\Theta_m$	-	$k_3\Theta_d$[3]
Type 4	$\left[\frac{f_d+k_1^{-\alpha}f_u+k_2^{-\alpha}\left(f_f-f_u\right)}{f_e(\alpha-1)}\right]^{1/\alpha}\Theta_m$	$k_1\Theta_d$	$k_2\Theta_d$[2]

[1] $k_1 = f_u/f_d\left[(1+\beta)^{1/(1-\beta)}\left(b/p_u\right)^{\beta/(1-\beta)} - 1\right]^{-1}$

[2] $k_2 = \left(f_f - f_u\right)/f_d\left[\left(b/b_f\right)^{\beta/(1-\beta)} - (1+\beta)^{1/(1-\beta)}\left(b/p_u\right)^{\beta/(1-\beta)}\right]^{-1}$

[3] $k_3 = f_f/f_d\left[\left(b/b_f\right)^{\beta/(1-\beta)} - 1\right]^{-1}$

To understand this result, let's see the equilibrium conditions of Type 1. Once we derive Θ_d as in Table 1.1, we use the zero profit cutoff condition,

$$\pi_d(\Theta_d) = (1-\beta)\left(\frac{1}{1+\beta}\right)^{\frac{1}{1-\beta}}\left(\frac{\beta}{b}\right)^{\frac{\beta}{1-\beta}} Q^{-\frac{\beta-\varsigma}{1-\beta}}\Theta_d - f_d = 0, \tag{1.27}$$

to get the equilibrium level of Q. From here, we can see that in Type 1 equilibrium, the production index should be adjusted to cancel out the changes in b, as Θ_d is unaffected by that. This means that if firms in Type 1 face a higher domestic labor market cost, they reduce production quantities to make the profit level the same. And the reduced Q makes the profit curves of Outsourcing and FDI steeper, as firms with either of them now enjoy higher domestic prices.

When the profit curve of FDI or Outsourcing becomes steeper than DI, firms with a high productivity level start to choose offshoring (Type 2 or Type 3). Now, firms that choose offshoring are not affected by the changes in the domestic labor market cost as they do not hire domestic labor. So the changes in Q cannot fully absorb all of the effects of the changes in b, and the profit level of firms that choose DI start to decrease. This process in turn forces more firms to exit (increase in Θ_d), and thus the average productivity level is increased.

And this process continues as b increases. The profit level of DI decreases, and that of offshoring increases. Thus, in both Type 2 and Type 3 equilibria, more firms exit (Θ_d increases), while more firms choose offshoring. This result implies that Θ_u in Type 2 and Θ_f in Type 3 decreases in b.

Even in Type 4 equilibrium, Θ_d will increase as b increases. Although it is difficult to predict the movement of two other cutoffs, it turns out that we can prove both Θ_u and Θ_f decreases in b. Intuitively, this result is driven by the following fact: the relative benefits of selecting FDI instead of Outsourcing do not depend on b. As we have seen in the Section 1.4.1, $\frac{A_f}{A_u}$ does not include any terms containing b. As b increases, the relative benefits of choosing Outsourcing or FDI compared to DI increases; but its effect is not biased toward a certain choice, i.e., both Θ_u and Θ_f decrease. Above discussion can be summarized in the following proposition.

Proposition 4. *As b increases, while keeping b_f and p_u fixed,*

1. *Θ_d is not affected in Type 1 equilibrium,*
2. *Θ_d increases in Type 2, Type 3, and Type 4 equilibrium,*
3. *both Θ_u and Θ_f decrease,*
4. *average firm productivity in the differentiated-goods sector increases.*

Proof. In Appendices □

1.5.3 Economic Implications of Offshoring

This model predicts how firms' organizational decision is made across heterogeneous firms when three possible choices are given. To see the economic implications of having these options, let's think about an autarky equilibrium, where offshoring is not allowed.

In autarky, firms cannot choose offshoring, and thus the equilibrium will stay in Type 1. As discussed in the previous chapter, in Type 1, Θ_d remains at the same level and Q decreases when b increases. Considering the indirect utility function of this economy, $V = E + \frac{1-\zeta}{\zeta} Q^{\zeta}$, these results imply that the welfare level of the autarky equilibrium decreases.

To compare the welfare level in autarky with that of an economy where offshoring is allowed, let's check the zero profit cutoff condition in both cases. In both economies, Q is defined by Equation (1.27):

$$
\begin{aligned}
Q_A^{-\frac{\beta-\zeta}{1-\beta}} &= \frac{1+\beta}{1-\beta}\left[\frac{b\,(1+\beta)}{\beta}\right]^{\frac{\beta}{1-\beta}} \frac{f_d}{\Theta_{d,A}}, \\
Q_O^{-\frac{\beta-\zeta}{1-\beta}} &= \frac{1+\beta}{1-\beta}\left[\frac{b\,(1+\beta)}{\beta}\right]^{\frac{\beta}{1-\beta}} \frac{f_d}{\Theta_{d,O}},
\end{aligned}
$$

where subscript A denotes the autarky equilibrium and O denotes an equilibrium with offshoring. By dividing one equation with the other, we get

$$\left(\frac{Q_O}{Q_A}\right)^{-\frac{\beta-\zeta}{1-\beta}} = \frac{\Theta_{d,A}}{\Theta_{d,O}}. \tag{1.28}$$

By Proposition 4, when b is sufficiently large, the right hand side of Equation (1.28) is smaller than one, and thus Q_O is greater than Q_A (they will be the same if b lies in a region that support Type 1 equilibrium). Simply taking a derivative with respect to b in Equation (1.28), we can prove that $\frac{Q_O}{Q_A}$ increases in b.[8] These are summarized in the following proposition.

Proposition 5. *The welfare level of an economy with offshoring is*

1. *higher than that in autarky*

2. *and the difference between the welfare levels increases in b.*

[8] It can also be shown that Q in all types of equilibria decreases in b.

Now, let's discuss the hiring level of domestic workers and the unemployment rate in this model. By using the same trick of Equation (1.28) with Equation (1.12), we get

$$\frac{h_O(\Theta)}{h_A(\Theta)} = \left(\frac{Q_O}{Q_A}\right)^{-\frac{\beta-\zeta}{1-\beta}}. \tag{1.29}$$

As $\frac{Q_O}{Q_A} > 1$, we can see that the hiring level of individual firms in autarky is higher than that of the offshoring equilibrium.

Moreover, under the Pareto assumption that I made, the number of firms that choose DI is smaller in the offshoring equilibrium. Thus, we can conclude that the total hiring, H, is smaller in an economy with offshoring (of course, if the economy stays in Type 1 equilibrium even though offshoring is allowed, Q and H will be the same).

The economy-wide unemployment rate is defined as

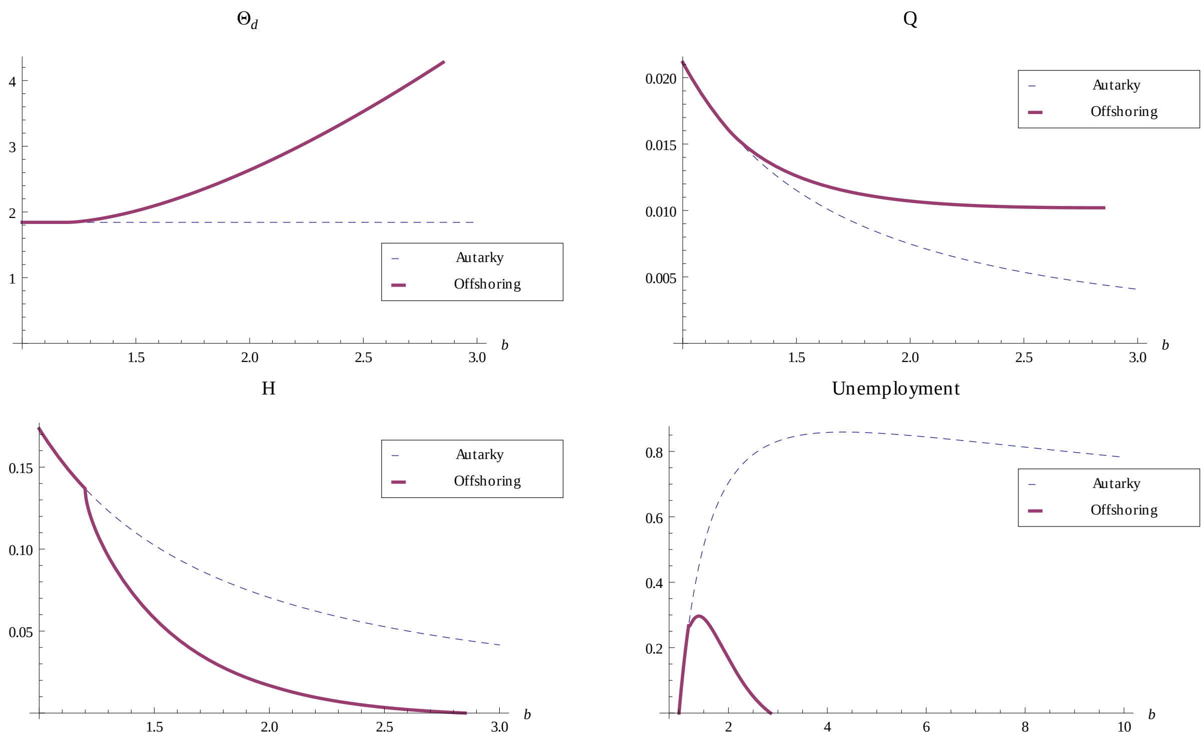
$$u = (N - H)/L = (b-1)H/L, \tag{1.30}$$

where the second equality holds by Equation (1.24). From here, we can see that the unemployment rate equals zero when $b = 1$. When b goes to infinity, the term $\left(1 - \frac{1}{b}\right)$ will get closer to one, but as H approaches zero, the unemployment rate will also go to zero. Thus, as b increases, we would expect a bell-shaped unemployment rate curve.

The bell-shaped unemployment rate curve is driven by the labor movement across two sectors. As b increases, more workers enter the differentiated-goods sector, as higher b means a higher wage level. However, as the total hiring, H, decreases at the same time, workers realize that the probability of getting a job in the differentiated-goods sector becomes lower and they choose the other sector. Even though this process hinders workers from entering the diffentiated-goods sector in both the offshoring equilibrium and the autarky equilibrium, it is much slower in autarky. In the offshoring equilibrium, increased labor market inefficiencies make firms choose offshoring, and thus adjustment in H is more dramatic than in autarky. With lower H, more workers choose the homogeneous sector, and thus the unemployment rate in the offshoring equilibrium becomes lower than that in autarky. Analytically, this is an obvious result, as H in autarky is higher than that in the offshoring equilibrium, and Equation (1.30) tells us, at a given level of b, higher H leads to a higher unemployment rate.

Proposition 6. *In an economy with offshoring, the total hiring in the differentiated-goods sector and the unemployment rate are lower than those in autarky.*

Figure 1.1: Autarky vs. Offshoring equilibrium



For illustrative purposes, I simulate the model with parameter values that support the second path (Type 1→Type 2→Type4).[9] From Figure 1.1, we can see that the total hiring in the differentiated-goods sector and the economy-wide unemployment rate are lower in the offshoring equilibrium. We can also find that the total output is higher, and the zero profit cutoff is increasing in b in the offshoring equilibrium. All of these results are fundamentally driven by the fact that offshoring allows the economy more options to

[9] I used $b_f = 1.2$, $p_u = 3$, $f_d = 5$, $f_u = 10$, $f_f = 15$, $f_e = 4$, $\Theta_m = 1$, $\alpha = 1.5$, $\zeta = 0.2$, $\beta = 0.6$ for this example.

react to the increased inefficiencies in the labor market. By choosing offshoring, firms can prevent the quantity from dropping too much, and this is the main source of the welfare gains in this economy.

1.6 CONCLUSION

In this paper, I studied an economy with two sectors where the labor market in one is under search and matching frictions. By focusing on four types of equilibria, I find that the welfare level of the economy decreases as the labor market inefficiency increases. Increased labor market inefficiency makes more firms choose offshoring, in which foreign labor is used and more firms exit. As firms with a high-productivity level choose to offshore and firms with a low-productivity level exit, the average productivity level increases. Since fewer firms hire domestic labor, total hiring is reduced and total output decreases in the differentiated-goods sector. As the increased wage level and the decreased total hiring cause the economy-wide unemployment rate to move in different directions, it shows a bell-shaped curve.

I also analyzed the economic implications of offshoring by comparing the offshoring equilibrium with the autarky equilibrium. In the offshoring equilibrium, the welfare level is weakly higher and the economy-wide unemployment rate is weakly lower than those in the autarky equilibrium. This implies that even though offshoring reduces the size of total hiring, it does help the economy by lowering the unemployment rate and lifting the welfare level. It is interesting to note that the clear prediction of the unemployment rate is driven by the assumption of a frictionless labor market in the homogeneous-good sector. With this assumption, the impact of the reduced total hiring in the differentiated-goods sector can be absorbed by the homogeneous-good sector. This is similar to Mitra and Ranjan's (2010) finding that offshoring decreases the economy-wide unemployment rate when perfect inter-sectoral mobility is satisfied. In both papers, the impact of offshoring on the unemployment rate depends on whether or not the other sector can partly absorb the negative effects of offshoring on unemployment.

It may be interesting to extend the proposed model in this study by relaxing the assumption of a frictionless labor market in the homogeneous-good sector; but the main point of this model will still be the same: the difference in the labor market cost across countries is the key factor that determines a firm's decision on offshoring. Only with the labor market frictions is this model able to produce the same segregation result that was found in previous studies.[10] This result hints that the full employment assumption which was used in many previous studies could be too strong in analyzing the motivation of offshoring.

[10]See Antràs and Helpman (2004) and Helpman et al. (2004).

APPENDIX

Appendix for Chapter 1

Equilibrium Conditions for Type 1, Type 2, and Type 3

Equilibrium with DI (Type 1)

Suppose that there only exist Domestic Integration in equilibrium. This happens when gains from offshoring are not enough to cover the fixed organizational costs.

Lemma 3. *The sufficient condition for Type 1 equilibrium are*

$$(1+\beta)^{\frac{1}{1-\beta}}\left(\frac{b}{p_u}\right)^{\frac{\beta}{1-\beta}} \;\leq\; 1 \;\; \textit{and} \;\; \left(\frac{b}{b_f}\right)^{\frac{\beta}{1-\beta}} \leq 1.$$

Proof. The first condition comes from $A_u \leq A_d$ and the second condition comes from $A_f \leq A_d$. As I assume $f_f > f_u > 0$, these two conditions ensure Type 1 equilibrium. $\square$

In Type 1 equilibrium, there only exist zero profit cutoff, which is defined by Equation (1.16a). Other equilibrium conditions for Type 1 will become as following:

(free entry)	$f_e = \int_{\Theta_d}^{\infty} \pi_d(\Theta) dG(\Theta)$
(labor market)	$x(1-\sigma)\bar{w} = 1$
(average wage)	$\bar{w} = \frac{M}{H}\int_{\Theta_d}^{\infty} w(\Theta) h_d(\Theta) dG(\Theta)$
(total hiring)	$H = M\int_{\Theta_d}^{\infty} h_d(\Theta) dG(\Theta)$
(total output)	$Q = M^{\frac{1}{\beta}}\left[\int_{\Theta_d}^{\infty} q_d(\Theta)^{\beta} dG(\Theta)\right]^{\frac{1}{\beta}}$

Equilibrium with DI and Outsourcing (Type 2)

Type 2 equilibrium exists when the benefits of choosing Outsourcing dominate those of choosing FDI.

Lemma 4. *Sufficient conditions to have Type 2 equilibrium are*

1. $(1+\beta)^{\frac{1}{1-\beta}}\left(\frac{b}{p_u}\right)^{\frac{\beta}{1-\beta}} > 1$ *&* $(1+\beta)^{-\frac{1}{1-\beta}}\left(\frac{p_u}{b_f}\right)^{\frac{\beta}{1-\beta}} \leq 1$,

2. $(1+\beta)^{\frac{1}{1-\beta}}\left(\frac{b}{p_u}\right)^{\frac{\beta}{1-\beta}} - 1 < \frac{f_u}{f_d}$.

Proof. The first condition comes from $A_d < A_u$ & $A_f \leq A_u$. And the second condition comes from $\Theta_d < \Theta_u$. □

In Type 2, there exist two cutoffs, zero profit cutoff, Θ_d, and Outsourcing cutoff, Θ_u. Other equilibrium conditions will be modified as following:

$$
\begin{array}{ll}
\text{(free entry)} & f_e = \int_{\Theta_d}^{\Theta_u} \pi_d(\Theta) dG(\Theta) + \int_{\Theta_u}^{\infty} \pi_u(\Theta) dG(\Theta) \\
\text{(labor market)} & x(1-\sigma)\bar{w} = 1 \\
\text{(average wage)} & \bar{w} = \frac{M}{H} \int_{\Theta_d}^{\Theta_u} w(\Theta) h_d(\Theta) dG(\Theta) + \int_{\Theta_u}^{\infty} w(\Theta) h_u(\Theta) dG(\Theta) \\
\text{(total hiring)} & H = M\left[\int_{\Theta_d}^{\Theta_u} h_d(\Theta) dG(\Theta) + \int_{\Theta_u}^{\infty} h_u(\Theta) dG(\Theta)\right] \\
\text{(total output)} & Q = M^{\frac{1}{\beta}}\left[\int_{\Theta_d}^{\Theta_u} q_d(\Theta)^{\beta} dG(\Theta) + \int_{\Theta_u}^{\infty} q_u(\Theta)^{\beta} dG(\Theta)\right]^{\frac{1}{\beta}}
\end{array}
$$

Equilibrium with DI and FDI (Type 3)

Type 3 equilibrium exists when the benefits of choosing FDI dominates those of choosing Outsourcing.

Lemma 5. *Sufficient conditions to have Type 3 equilibrium are*

1. $\left(\frac{b}{b_f}\right)^{\frac{\beta}{1-\beta}} > 1$ & $(1+\beta)^{-\frac{1}{1-\beta}}\left(\frac{p_u}{b_f}\right)^{\frac{\beta}{1-\beta}} > 1$,

2. $\left(\frac{b}{b_f}\right)^{\frac{\beta}{1-\beta}} - 1 < \frac{f_f}{f_d}$ & $\frac{f_f}{f_u}\left[(1+\beta)^{\frac{1}{1-\beta}}\left(\frac{b}{p_u}\right)^{\frac{\beta}{1-\beta}} - 1\right] < \left(\frac{b}{b_f}\right)^{\frac{\beta}{1-\beta}} - 1$.

Proof. The first condition comes from $A_d < A_f$ & $A_u < A_f$. The second condition comes from $\Theta_d < \Theta_f$ & $\Theta_f < \Theta_u$. □

In Type 3, two cutoffs exist, zero profit cutoff, Θ_d, and FDI cutoff, Θ_f. Other equilibrium conditions will be modified as following:

(free entry)	$f_e = \int_{\Theta_d}^{\Theta_f} \pi_d(\Theta) dG(\Theta) + \int_{\Theta_f}^{\infty} \pi_f(\Theta) dG(\Theta)$
(labor market)	$x(1-\sigma)\bar{w} = 1$
(average wage)	$\bar{w} = \frac{M}{H} \int_{\Theta_d}^{\Theta_u} w(\Theta) h_d(\Theta) dG(\Theta) + \int_{\Theta_u}^{\infty} w(\Theta) h_u(\Theta) dG(\Theta)$
(total hiring)	$H = M \left[\int_{\Theta_d}^{\Theta_f} h_d(\Theta) dG(\Theta) + \int_{\Theta_f}^{\infty} h_f(\Theta) dG(\Theta) \right]$
(total output)	$Q = M^{\frac{1}{\beta}} \left[\int_{\Theta_d}^{\Theta_f} q_d(\Theta)^{\beta} dG(\Theta) + \int_{\Theta_f}^{\infty} q_f(\Theta)^{\beta} dG(\Theta) \right]^{\frac{1}{\beta}}$

Proof of Proposition 4

The zero profit cutoff (Θ_d)

Before proceeding further, let's define

$$R_1 \equiv \frac{A_u}{A_d} = (1+\beta)^{\frac{1}{1-\beta}} \left(\frac{b}{p_u} \right)^{\frac{\beta}{1-\beta}}$$

and

$$R_2 \equiv \frac{A_f}{A_d} = \left(\frac{b}{b_f} \right)^{\frac{\beta}{1-\beta}}.$$

One can easily show that $\frac{dR_1}{db} > 0$ and $\frac{dR_2}{db} > 0$. It is also convenient to define k_1, k_2, and k_3 as

$$\begin{aligned} k_1 &= \frac{f_u}{f_d} (R_1 - 1)^{-1}, \\ k_2 &= \frac{f_f - f_u}{f_d} (R_2 - R_1)^{-1}, \\ k_3 &= \frac{f_f}{f_d} (R_2 - 1)^{-1}. \end{aligned}$$

For Type 2 equilibrium, $\Theta_d = \left[\frac{f_d + k_1^{-\alpha} f_u}{f_e(\alpha - 1)} \right]^{1/\alpha} \Theta_m$. By taking a derivative with respect to

b, we get

$$\frac{d\Theta_d}{db} = \frac{d\Theta_d}{dk_1}\frac{dk_1}{db} = \left\{ -\left[\frac{f_d + k_1^{-\alpha} f_u}{f_e(\alpha-1)}\right]^{\frac{1}{\alpha}-1} \frac{f_u}{f_e(\alpha-1)} k_1^{-\alpha-1}\Theta_m \right\} \left\{ -\frac{f_u}{f_d(R_1-1)^2}\frac{dR_1}{db} \right\} > 0.$$

For Type 3 equilibrium, $\Theta_d = \left[\frac{f_d + k_3^{-\alpha} f_f}{f_e(\alpha-1)}\right]^{1/\alpha} \Theta_m$. By taking a derivative with respect to b, we get

$$\frac{d\Theta_d}{db} = \frac{d\Theta_d}{dk_3}\frac{dk_3}{db} = \left\{ -\left[\frac{f_d + k_3^{-\alpha} f_u}{f_e(\alpha-1)}\right]^{\frac{1}{\alpha}-1} \frac{f_u}{f_e(\alpha-1)} k_3^{-\alpha-1}\Theta_m \right\} \left\{ -\frac{f_u}{f_d(R_2-1)^2}\frac{dR_2}{db} \right\} > 0.$$

For Type 4 equilibrium, $\Theta_d = \left[\frac{f_d + k_1^{-\alpha} f_u + k_2^{-\alpha}\left(f_f - f_u\right)}{f_e(\alpha-1)}\right]^{1/\alpha} \Theta_m$. As both $k_1$and k_2 depend on b, we have to check the sign of

$$\frac{d\Theta_d}{db} = \frac{\partial\Theta_d}{\partial k_1}\frac{dk_1}{db} + \frac{\partial\Theta_d}{\partial k_2}\frac{dk_2}{db},$$

where $\frac{dk_1}{db} = -\frac{f_u}{f_d(R_1-1)^2}\frac{dR_1}{db} < 0$. We can find signs of other three parts as

$$\frac{\partial\Theta_d}{\partial k_1} = -\left[\frac{f_d + k_1^{-\alpha} f_u + k_2^{-\alpha}\left(f_f - f_u\right)}{f_e(\alpha-1)}\right]^{1/\alpha-1} \Theta_m \frac{f_u}{f_e(\alpha-1)} k_1^{-\alpha-1} < 0,$$

$$\frac{\partial\Theta_d}{\partial k_2} = -\left[\frac{f_d + k_1^{-\alpha} f_u + k_2^{-\alpha}\left(f_f - f_u\right)}{f_e(\alpha-1)}\right]^{1/\alpha-1} \Theta_m \frac{f_f - f_u}{f_e(\alpha-1)} k_2^{-\alpha-1} < 0,$$

$$\frac{dk_2}{db} = -\frac{f_f - f_u}{f_d}\left(\frac{1}{R_2 - R_1}\right)^2 \left[\frac{\beta\left(R_2 - R_1\right)}{(1-\beta)\, b}\right] < 0.$$

The inequality of the last equation holds because, in Type 4, $R_2 = \frac{A_f}{A_d} > \frac{A_u}{A_d} = R_1$.

Outsourcing cutoff (Θ_u) and FDI cutoff (Θ_f)

In Type 2 equilibrium, we have one additional cutoff,

$$\Theta_u = k_1 \Theta_d.$$

Taking a derivative with respect to b, we get $\frac{d\Theta_u}{db} = k_1 \frac{d\Theta_d}{db} + \Theta_d \frac{dk_1}{db}$. As the sign of $\frac{d\Theta_d}{db} (> 0)$ and $\frac{dk_1}{db} (< 0)$ are different, we have to solve for each term to see whether we could determine the sign of the whole equation.

Let's define B_2 as $\frac{f_d + k_1^{-\alpha} f_u}{f_e(\alpha-1)}$. Then, $\Theta_d = \left[\frac{f_d + k_1^{-\alpha} f_u}{f_e(\alpha-1)}\right]^{1/\alpha} \Theta_m \equiv B_2^{1/\alpha} \Theta_m$. Using this equation, we get

$$\begin{aligned}
\frac{d\Theta_u}{db} &= \frac{dk_1}{db}\left(\Theta_d + \frac{d\Theta_d}{dk_1} k_1\right) \\
&= \frac{dk_1}{db}\left[B_2^{\frac{1}{\alpha}} \Theta_m - B_2^{\frac{1}{\alpha}-1} \Theta_m \frac{f_u}{f_e(\alpha-1)} k_1^{-\alpha}\right] \\
&= \frac{dk_1}{db} B_2^{\frac{1}{\alpha}-1} \Theta_m \frac{f_d}{f_e(\alpha-1)},
\end{aligned}$$

which is negative as α assumed to be greater than 1 and $\frac{dk_1}{db} < 0$.

In Type 3 equilibrium, we have FDI cutoff,

$$\Theta_f = k_3 \Theta_d.$$

Let's denote $\Theta_d = B_3^{1/\alpha} \Theta_m$ by defining $B_3 \equiv \frac{f_d + k_3^{-\alpha} f_u}{f_e(\alpha-1)}$. Then, we get

$$\begin{aligned}
\frac{d\Theta_f}{db} &= \frac{dk_3}{db}\left(\Theta_d + \frac{d\Theta_d}{dk_3} k_3\right) \\
&= \frac{dk_3}{db}\left[B_3^{\frac{1}{\alpha}} \Theta_m - B_3^{\frac{1}{\alpha}-1} \Theta_m \frac{f_u}{f_e(\alpha-1)} k_1^{-\alpha}\right] \\
&= \frac{dk_3}{db} B_3^{\frac{1}{\alpha}-1} \Theta_m \frac{f_d}{f_e(\alpha-1)},
\end{aligned}$$

which is negative as $\frac{dk_3}{db} < 0$.

Now, we have to check how two cutoffs react to changes in the labor market cost in Type 4 equilibrium. Offshoring and FDI cutoffs are defined as

$$\begin{aligned}\Theta_u &= k_1\Theta_d, \\ \Theta_f &= k_2\Theta_d.\end{aligned}$$

And by defining $B_4 \equiv \frac{f_d + k_1^{-\alpha} f_u + k_2^{-\alpha}\left(f_f - f_u\right)}{f_e(\alpha-1)}$, we get

$$\begin{aligned}\Theta_d &= \left[\frac{f_d + k_1^{-\alpha} f_u + k_2^{-\alpha}\left(f_f - f_u\right)}{f_e(\alpha-1)}\right]^{1/\alpha}\Theta_m \\ &\equiv B_4^{1/\alpha}\Theta_m.\end{aligned}$$

As both k_1 and k_2 depend on b, we have to check the sign of

$$\frac{d\Theta_u}{db} = \frac{d(k_1\Theta_d)}{db} = k_1\frac{d\Theta_d}{db} + \Theta_d\frac{dk_1}{db} \tag{1.31}$$

to determine the sign of $\frac{d\Theta_u}{db}$. We can calculate each part as

$$\begin{aligned}\frac{dk_1}{db} &= -\frac{\beta}{b\left(1-\beta\right)}\frac{f_u}{f_d}\frac{R_1}{\left(R_1-1\right)^2}, \\ \frac{dk_2}{db} &= -\frac{\beta}{b\left(1-\beta\right)}\frac{f_f - f_u}{f_d}\frac{1}{\left(R_2-R_1\right)},\end{aligned}$$

$$\begin{aligned}\frac{\partial\Theta_d}{\partial k_1} &= -\Theta_m B_4^{\frac{1}{\alpha}-1}\frac{f_u}{f_e\left(\alpha-1\right)}k_1^{-\alpha-1}, \\ \frac{\partial\Theta_d}{\partial k_2} &= -\Theta_m B_4^{\frac{1}{\alpha}-1}\frac{f_f - f_u}{f_e\left(\alpha-1\right)}k_2^{-\alpha-1}.\end{aligned}$$

If we plug these four equations into the original equation, we get

$$\frac{d\Theta_d}{db} = B_4^{\frac{1}{\alpha}-1} C \left[\frac{R_1}{(R_1-1)^2} f_u^2 k_1^{-\alpha-1} + \frac{(f_f - f_u)^2}{R_2 - R_1} k_2^{-\alpha-1} \right]$$

where $C = \Theta_m \frac{1}{f_e f_d(\alpha-1)} \frac{\beta}{b(1-\beta)}$. If we plug this into (1.31), we getFinally, if we plug in $k_1 = \frac{f_u}{f_d}(R_1-1)^{-1}$ and $k_2 = \frac{f_f - f_u}{f_d}(R_2 - R_1)^{-1}$ into the above equation, we get

$$\frac{d\Theta_u}{db} = B_4^{\frac{1}{\alpha}-1} C \left[-f_d^{\alpha} f_u (f_f - f_u)^{-\alpha+1} \frac{(R_2-R_1)^{\alpha}}{(R_1-1)^2} - \frac{R_1 f_d f_u}{(R_1-1)^2} \right]$$

which is negative as $R_2 > R_1$ and $f_f > f_u$.

Similarly, we can simplify $\frac{d\Theta_f}{db}$ as

$$\begin{aligned}
\frac{d\Theta_f}{db} = \tfrac{d(k_2\Theta_d)}{db} = \quad & k_2 \frac{d\Theta_d}{db} + \Theta_d \frac{dk_2}{db} \\
= \quad & B_4^{\frac{1}{\alpha}-1} C \left[\frac{R_1}{(R_1-1)^2} f_u^2 k_1^{-\alpha-1} k_2 + \frac{(f_f - f_u)^2}{R_2 - R_1} k_2^{-\alpha} \right] \\
& - B_4^{\frac{1}{\alpha}-1} C \left\{ \frac{f_f - f_u}{(R_2 - R_1)} \left[f_d + k_1^{-\alpha} f_u + k_2^{-\alpha} (f_f - f_u) \right] \right\} \\
= \quad & B_4^{\frac{1}{\alpha}-1} C \left[\frac{R_1}{(R_1-1)^2} f_u^2 k_1^{-\alpha-1} k_2 - \frac{f_u (f_f - f_u)}{(R_2 - R_1)} k_1^{-\alpha} - \frac{f_d (f_f - f_u)}{(R_2 - R_1)} \right].
\end{aligned}$$

If we plug in k_1 and k_2 into the above equation, we get

$$\frac{d\Theta_f}{db} = B_4^{\frac{1}{\alpha}-1} C \frac{f_d (f_f - f_u)}{R_2 - R_1} \left[\left(\frac{f_u}{f_d} \frac{1}{R_1 - 1} \right)^{1-\alpha} - 1 \right].$$

As $\alpha > 1$ and $\frac{f_u}{f_d}\frac{1}{R_1-1}$ is greater than one by the Lemma 2, $\left(\frac{f_u}{f_d}\frac{1}{R_1-1}\right)^{1-\alpha} < 1$, and thus Θ_f is also decreasing in b.

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CHAPTER 2
Anonymity Concerns and Bitcoin

2.1 Introduction

Bitcoin is a peer-to-peer network-based electronic currency system. The key structure of Bitcoin was initially proposed in Nakamoto (2008). After that, an open-source project was initiated, and the first Bitcoin was created in January 2009. Since then, Bitcoin has gained much attention from users and has had huge success. At the time of this writing, around 65,000 transactions are taking place each day using Bitcoin, grossing about 88 million USD per day. While Bitcoin is a topic of interest in the media, its economic implications have not been much studied.

A key question regarding Bitcoin is whether it can be a substitute for the traditional currency system or not. To answer this question, we need to check how well Bitcoin can perform the function of a medium of exchange. Even though it is being used for various types of goods, this is not obvious. Indeed, the number of merchants who accept Bitcoin is still relatively small and most of them are Internet-based merchants.

Moreover, considering the fact that we already have various types of currencies which do not require additional knowledge on the technology essential for using Bitcoin, the question naturally arises: why do people choose Bitcoin instead of traditional currencies? There could be different explanations; in this study, I use one of the most essential properties of Bitcoin, its anonymity, to answer this question.

By using recent technical inventions on digital cryptography, Bitcoin has become the first electronic currency system without having a trusted third party (e.g., central bank). Instead, the system stands on a peer-to-peer network, allowing users to send Bitcoin without having to go through financial institutions. Furthermore, Bitcoin users can hide their identity by using different public keys when carrying out different transactions. This property confers the most cash-like status to Bitcoin among the electronic currency systems.

At the same time, Bitcoin's anonymity raises concerns regarding its role in illegal activities. Several governments regard using Bitcoin in some cases as unlawful because it can be used for illegal activities.[1] The online market 'Silk Road,' which intermediated many prohibited goods with Bitcoin before it was shut down by the FBI, serves as a good example of how Bitcoin can be associated with illegal activities. However, the relationship between the two is not clear, in the sense that people may still want anonymity in legal activities. Even the 'Silk Road' had many categories of legal goods like art, books, computer equipment, etc.

In this study, I propose a model in which an agent's choice over currencies depends on her anonymity concerns. In the model, two currency markets exist. In the Debit market, Debit is used for trading goods; and in the Bitcoin market, Bitcoin is used for transactions. In the Debit market, agents have to reveal their identity in a transaction, while in the Bitcoin market, they can hide their identity by using Bitcoin. At the beginning of the economy, agents compare the expected value of entering each currency market and choose one of them. Under this setting, I find that agents with high anonymity concerns choose the Bitcoin market, while others choose the Debit market.

When I extend the model by adding intermediaries which accept Bitcoin only for legal goods, I find that the number of agents who use Bitcoin increases, while the share of Bitcoin users who are engaged in illegal activities decreases. This result tells us a way of resolving concerns regarding the usage of Bitcoin in illegal activities: even though it is not fully possible to control each individual's use of Bitcoin due to its anonymity, it is possible to reduce the extent of illegal activities associated with Bitcoin by regulating the

[1]See http://en.wikipedia.org/wiki/Legality_of_Bitcoins_by_country

intermediaries.

This study is related to several studies in the literature on search-theoretic models. The basic structure of the model that I propose is based on Kiyotaki and Wright (1993), which shows the existence of a monetary equilibrium where fiat currency solves the 'double coincidence of wants problem' in a pure barter. To introduce the role of intermediaries into the model, I introduce a new currency market, where agents can trade legal goods with Bitcoin. In the literature, intermediaries are introduced in several different ways. Rubinstein and Wolinsky (1987) introduce intermediaries as agents with the ability to buy goods from producers and sell them to consumers; Shevchenko (2004) introduces middlemen to be agents who can hold inventories of several goods; and Li (1998) analyzes the role of middlemen in a model with private information where agents become middlemen by investing to acquire quality-testing technology.

The remainder of this paper is organized as follows. Section 2.2 introduces the environment and solves the model. Section 2.3 adds intermediaries. Section 2.4 offers a summary of the analysis with concluding remarks.

2.2 Model

2.2.1 Environment

Consider an economy with a continuum of agents, measure one. Time is continuous and agents live infinitely. Agents are heterogeneous in terms of their preference with respect to anonymity concerns. More specifically, an agent $i \in [0,1]$ incurs a cost c_i by revealing herself to the other party during a trade, and the cumulative distribution function of c_i, $F(c_i)$, is common knowledge. c_i and Agents' preferences over goodsare specified in the below. To motivate agents to trade, it is assumed that they cannot consume the good they produce, i.e., they produce and engage in a pairwise random meeting to trade with other agents.

In the economy, there exist two currency markets, the Debit market and the Bitcoin market. Only one type of currency circulates in each market. In the Debit market, agents produce a good X, which is not related to any illegal activities, while in the Bitcoin market, they produce a good Y, which is potentially associated with both legal and illegal activities. For the purpose of this study, it is important to note that in the Bitcoin market, it is not possible to distinguish legal from illegal activities.

At the beginning of the economy, agents choose one of the markets to produce and consume goods. Debit and Bitcoin are randomly distributed after agents have made this decision. Let μ be the measure of agents who choose the Debit market; and let $1-\mu$ be the measure of agents who choose the Bitcoin market. Total D units of Debit and B units of Bitcoin are distributed to each market. I assume that $\frac{D}{\mu} = d \in (0, \frac{1}{2}]$ and $\frac{B}{1-\mu} = b \in (0, \frac{1}{2}]$ are constant over μ. Agents cannot produce currencies.

As in Kiyotaki and Wright (1993), all currencies and goods are assumed to be indivisible. Moreover, agents cannot hold more than one unit of goods or currencies. Thus, at any given point in time, agents are holding either one unit of currency (Bitcoin or Debit) or good.

Agents in each economy meet pairwise in a random meeting with an arrival rate of β. When two agents meet, they observe the other agent's inventory and decide whether to trade or not. It is assumed that with probability $x \in (0,1)$, agents find a good that they like, in which case a trade occurs and their inventories are swapped. Once a trade takes place, agents who have consumed a good return to the production process. The production cost is assumed to be zero.[2] Agents who received Debit or Bitcoin keep searching until they find a counterpart with a desirable good.

Lastly, let me explain c_i and agents' preferences in more detail. c_i is ordered to be increasing in i so that it has the lowest value of zero when $i = 0$, and it has the highest

[2]See Kiyotaki and Wright (1993) for the same assumption.

value of c_{max} when $i = 1$:

$$c_i \in [0, c_{max}], \ \frac{\partial c_i}{\partial i} > 0, \ \forall i.$$

When agents consume a good X, they obtain utility u. When they consume a good Y, however, the utility level that they get depends on their level of anonymity concerns. Agents with high anonymity concerns are assumed to get higher utility from consuming a good Y because it can be purchased with Bitcoin, and thus they can hide their identity. Specifically, an agent i gets utility of αc_i from a good Y. As an agent i perceives costs c_i in a transaction associated with Debit, the utility that an agent i gets from each good can be summarized as

$$u_X(i) = u - c_i \tag{2.1}$$

$$u_Y(i) = \alpha c_i, \ \alpha > 0, \tag{2.2}$$

2.2.2 Value Functions

We can write the flow returns of choosing the Debit market as

$$rV_D(c_i) = \beta(1-d)x\left(u_X(i) + V_D^g(c_i) - V_D(c_i)\right), \tag{2.3}$$

$$rV_D^g(c_i) = \beta dx\left(V_D(c_i) - V_D^g(c_i)\right), \tag{2.4}$$

where $V_D(c_i)$ denotes the value function of an agent who is holding a Debit, and $V_D^g(c_i)$ denotes the value function of a good producer in the Debit market. Equation (2.3) states that the flow return to a Debit holder, $V_D(c_i)$, equals the probability that she meets someone who is holding a good that she likes, $\beta(1-d)x$, multiplied by the sum of gains from the trade and value changes, $u_X(i) + V_D^g(c_i) - V_D(c_i)$. Equation (2.4) sets the flow return to a good holder in the Debit market, $rV_D^g(c_i)$, equal to the probability of meeting a Debit holder who likes the good that she produced, βmx, multiplied by changes in the value functions, $V_D(c_i) - V_D^g(c_i)$.

Similarly, we can denote the value functions of choosing the Bitcoin market as

$$rV_B\left(c_i\right) = \beta\left(1-b\right)x\left(u_Y\left(i\right)+V_B^g\left(c_i\right)-V_B\left(c_i\right)\right), \tag{2.5}$$

$$rV_B^g\left(c_i\right) = \beta bx\left(V_B\left(c_i\right)-V_B^g\left(c_i\right)\right), \tag{2.6}$$

where $V_B(c_i)$ denotes the value function of an agent who is holding a Bitcoin and $V_B^g\left(c_i\right)$ denotes the value function of a good producer in the Bitcoin market.

2.2.3 Equilibrium

Agents compare the expected values of entering either market and choose the market with greater expected value. Using Equations (2.3), (2.4), (2.5), and (2.6), we can express the expected values of entering each market as

$$EV_D\left(c_i\right) = dV_D\left(c_i\right)+\left(1-d\right)V_D^g\left(c_i\right) = d\left(1-d\right)\beta xu_X\left(c_i\right)/r, \tag{2.7}$$

$$EV_B\left(c_i\right) = bV_B\left(c_i\right)+\left(1-b\right)V_D^g\left(c_i\right) = b\left(1-b\right)\beta xu_Y\left(c_i\right)/r, \tag{2.8}$$

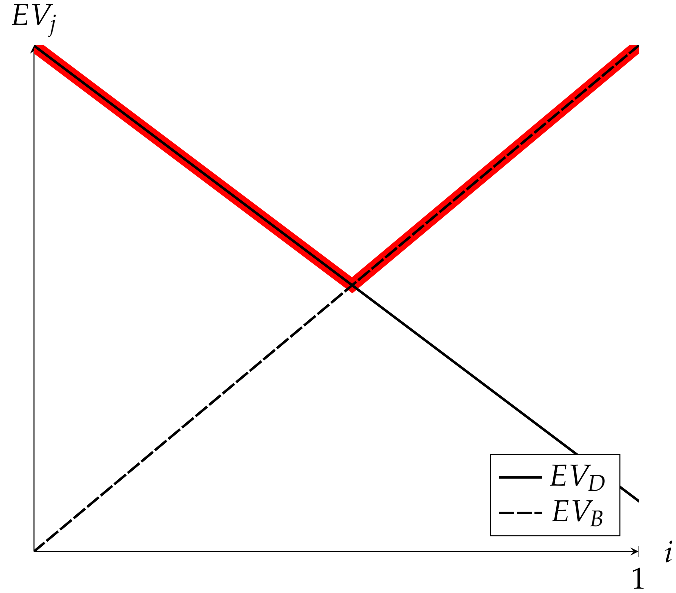
where $EV_j\left(c_i\right)$ denotes the expected value entering the market j of an agent i. From the above two equations, we can calculate the relative gain of choosing the Debit market as

$$\frac{EV_D\left(c_i\right)}{EV_B\left(c_i\right)} = \frac{d\left(1-d\right)}{b\left(1-b\right)}\frac{u_X\left(c_i\right)}{u_Y\left(c_i\right)}. \tag{2.9}$$

The ratio depends on two components. The first component is the relative utility level of a good X to a good Y for an agent i, $\frac{u_x(c_i)}{u_Y(c_i)}$. By setting Equation (2.10) equal to one, we can derive the cutoff c^*, with which the agent i^* is indifferent between two currency systems as

$$c^* = \frac{d\left(1-d\right)}{\alpha b\left(1-b\right)+d\left(1-d\right)}u. \tag{2.10}$$

Figure 2.1: Equilibrium in the Benchmark Model



An agent i will simply compare her anonymity cost c_i with the cutoff cost, c^*, then decide which currency system to enter. If c_i is higher than c^*, it will be better for the agent to enter the Bitcoin market, while if it is lower than c^*, she will be better off to choose the Debit market.

The second component of Equation (2.9) is the relative matching efficiency of the Debit market compared to that of the Bitcoin market, $\frac{d(1-d)}{b(1-b)}$, which is governed by the market structure. As the relative size of d compared to b increases, the relative matching efficiency of the Debit market increases, and thus more agents choose the Debit market. In other words, c^* is an increasing function of d, and a decreasing function of b. We can summarize this discussion in the following proposition.

Proposition 7. *With the cutoff* $c^* = \frac{d(1-d)}{\alpha b(1-b)+d(1-d)}u$, *agents with* $c_i > c^*$ *choose the Bitcoin market, while agents with* $c_i < c^*$ *choose the Debit market. Moreover,* $\frac{\partial c^*}{\partial d} > 0$ *and* $\frac{\partial c^*}{\partial b} < 0$.

2.3 A Model with the Intermediary Market

In this section, I extend the benchmark model into a model with the intermediary market. I introduce the intermediary market as a place where agents produce a good X and trade it with Bitcoin. As agents are forced to produce only good X in this market, unlike in the Bitcoin market, no illegal activities are associated with Bitcoin. This is the key benefit of using the intermediary market, i.e., agents can consume the legal goods and still keep their identities. I assume that to participate in the intermediary market, agents pay a fixed fee of p when they consume a good X. The total money supply of the intermediary market is exogeneously given by B_I.

The flow returns of an agent i who chooses the intermediary market are

$$\begin{aligned} rV_I(c_i) &= \beta(1-b_I)x\left(u-p+V_I^g(c_i)-V_I(c_i)\right), \qquad (2.11) \\ rV_I^g(c_i) &= \beta b_I x\left(V_I(c_i)-V_I^g(c_i)\right), \qquad (2.12) \end{aligned}$$

where b_I denotes the fixed share of Bitcoin holder; $V_I(c_i)$ is the value function of holding Bitcoin; and $V_I^g(c_i)$ is the value function of a good producer in the intermediary market. The interpretation of the value functions are similar to those of the other two currency markets, except that agents can obtain u without losing c_i, and in return for that they pay the fixed transaction cost, p, whenever they consume goods.

Similar to the benchmark model, agents choose the currency market that gives the highest expected value. Let μ_1 and μ_2 denote the measure of agents who choose the Debit market and Bitcoin market, respectively. Then, we can express the expected value of entering each market as

$$EV_D(c_i) = d(1-d)\beta x(u-c_i)/r, \tag{2.13}$$

$$EV_B(c_i) = b(1-b)\beta x\alpha c_i/r, \tag{2.14}$$

$$EV_I(c_i) = b_I(1-b_I)\beta x(u-p)/r, \tag{2.15}$$

where $d=\frac{D}{\mu_1}$, $b=\frac{B}{\mu_2}$, and $b_I=\frac{B_I}{1-\mu_1-\mu_2}$.

By equalizing three pairs of equations, we can derive the three cutoff values of c_i as

$$\begin{aligned} c_1 &= u-\frac{b_I(1-b_I)}{d(1-d)}u+\frac{b_i(1-b_I)}{d(1-d)}p, \\ c_2 &= \frac{b_I(1-b_I)}{\alpha b(1-b)}(u-p), \\ c^* &= \frac{d(1-d)}{\alpha b(1-b)+d(1-d)}u, \end{aligned}$$

where c_1 is the cutoff value that equalizes the expected value of choosing the Debit and intermediary markets; c_2 is the cutoff value that gives the same expected value of choosing the intermediary and Bitcoin markets; and c^* is the cutoff value that divides the Debit and Bitcoin markets in the benchmark model.

Depending on realized parameter values, we can have different types of equilibria. In Figure 2.2, I graph an example of equilibria with and without the intermediary market. If c_1 becomes equal or greater than c^*, we have an equilibrium where no one chooses the intermediary market. Instead, if c_1 is smaller than c^*, the intermediary market is used by a positive mass of agents in the equilibrium. We can find the condition to have the equilibrium with the intermediary market by solving the condition, $c_1 < c^* < c_2$, which is identical to the following condition:

$$u > \frac{a_1+\alpha a_2}{a_1+\alpha a_2-\alpha a_3}p, \tag{2.16}$$

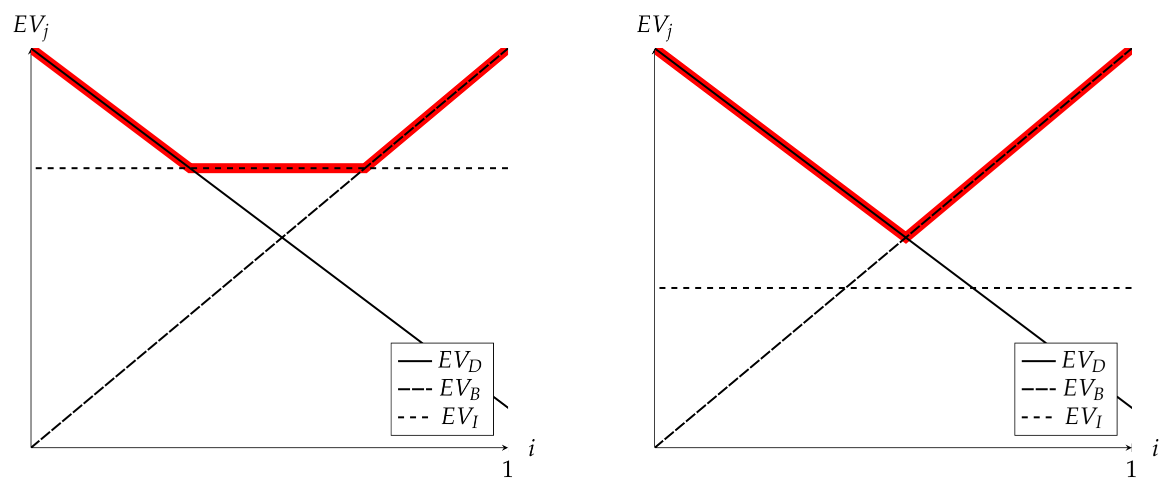
where $a_1 = d(1-d)\, b_I (1-b_I)$, $a_2 = b(1-b)\, b_I (1-b_I)$, and $a_3 = d(1-d)\, b(1-b)$.

Lemma 6. *Depending on the realized values of parameters, there exist two types of equilibria. When $u > \frac{a_1+\alpha a_2}{a_1+\alpha a_2-\alpha a_3} p$, we have an equilibrium with the intermediary market; and when $u \leq \frac{a_1+\alpha a_2}{a_1+\alpha a_2-\alpha a_3} p$, we have an equilibrium without the intermediary market.*

The economic interpretation of the condition in Equatioin (2.16) is quite simple: the fee for using the intermediary market should be low enough to attract agents from Debit or Bitcoin markets. If p is too high, no one will choose the intermediary market and the equilibrium becomes the same as the benchmark case. On the other hand, as the fee approaches zero, the expected value of choosing the intermediary market increases, and thus more agents enter the intermediary market.[3]

Another parameter that affects the condition in Equation (2.16) is d, b, and b_I. By taking the derivative of $\frac{a_1+\alpha a_2}{a_1+\alpha a_2-\alpha a_3} p$ with respect to the three parameters, we can verify that as $\frac{b_I(1-b_I)}{d(1-d)}$ or $\frac{b_I(1-b_I)}{b(1-b)}$ increases, it becomes easier to satisfy the condition in Equation (2.16). The intepretation of this result is similar to the benchmark case: as the relative matching efficiency in the intermediary market increases, it becomes easier to attract agents to the intermediary market.

Figure 2.2: Equilibrium with the intermediaries



[3]If $\alpha \leq 1$, all agents choose the intermediary market. If $\alpha > 1$, a positive mass of agents choose the Bitcoin market.

Let us focus on the equilibrium with the intermediary market. As we can see in Figure 2.2, agents with c_i between c_1 and c_2, who would have chosen the Debit or Bitcoin markets in the benchmark model, choose the intermediary market. They choose the intermediary market to seek either Bitcoin's anonymity or to consume the legal goods. Agents from c_1 to c^* are the first case, and agents from c^* to c_2 are the latter case. Thus, compared to the equilibrium of the benchmark model, we can see that more agents use Bitcoin as a medium of exchange, but fewer agents choose the Bitcoin market. So among the agents who use Bitcoin, the share of agents who are possibly associated with illegal activities becomes smaller than that in the benchmark model.

This result implies that the existence of a well-regulated intermediary market can not only enhance the acceptability of Bitcoin, but also reduce the size of Bitcoin usage associated with illegal activities. Considering the fact that it is almost impossible to regulate an individual agent's activities with Bitcoin, this result shows an alternative way of controlling the illegal usage of Bitcoin, while keeping the benefits from the electronic currencies.

Let us summarize the above discussion by the following propositions.

Proposition 8. *When* $u > \frac{a_1+\alpha a_2}{a_1+\alpha a_2-\alpha a_3}p$, an agent i chooses

1. *the Debit market if* $c_i < c_1$,
2. *the intermediary market if* $c_1 < c_i < c_2$,
3. *the Bitcoin market if* $c_2 < c_i$.

Proposition 9. *As the benefit from choosing the intermediary market increases, fewer agents choose Debit and more agents choose Bitcoin as currency. Also, as more agents choose the intermediary market, the number of agents who are associated with illegal activities decreases.*

2.4 CONCLUSION

In this study, I propose a simple search-theoritic model where Debit and Bitcoin compete with each other. In the model, agents compare the expected values of entering each market and decide which currency market to enter. In the benchmark model, where only the Debit and Bitcoin markets exist, I show that the agents' preferences regarding the anonymity concerns drive some agents to choose the Bitcoin market. In the extended model where the intermediary market is introduced, agents choose the intermediary market to have both Bitcoin's anonymity and consumption of legal goods.

The results of this model are quite simple, but they are meaningful, considering the general concerns regarding the relationship between Bitcoin and illegal activities. The model shows that even if the fundamental motivation of using Bitcoin lies in the anonymity-seeking behaviors, its relationship with illegal activities is not clear and can be reduced by having well-regulated intermediaries. It also shows that introduction of intermediaries has a positive effect on the acceptability of Bitcoin among agents.

As this study is based on quite a simple model, it cannot capture various aspects of the demands of Bitcoin. However, by focusing on the key aspects of Bitcoin that distinguish it from other electronic currency systems, this model clearly shows that agents' desire to protect their identity can be a source of fundamental motivation to use anonymous electronic currencies, and the demand can be enhanced and controlled by having well-regulated intermediaries.

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CHAPTER 3

FDI vs. outsourcing: the Role of Labor Market Flexibility

3.1 Introduction

The literature has focused on multinational firms' activities, and many studies have tried to identify the key determinants of the decision between foreign direct investment (FDI) and outsourcing when multinationals offshore. Several aspects in heterogeneity across industries have been identified as the key determinants in that decision.

However, institutional heterogeneity across countries, which can possibly be an important factor, has not been discussed much. Suppose that a multinational firm tries to enter several foreign markets. If there exists a substantial heterogeneity in the institutional structures across those markets, then the organizational choice in each market can depend on each markets' institutional structure.

In particular, this study takes heterogeneity in labor market flexibility across countries to be the key factor that affects the decision. Chapter 1 proposed a theoretical model that shows how labor market flexibility affects firms' organizational decision. Under the assumption that the fixed cost of FDI is greater than that of outsourcing, the model predicts that for a country with low labor market flexibility, outsourcing is the optimal choice for all firms, while for a country with high labor market flexibility, FDI can be chosen for the most productive firms.

In this study, I test the above prediction by using the data set for 2006 through 2012 from the U.S. Census related-party trade and the Global Competitiveness Report (GCR) on labor market flexibility. The data yields supporting results for the first chapter: the share of intrafirm import is positively correlated with the industry productivity dispersion only in the countries with the most flexible labor market. For countries with a rigid labor market, I cannot find a positive relationship between the two.

This study is related to several studies in the literature. Most studies on this topic focus on the relationship between a multinational firm (the headquarter) and an intermediate goods supplier. In their model, a multinational firm and a supplier produce relationship-specific inputs. As inputs produced in the relationship have zero value outside the relationship, if the contract between the two parties is not complete, a typical 'hold-up' problem arises, and both parties tend to under-invest. Under these circumstances, when the headquarter firm provides more services, motivating the headquarter firm reduces the size of underinvestment. As FDI gives higher outside options when the bilateral bargaining breaks down, choosing FDI becomes optimal. Similarly, when the service from the supplier is more important, choosing outsourcing becomes optimal.

Antràs (2003) developed the incomplete-contract and property-rights model with the idea, and also found supporting estimation results by using the U.S. trade data from the Bureau of Economic Analysis (BEA). This study is further developed in Antràs and Helpman (2004) and Antràs and Helpman (2006). In their 2004 study, Antras and Helpman introduced heterogeneity in firms' productivity level; and in their 2006 study, they allowed partial contractibility in the relationship.

Several studies have tried to empirically test theoretical results in the above models. Yeaple (2006) tested Antràs (2003) and Antràs and Helpman (2004) with the 1994 Benchmark Survey from BEA. This paper examined how industry-specific variables affect the intrafirm import/export of U.S. multinationals, and found that capital intensive industries and R&D intensive industries are associated with higher intrafirm trade. It also found that an industry with higher productivity dispersion has a greater share of intrafirm trade. This result is further strengthened in Nunn and Trefler (2013), which used a much larger number of data from the 2005 U.S. Census trade and found supporting results. Nunn and Trefler (2013) also tested the key implication of Antràs and Helpman (2006), that better contracting leads to more internalization, and found consistent results. However, all of the empirical studies above have focused on industry characteristics rather than country characteristics, a key focus of this paper.

This study is organized as follows. Section 3.2 introduces the theoretical model and summarizes its key implications. Section 3.3 explains the primary measures and data used, and Section 3.4 sets up the empirical specification. Section 3.5 shows and explains the estimation results, and finally Section 3.6 summarizes the analysis.

3.2 Theoretical Model

Let us begin by reviewing the key features of the model proposed in the first chapter. A firm located in the home country produces differentiated goods and the demand is set by CES preferences. A firm produces by using the only input, labor. When it decides to produce, it has three different options regarding its organizational form. It can produce in the home country by hiring domestic workers or it can offshore the production process by forging an arm's-length relationship with a supplier (outsourcing) or hiring foreign labor (FDI). As in Helpman and Itskhoki (2010), the production technology is defined to be linear to the number of inputs, h,

$$q(\theta) = \theta h, \tag{3.1}$$

where θ is the productivity parameter and h represents either domestic labor (domestic integration), intermediate inputs (outsourcing), or foreign labor (FDI).

There are two countries in the model, home and foreign. Labor markets in both countries are under search and matching frictions, and thus a firm bears not only wages, but also an additional cost (labor market cost) when it hires workers. This additional cost from the labor market is assumed to be different across countries. So, when the labor market cost of the foreign country is lower than that of the home country, a firm has an incentive to choose offshoring as it can reduce the variable cost indirectly (outsourcing) or directly (FDI).

Wage is determined in a generalized Nash bargaining procedure. It is also assumed that offshoring comes with an additional fixed organizational cost, where the fixed cost of outsourcing is lower than that of FDI. Under this setting, a firm faces a new tradeoff that was not recognized in previous studies: outsourcing allows a firm to avoid dealing with the labor market directly, and thus it can keep all of the revenue without sharing it with the labor. With FDI, a firm has to share the total revenue with the labor, but FDI offers a lower variable cost than outsourcing.

Specifically, with the constant measure of the elasticity of substitution β,[1] the profit function of each choice is given as

$$\pi_u(\theta) = A_u(Q, b, p_u)\,\Theta - f_u, \tag{3.2}$$

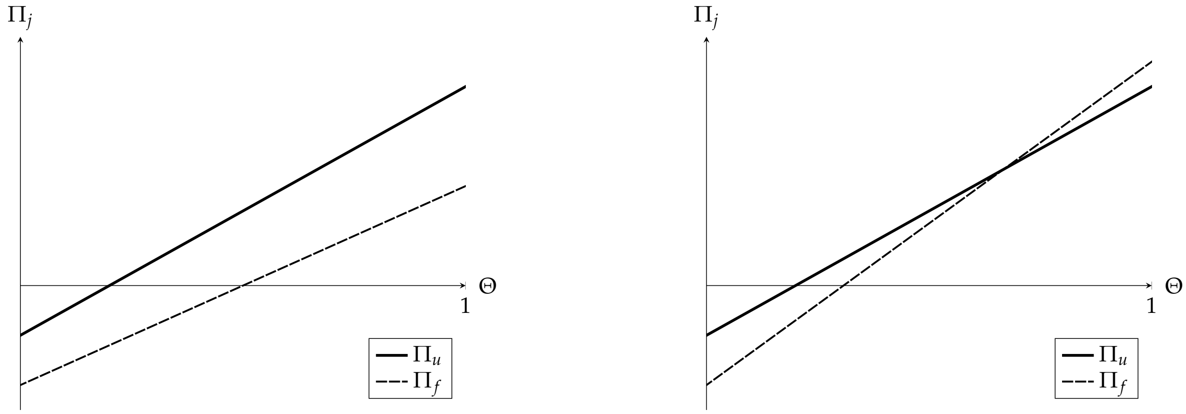
$$\pi_f(\theta) = A_f(Q, b, b_f)\,\Theta - f_f, \tag{3.3}$$

where $\Theta = \theta^{\frac{\beta}{1-\beta}}$ is the measure of productivity, Q is the quantity index in the differentiated goods sector, b is the labor market cost of the home country, p_u is the unit price of an intermediate input, and b_f is the foreign labor market cost that a final good producer from a home country faces.

Figure 3.1 shows two types of equilibria depending on the relative size of A_u and A_f. Both graphs plot two profit curves, outsourcing and FDI, as a function of productivity measure $\Theta = \theta^{\frac{\beta}{1-\beta}}$. Given the assumption of the fixed cost, $f_f > f_u$, we know that an offshoring firm always chooses outsourcing if $\Pi_u(\Theta)$ is steeper than $\Pi_f(\Theta)$. This case is shown in the left-hand graph of Figure 3.1, where choosing outsourcing always gives a

[1]The elasticity of substitution σ is defined to be $\frac{1}{1-\beta}$.

Figure 3.1: Equilibrium Type and The Labor Market Flexibility



higher profit level for all firms.

When b_f is sufficiently lower than p_u, $\Pi_f(\Theta)$ becomes steeper than $\Pi_u(\Theta)$. This case is shown in the right-hand graph of Figure 3.1. In this case, two profit curves must cross once, and firms with a productivity level to the right of the crossing point choose FDI, while firms to the left of the point choose outsourcing.

From this figure, we can see that the relationship between the productivity level and the share of firms that choose FDI is only valid when $A_f > A_u$. In other words, if the underlying conditions do not support the equilibrium with FDI, heterogeneity in productivity does not affect firms' organizational choices. More specifically, the ratio between A_u and A_f is given as

$$\frac{A_u}{A_f} = (1+\beta)^{\frac{1}{1-\beta}} \left(\frac{b_f}{p_u}\right), \tag{3.4}$$

where p_u is the unit price of intermediate input, which is assumed to be greater than b_f. In this equation, we can see that the ratio increases in b_f, while it decreases in p_u. As the labor market cost that an FDI firm faces becomes smaller, the relative benefits from FDI increase, when p_u is fixed.

These results lead us to an interesting empirical prediction about offshoring firms' organizational decision: the productivity level of an offshoring firm affects its organizational choice only for the host (foreign) countries with a sufficiently low labor market cost.

3.3 Data Sources and Measurement

To test the hypothesis, we need a proper measure to compare the size of FDI and outsourcing. For this, I use the related-party trade data from the U.S. Census Bureau. This data is compiled from U.S. customs documentation which includes a yes or no mandatory question whether a shipment is between related parties or not. For U.S. imports, related-party trade is defined to be a trade between two parties in which one party has, directly or indirectly, "5 percent or more of the outstanding voting stock or shares of any organization." For U.S. exports, two parties are defined to be 'related' if one party owns, directly or indirectly, "10 percent or more of the other party".[2]

This information allows me to distinguish intrafirm imports from all imports as I can treat the related-party imports as intrafirm, while I treat the non-related party import as outsourcing. All data is at the 6-digit North American Industry Classification System (NAICS6) level and each observation has information on the origin (country) of the goods and whether the import is from a related party or not. With the data, I set up the key dependent variable, the share of intrafirm imports, as

$$\frac{IM^V_{ict}}{IM^V_{ict} + IM^O_{ict}}, \tag{3.5}$$

where IM^V denotes the related-party imports and IM^O denotes the unrelated-party imports. Subscripts i, c, and t mean industry, country, and year.

[2]See Ruhl (2013) for more detailed information on the comparison between the U.S. Census Bureau related-party data and the BEA intrafirm trade data.

Table 3.1: Labor Market Flexibility Index (2012) by Developed/Developing Countries

Developing Countries				Developed Countries	
Name	Flexibility	Name	Flexibility	Name	Flexibility
Venezuela	2.54	Kuwait	4.46	Argentina	2.9
Zimbabwe	2.54	Senegal	4.5	Portugal	3.38
Bolivia	3.09	Nicaragua	4.5	Greece	3.62
Mozambique	3.15	Mali	4.51	South Korea	3.85
Uruguay	3.25	Jamaica	4.53	Spain	3.91
Ecuador	3.31	Gambia	4.53	Italy	3.94
Sri Lanka	3.44	Suriname	4.54	Germany	3.97
Egypt	3.52	Malawi	4.59	Slovenia	4
Indonesia	3.55	Serbia	4.59	Croatia	4.13
Ghana	3.58	Cambodia	4.62	France	4.15
Nepal	3.61	Chad	4.66	Slovakia	4.17
Zambia	3.64	Albania	4.67	Lithuania	4.23
Honduras	3.69	Taiwan	4.7	Belgium	4.25
South Africa	3.71	Peru	4.71	Czech Republic	4.25
Sierra Leone	3.72	India	4.71	Israel	4.32
Iran	3.82	Madagascar	4.73	Sweden	4.32
Algeria	3.84	Benin	4.73	Malta	4.33
Thailand	3.96	Costa Rica	4.74	Australia	4.35
Philippines	3.99	Cameroon	4.75	Luxembourg	4.4
Trinidad And Tobago	4.02	Ukraine	4.76	Austria	4.51
Libya	4.1	Mauritania	4.77	Finland	4.57
Montenegro	4.1	Nigeria	4.79	Hungary	4.58
Turkey	4.11	Kenya	4.79	Barbados	4.6
Bangladesh	4.18	Haiti	4.81	Norway	4.6
Botswana	4.19	Bosnia And Herzegovina	4.81	Poland	4.71
Liberia	4.19	Timor-Leste	4.82	Seychelles	4.76
Paraguay	4.21	Macedonia	4.86	Netherlands	4.76
Brazil	4.22	Guyana	4.89	Chile	4.76
Yemen	4.24	Malaysia	4.9	Cyprus	4.85
Pakistan	4.24	Mauritius	4.9	Latvia	4.91
Dominican Republic	4.26	Bulgaria	4.91	Ireland	5.01
Mexico	4.27	Kyrgyzstan	4.92	Japan	5.07
Ethiopia	4.28	Jordan	4.92	Iceland	5.09
Russia	4.29	Azerbaijan	4.93	Qatar	5.16
Lesotho	4.29	Burkina Faso	4.94	Estonia	5.28
China	4.3	Rwanda	4.96	United Kingdom	5.33
Morocco	4.33	Cote D'Ivoire	5.01	Denmark	5.37
Swaziland	4.33	Lebanon	5.02	Canada	5.38
Moldova	4.35	Saudi Arabia	5.08	New Zealand	5.45
Romania	4.35	Mongolia	5.15	Brunei	5.52
Burundi	4.36	Guinea	5.16	United Arab Emirates	5.88
Gabon	4.39	Kazakhstan	5.22	Switzerland	5.91
El Salvador	4.42	Georgia	5.26		
Colombia	4.44	Armenia	5.28		
Panama	4.45	Uganda	5.34		
Guatemala	4.45	Oman	5.41		
Namibia	4.46	Bahrain	5.61		
Vietnam	4.46				

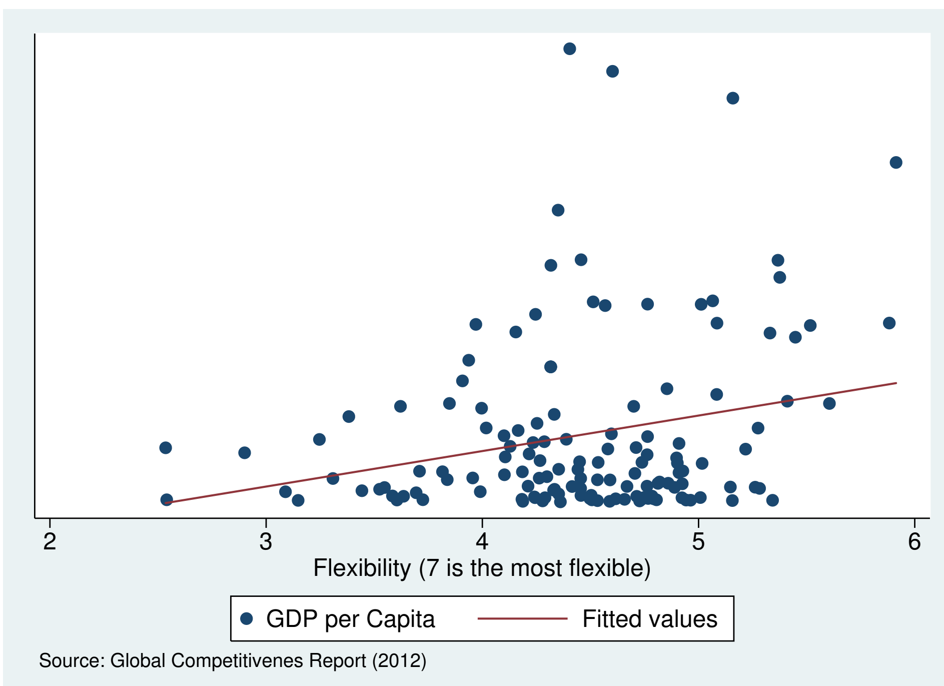
For labor market flexibility, I use the Global Competitiveness Report (GCR) by the World Economic Forum. Even though there are several other measures to compare labor market flexibility across countries, the GCR report covers the greatest number of countries in its survey. In the period of 2012-2013, 144 countries are included. By using this data, I can utilize most of the U.S. import data in the following empirical test.

In the GCR report, the labor market flexibility is compiled with four different measures: hiring and firing practices, flexibility of wage determination, cooperation in the labor-employer relationship, and redundancy cost. Except for redundancy cost, all measures report numbers from 1 to 7, where 1 is the most rigid and 7 is the most flexible.

The redundancy cost is reported as 'weeks of salary,' and to use this properly, we have to recalculate it in terms of 'cost' by multiplying it by the average weekly salary. However, as average wage data cover a small number of countries compared to the GCR report, I do not use the redundancy cost measure in the analysis.

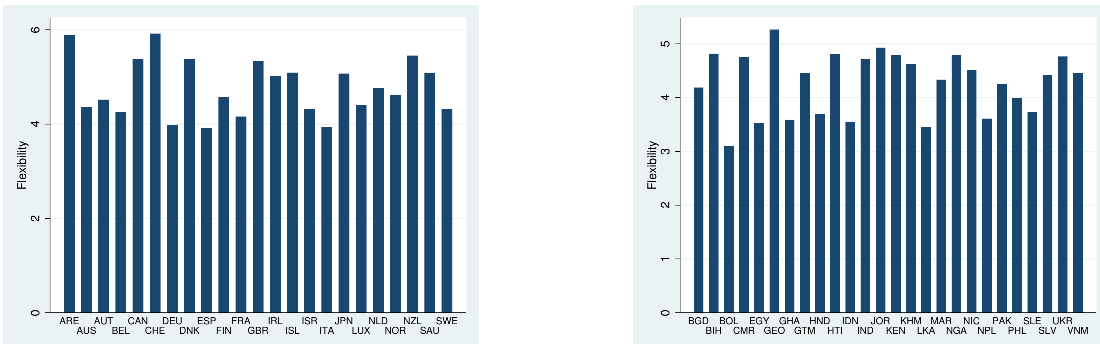
With these measures, the GCR report produces the overall labor market flexibility index, which I list in Table 3.1 for both developing and developed countries. As we can see in the table, there exists substantial variation across countries in both groups.

Figure 3.2: GDP per Capita and Labor Market Flexibility



In Figure 3.2, I plot the relationship between the labor market flexilibity and the GDP per capita (nominal) of all countries listed in Table 3.1 for 2012. In this figure, we can find that there exists a high correlation between the labor market flexibility and a country's income level. However, when I divide them into smaller groups by income level, I can still find a significant heterogeneity in the labor market flexibility index. In Figure 3.3, the left-hand side graph shows the labor market flexibility of the richest countries, while the right-hand side graph shows that of the poorest countries.

Figure 3.3: Labor Market Flexibility in Rich/Poor Countries



GDP per Capita > 25,000 GDP per Capita < 5,000

The last key variable in this study is the productivity measure. Chapter 1 assumes that the distribution of productivity measure Θ follows the Pareto distribution with the minimum value of Θ_m and the shape parameter α. Specifically, the cumulative distribution function of Θ is given as

$$G(\Theta) = 1 - \left(\frac{\Theta}{\Theta_m}\right)^{\alpha}. \tag{3.6}$$

With the Pareto assumption, we can easily show that in the model, the share of production by FDI compared to that by outsourcing decreases in α . In other words, as the productivity dispersion increases, i.e., α decreases, the relative quantity produced by FDI firms increases. Increases in the productivity dispersion move more firms to the extreme, where they find it more profitable to choose FDI when the host country's labor market flexibility is high enough. Thus, the share of production from FDI should increase in the degree of productivity dispersion for host countries with low labor market cost.

As shown in Antràs and Helpman (2004), the difference in the sales of final goods across firms can be a measure of the difference in firm productivity. This idea is accepted in several empirical studies. Especially, Helpman et al. (2004) and Yeaple (2006) construct a measure of productivity dispersion by using firm sales. Both studies use the standard deviation in the logarithm of firm sales within an industry to construct industry-specific productivity dispersion.

However, as the unit of observation in my data is not at the firm-level, I propose an alternative way to follow the idea in Antràs and Helpman (2004). One method is to adapt Nunn and Trefler (2007) approach, in which they use U.S. export data instead of firm sales in calculating the productivity measure. As more productive firms produce more and export more, the variation in exports can be thought of as a measure of productivity dispersion.

Nunn and Trefler (2007) substitute the firm-level data with industry-level data, by taking the more aggregated industry level to be 'notional' industries and the less aggregated industry level to be 'notional' firms. For example, with the data that I use, their approach takes NAICS6 level data to be 'notional' firm data within an industry of the NAICS4 level. In an industry of NAICS4 code 3262 (rubber product manufacturing), there are five NAICS6 categories: 326211 (tire manufacturing except retreading), 326212 (tire retreading), 326220 (rubber and plastics hoses and belting manufacturing), 326291 (rubber product manufacturing for mechanical use), and 326299 (all other rubber product manufacturing). All of the observations in those 5 NAICS6 codes will be taken to be 'notional' firm exports, and the standard deviation in their logarithm becomes the productivity dispersion measure of the NAICS4 3262 industry.

However, this approach has two limitations. First, there exists an aggregation error in this method. Even within a single NAICS6 code, there are many different goods, and firms that differ in size. As this method aggregates all firms into one number, the resulting standard deviation can be smaller than the actual one. Second, the calculated measure in the method is closer to the productivity dispersion of U.S. final goods, rather than that of U.S. intermediate goods. Except for firms whose NAICS4 codes of intermediate and final goods are the same, this is not a proper dispersion measure corresponding to the key dependent variable, intrafirm imports, which is mostly intermediate goods. For example, if we look at the share of intrafirm imports in the tire industry from China in the dependent variable, a proper measure will be the U.S. motor industry's productivity dispersion or the Chinese tire industry's productivity dispersion. The above method leads to a productivity dispersion of the U.S. tire industry.

To alleviate these limitations, I choose an alternative method that utilizes additional information, the destination country of U.S. exports. I calculate the productivity dispersion of NAICS4 industries with 'notional' NAICS6 firms in each destination country. In other words, I distinguish the NAICS6 exports by their destination country, and calculate the standard deviation for each.

This method can alleviate the two limitations of the method in Nuun and Trefler (2007). According to the comparative advantage, the composition of goods in the same NAICS6 exports is very different from each other, depending on the destination country. Thus, separating exports by their destination countries gives us more detailed data and alleviates the aggregation error of the above method.

The new method creates a productivity dispersion that varies by country dimension, which I interpret to be a productivity dispersion of suppliers or subsidiaries of each country. This interpretation is also exposed to the problem that the above measure has; however, as we take foreign countries to be suppliers of intermediate goods in the model, this method is more consistent with the theory. It is also justified by the fact that the total productivity level comes from not only a headquarter firm, but also its counterparts (either subsidiaries or suppliers). **?** also measure productivity dispersion of the counterparts and use it as a proxy of productivity dispersion in the headquarter firm.

More specifically, let X denote export, subscript i, $g(i)$, and c denote NAICS4 level industry, NAICS6 level goods, and the destination country of the export respectively.

Then, the measure of the productivity dispersion of an industry i in year t by a destination country c is calculated as

$$prod_{ict} = \sqrt{Var\left(lnX_{g(i),c,t}\right)}. \tag{3.7}$$

3.4 Empirical Specification

The main focus of this study is to check whether the positive correlation between the productivity dispersion and the intrafirm trade is only valid for the countries with the most flexible labor market or not. As mentioned in the previous section, I expect the relationship to be zero when b_f is large, while I expect it to be positive when b_f is low. Even though the theoretical model shows a clear prediction on the cutoff foreign labor market flexibility level over which the relationship becomes positive, I cannot predict where the cutoff b_f will be in the data, but let the data determine its location.

To do this, I rank all countries by labor market flexibility. They are measured by all four different labor market flexibility indexes: hiring and firing practice, flexible wage determination, cooperation in the labor-employer relationship, and the overall index. With this ranking, I divide the countries into five sub-groups. Let p index the groups, where $p = 1$ means the least flexible countries and $p = 5$ means the most flexible countries.

With the indicator function I^p_{ct}, which equals 1 if Country c belongs to Group p in year t, I estimate the following regression:

$$\frac{IM^V_{ict}}{IM^V_{ict} + IM^O_{ict}} = D_i + D_c + D_t + \sum_{p=1}^{5} \beta_I I^p_{ct} + \sum_{p=1}^{5} \beta^I_p \left(prod_{ict} \cdot I^p_{ct}\right) + \epsilon_{cit}, \tag{3.8}$$

where D_i, D_c, and D_t denote industry, country, and year dummies, respectively.

The sign and size of the coefficient β^I_p are the main focus of this regression. The model predicts that for low p, β^I_p should be zero as all the offshoring firms find outsourcing to be more profitable, and thus the productivity dispersion has no effect on the share of intrafirm import. For high p, the model predicts that β^I_p should be positive, as the most productive firms choose FDI over outsourcing.

3.5 Empirical Results

Table 3.2 shows the result of estimating Equation (3.8) using all countries in the sample. In all four regressions, the dependent variable is $IM_{ict}^{V} / \left(IM_{ict}^{V} + IM_{ict}^{O} \right)$ and each column shows a regression result by using four different labor market flexibility measures. More specifically, the first column shows the regression result of Equation (3.8) by using the 'overall' labor market flexibility index when we divide countries into five groups. Similarly, the second column uses the 'hiring and firing practice' index, the third column uses the 'flexibility in wage determination,' and the last column uses the 'cooperation in the labor-employer relationship.' All of the regressions reported in the table include country, industry, and year fixed effects.

In this table, we expect the coefficient to be zero for countries with a rigid labor market, while we expect it to be positive for countries with a flexible labor market. With the productivity measure in Equation (3.7), we find a consistent result for the prediction in columns (1), (2), and (3). In all three columns, the coefficient jumps to positive and becomes significant when we move from Group 4 to Group 5. In other words, the productivity dispersion only affects the intrafirm import share when the host countries have the most flexible labor market. With the flexibility measure, cooperation in the labor-employer relationship, I cannot find a supporting result.

As I report the beta coefficient, we can interpret the coefficients more easily. For example, the coefficient for I^5 in the first column means that as we increase the productivity index as 1 standard deviation, the intrafirm import share increases as 0.012 standard deviation in Group 5 countries. As the standard deviation of the dependant variable is 0.317, the intrafirm trade share increases about 0.4 percent.

To explore the relationship in more detail, I divide countries into two different groups, developed and developing countries. Surprisingly, I find very different results in each

Table 3.2: Estimation Results with Data from All Countries

	Dependent Variable: $IM^V_{ict} / \left(IM^V_{ict} + IM^O_{ict}\right)$			
	(1)	(2)	(3)	(4)
Using labor market index of	overall	hiring firing	flexible wage	cooperation
$Prod_{cit}$ interacted with:				
I^1	0.001	-0.016***	-0.018***	0.002
	(0.002)	(0.002)	(0.002)	(0.002)
I^2	-0.019***	-0.003	0.004	-0.010*
	(0.002)	(0.002)	(0.002)	(0.003)
I^3	0.001	0.008	-0.002	-0.007
	(0.002)	(0.002)	(0.002)	(0.003)
I^4	-0.000	-0.000	0.001	0.008
	(0.003)	(0.002)	(0.002)	(0.002)
I^5	0.012**	0.011**	0.014**	-0.002
	(0.002)	(0.003)	(0.002)	(0.002)
Country fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	151,146	151,146	151,146	151,146
R-squared	0.18	0.18	0.18	0.18

Notes: This table shows the estimation results of Equation (3.8) by using data from all countries. The dependent variable is $IM^V_{ict} / \left(IM^V_{ict} + IM^O_{ict}\right)$. The productivity measure in Equation (3.7) is used. Beta coefficients are reported and standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

group. Table 3.3 shows the result of the estimation using developed countries only. In columns (1), (2), and (3), I find a positive coefficient for the most flexible countries, but none of them are significant. In the estimation with the flexibility measure, 'cooperation in the labor-employer relationship,' I find a positive and significant coefficient for Group 3 and Group 4, but the coefficient for Group 5 is negative and significant.

However, when I estimate Equation (3.8) only using data from developing countries, I get dramatically different results. Table 3.4 reports the result where coefficients for Group 1 through Group 4 are either zero or negative, while the coefficients for Group 5 are positive, and three of them are significant. These results strongly support the prediction of the model in the first chapter.

Table 3.3: Estimation Results with Data from Developed Countries

	Dependent Variable: $IM^V_{ict} / \left(IM^V_{ict} + IM^O_{ict}\right)$			
	(1)	(2)	(3)	(4)
Using labor market index of	overall	hiring firing	flexible wage	cooperation
$Prod_{cit}$ interacted with:				
I^1	-0.012	-0.022***	-0.013*	-0.007
	(0.003)	(0.003)	(0.003)	(0.003)
I^2	-0.023***	-0.013	-0.026***	-0.021***
	(0.004)	(0.003)	(0.003)	(0.003)
I^3	-0.022***	0.002	-0.006	0.013*
	(0.003)	(0.003)	(0.004)	(0.004)
I^4	0.006	-0.010	0.005	0.014*
	(0.003)	(0.004)	(0.003)	(0.004)
I^5	0.011	0.008	0.004	-0.033***
	(0.003)	(0.003)	(0.004)	(0.003)
Country fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	77,737	77,737	77,737	77,737
R-squared	0.15	0.15	0.15	0.15

Notes: This table shows the estimation results of Equation (3.8) by using data from developed countries. The productivity measure in Equation (3.7) is used. Beta coefficients are reported and standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

When we compare the coefficient in Table 3.4 with the result in Table 3.2, we find that the coefficients are greater in magnitude and they are more statistically significant in Table 3.4. The beta coefficient of Group 5 in the first column is 0.027, which means that a standard deviation increase in the productivity dispersion gives about a 0.9 percent increase in the intrafirm trade share, which is about twice the increase that we get in the estimation from all countries.[3]

[3]The standard deviation of the intrafirm import share is about 0.33.

Table 3.4: Estimation Results with Data from Developing Countries

	Dependent Variable: $IM^V_{ict} / \left(IM^V_{ict} + IM^O_{ict}\right)$			
	(1)	(2)	(3)	(4)
Using labor market index of	overall	hiring firing	flexible wage	cooperation
$Prod_{cit}$ interacted with:				
I^1	0.010	0.002	0.019**	-0.000
	(0.003)	(0.003)	(0.003)	(0.003)
I^2	-0.023***	0.000	-0.019**	-0.003
	(0.003)	(0.003)	(0.003)	(0.004)
I^3	0.008	0.005	-0.008	-0.011
	(0.003)	(0.003)	(0.003)	(0.004)
I^4	-0.006	-0.015*	-0.004	0.000
	(0.004)	(0.003)	(0.003)	(0.003)
I^5	0.027***	0.016*	0.022***	0.013
	(0.004)	(0.004)	(0.004)	(0.003)
Country fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	73,409	73,409	73,409	73,409
R-squared	0.16	0.16	0.16	0.16

Notes: This table shows the estimation results of Equation (3.8) by using data from developing countries. The productivity measure in Equation (3.7) is used. Beta coefficients are reported and standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Although the reason behind the huge difference in the results shown in Table 3.3 and Table 3.4 is not clear, I can point to a possible cause of it in the U.S. Census data that I use. The U.S. Census trade data includes information which tells us whether a certain trade is between a related party or not; but it does not give any information on which one is the headquarter and which one is the subsidiary. This is a drawback of the U.S. Census data compared to the BEA intrafirm trade data as I want to focus on the case where the U.S. firms are the headquarters.

Table 3.5: U.S FDI Inflows by Partner Country (2012)

Country / Organization	Inflows (Million Dollars)	Share
Netherlands	29934	18.64
France	21664	13.49
United Kingdom	20547	12.80
Japan	19169	11.94
Canada	16460	10.25
Belgium	11876	7.40
Luxembourg	6216	3.87
South Korea	5240	3.26
Hungary	3640	2.27
Germany	3103	1.93
OECD	150595	93.79
Non-OECD	9974	6.21

Source: OECD

As firms in foreign countries also do FDI in the U.S., there are many cases, in the related-party data from those countries, in which U.S. firms are subsidiaries, and thus weaken the result that we are looking for. Also, considering the fact that in 2012 about 94 percent of FDI inflow to the U.S. came from other OECD countries, we can think of the data set only with developing countries to have more cases where U.S. firms are headquarters.[4] This explanation is also consistent with the result that the coefficient in Table 3.4 is greater and significantly stronger than the coefficients in Table 3.2. Considering this, the size of the coefficients that I get in Table 3.2 and 3.4 is not economically negligible.

We can find similar results in Yeaple (2006). Yeaple found generally supporting result that the higher the dispersion across firms, the greater the intrafirm import share. But when the countries were divided into three different groups, developing, emerging, and developed, a positive correlation in the developed country group was not found.

[4]See Table 3.5, which is from OECD FDI in/outflows data by partner country in 2012.

3.6 Conclusion

The model in the first chapter suggests that cross-country heterogeneity in labor market flexibility can be a source of different organizational forms of multinational firms. The key prediction is that the productivity dispersion affects a firm's decision only for countries with a flexible labor market, as outsourcing is a dominant choice for all multinationals, otherwise. I analyze this prediction using the U.S. Census data on the U.S. related-party trade data of 453 NAICS6-level products from 137 countries from 2006 to 2012.

I find strong support for the prediction in the benchmark model: the productivity dispersion increases the intrafirm share only in countries with a more flexible labor market. This result stands out more with the data set with developing countries, which are mostly host countries in trade with U.S. multinationals. Overall, findings in this study provide evidence for and confirm the prediction in the first chapter.

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