ESSAYS ON FOREIGN DIRECT INVESTMENT AND INTERNATIONAL BUSINESS CYCLES

by

Cagatay Bircan

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Doctoral Committee:

Professor Alan V. Deardorff, Chair
Professor Jan Svejnar
Professor Linda L. Tesar
Assistant Professor Andrei A. Levchenko

To my family.

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CHAPTER I

Optimal Degree of Foreign Ownership Under Uncertainty

1.1 Introduction

In a comprehensive empirical and theoretical review of multinational firms, Navaretti and Venables (2004) identify three facts about foreign direct investment (FDI) activity. First, mergers and acquisitions (M&As) account for the dominant share of FDI flows; this share increased steadily from 66.3% in the 1980s to 76.2% in the late 1990s. Second, most FDI is concentrated in skill- and technology-intensive industries. Third, multinational firms are increasingly engaged in international production networks, which gives rise to intra-firm trade that currently takes up around one third of world trade (Antras, 2003).

The incomplete contracts setting of Antras (2003) has proved extremely useful in explaining the recent trend in intra-firm trade and how it depends on industry-level factor intensities. Antras and Helpman (2004) extend this approach to the integration strategies of multinational firms but have restricted attention to two forms of sourcing inputs abroad: complete outsourcing and complete integration. However, the prevalence of M&As suggests that multinationals may split ownership shares with domestic partners every time they engage in FDI. As Desai et al. (2004) note, multinational firms frequently have the option to own 100%, majority, or minority shares of newly created foreign entities. In their words, “the appropriate ownership of productive enterprise is a central issue in economic theory and a practical question for multinational firms establishing new foreign affiliates.”

The choice of the degree of foreign ownership raises issues of incentives and governance at the acquired firm. Traditional theories of FDI posit that MNEs engage in operations abroad to exploit firm-specific (often intangible) assets. Yet, as Caves (2007) argues: “Collaborator A in a joint venture cannot agree to reward party B highly for B's contribution of proprietary technology to the project, without evidence of the technology's worth.” Hence, a multinational seeking to acquire a firm abroad faces idiosyncratic uncertainty about the complementarity of its proprietary assets and the production technologies and organization of the target firm. This uncertainty will surely affect the multinational's choices at the acquisition stage as well as its behavior about the delivery of its proprietary assets over time.

I refer to the variety of organizational forms that entail less than 100% ownership for a multinational abroad as partial integration. Using detailed plant-level data from the census of Turkish manufacturing firms over the period 1993-2001, I demonstrate three empirical findings. First, there is a substantial degree of partial integration among multinationals and their domestic partners, regardless of the industry they operate in. Second, the average degree of foreign ownership at a multinational plant rises over time (conditional on survival). Third, firms display substantial heterogeneity *within* sectors in their factor use and productivity. These findings motivate the theoretical model in this paper, which incorporates partial integration into an existing model of FDI. I focus on integration strategies by a foreign direct investor in a search and matching framework under a setting of incomplete contracts and uncertainty. Given the long-term nature of the investment relationship with a host country firm, I study not only a static problem of integration, but also a dynamic problem of optimal takeover strategies.

Specifically, I extend the model in Antras and Helpman (2004) to describe the optimal path of integration when there is uncertainty over the quality of the match between integrated firms. The uncertainty is modeled as the lack of sufficient information on the joint productivity of the integrated firms in the first period of production. The parties to the match learn about their joint productivity only after joint production has taken place. The model delivers a nondegenerate distribution of foreign ownership at the firm level and shows that the optimal level of integration rises with the age of the multinational firm. Additionally, the model highlights the role of heterogeneous firms in determining the level of integration and accounts for heterogeneity in factor use within sectors. The driving force behind the optimal path of integration is the search and learning framework that is built on Jovanovic (1979). This framework helps reconcile some potentially conflicting results concerning the direction of causation between foreign ownership and productivity and the manner in which they interact.

In contrast to the framework of Antras and Helpman (2004), which highlights industry-specific intensities of intermediate inputs, my major results are driven by the joint productivity between the multinational firm and its input supplier within an industry. The key comparative static of the model says that the degree of foreign ownership is an increasing function of joint productivity. The search and matching framework, along with this comparative static, imply that multinationals follow reservation strategies with regard to observed productivity levels when they make their investment decisions. In equilibrium, we only see the highly productive firms being targeted by multinationals, and the most productive staying in a long-lasting relationship. Multinationals increase their degree of equity participation when they find themselves in a fruitful match, while they divest (dissolve their match) if revealed joint productivity does not meet their expectations. This selection mechanism implies that equity investment decisions precede physical investment decisions. Since the degree of equity participation determines the factor intensity of the production line, the optimal ratio of intermediate inputs by the multinational firm to that by the supplier rises as the match endures. As such, the model identifies increased control by the multinational as the source of the transfer of proprietary assets.

Consider Honda Turkey, which is the second European production facility of the well-known Japanese automaker Honda. Honda Turkey represents a story of foreign direct investment which the theoretical model developed in this paper aims to capture.[1] The company was established in 1992 under the name Anadolu Honda Otomobil with a 50 percent stake controlled by each of Honda Motor Co and its Turkish business partner Anadolu Group. Production started in 1998 and focused on serving the Turkish market with the Civic Sedan model. Production of the Civic averaged around 7,000 until 2003, when Honda Motor Co acquired its Turkish partner's shares in its totality and became a fully integrated subsidiary assuming its current name. Honda Turkey started producing a second model, City, in 2005 and started an ambitious investment project worth $100 million to increase its yearly production capacity to 50,000 in 2006. By 2008, Honda Turkey reached its production goal of 50,000 units, 70 percent of which were destined for export markets. While Honda Turkey imports key mechanical pieces as well as engine and electrical

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[1] Data related to Honda Turkey are retrieved from http://www.honda.com.tr/honda_turkiye.aspx. Similar patterns of equity and physical investment, not necessarily resulting in complete takeover, can be found with other multinationals in Turkey. For instance, Ford Motor Company was a much earlier entrant to the Turkish market and it assumed 11 percent of ownership in 1983 at Otosan, which operated as the Ford assembler in Turkey. Ford increased its stake first to 30 percent in 1987, and later to 41 percent in 1997, and it continues production with Ford Motor Co and Otosan holding 41.04 percent each of the equity, the remainder of which is traded publicly.

components, it either produces the remaining components on-site or sources them domestically.

The multi-period model developed here is also motivated by and able to explain several findings from the literature on FDI. Firstly, the most common argument in the literature is that domestic firms that are controlled by foreign direct investors are typically the cream (Razin and Sadka, 2007).[2] Second, citing Pérez-González (2005) and Chari et al. (2010), Razin and Sadka (2007) argue that control by multinationals increases the efficiency and value of the firm. Similarly, Lipsey and Sjoholm (2006) suggest that higher wages observed at multinationals may be explained if a majority foreign ownership share is required to transfer technology. Third, Barbosa and Louri (2002) argue that a foreign partner will demand higher ownership in case of profitable affiliates and large intangible assets to be transferred. The model I present here sheds light on these predictions by linking the investment decision of foreign investors to firm-level productivity. Moreover, it is able to account for the intensive margin of imports when intrafirm trade occurs through vertical integration, on which theory has essentially been silent (Corcos et al., 2010).

I test the predictions of my model using data from the census of manufacturing firms in Turkey. After constructing plant-level estimates of total factor productivity (TFP) to proxy match quality, I study the determinants of the degree of foreign ownership and its relationship with productivity. I find that match quality can explain more of the variation in the degree of foreign ownership as compared to sectoral measures of capital and skill intensity. This finding remains even after taking into account firm-level heterogeneity in factor use. Moreover, I test the existence

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[2] Harris and Robinson (2002) and Benfratello and Sembenelli (2006) provide empirical evidence in favor of “cream-skimming” in their studies of the UK and Italian manufacturing industries, respectively. Djankov and Hoekman (2000) provide similar evidence for transition economies.

of a causal effect from productivity to the degree of foreign ownership and find strong evidence in favor of this effect. My empirical analysis also documents, using nonparametric and semi-parametric methods of survival analysis, ample evidence for the existence of a selection mechanism that is key to the theory. In line with the model's predictions, I find that multinational firms with lower productivities are most likely to engage in divestment.

The structure of the paper is as follows. Section 2 introduces the Turkish data to demonstrate three empirical regularities. Sections 3 and 4 develop the static and dynamic sides of the theoretical model, respectively. The multi-period model is able to generate the empirical regularities identified as well as "cream-skimming." Section 5 discusses the construction of the productivity measure to be used in the econometric analysis, lays out the econometric strategy to test the model, and presents the results from this analysis. Section 6 concludes. All proofs are relegated to the Appendix.

1.2 Plant-Level Evidence on Extent of Integration

Plant-level data for the current study come from the Industrial Analysis Database collected by the Turkish Statistical Institute (TurkStat). TurkStat annually conducts a census of all manufacturing establishments in Turkey with ten or more employees with detailed information on plant characteristics such as size, wages, investment, inventories, and value added. The database has been recently used in a study of export decision by Ozler et al. (2009) and discussed in more detail there. Most importantly for the current study, the database indicates whether the plant is vertically integrated with a multinational firm and provides a breakdown of equity ownership between the foreign direct investor and the Turkish plant operator.[3] I focus on the

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[3] The database includes further information about the foreign direct investor as surveyed in the census form. If a plant is vertically integrated, plants are asked to report the countries of the top three shareholders and their respective shares at the plant. Since I do not focus on this further breakdown, I simply work with

period 1993-2001, which is a period of stable capital inflows to Turkey.[4] Since Turkey did not impose any limitations on the foreign ownership of manufacturing plants in this period, I am able to observe maximal amount of variation in the degree of foreign ownership at the plant level and document the extent of partial integration.

Table 1.1 summarizes the presence of multinationals by year and sector in the sample of Turkish manufacturing plants used for the empirical analysis in this paper. I define a plant to be a multinational enterprise (MNE) in any given year if it has any positive level of equity held by a foreign direct investor. In the sample, the minimum degree of foreign ownership is 1% and the maximum degree is 100%. Panel (b) shows that while MNEs are most prevalent in industries such as other chemicals, transport equipment, and electrical machinery, they also operate actively in industries such as food, wearing apparel, textiles, and non-electrical machinery.[5] Hence, we observe vertical integration not only in those industries that are relatively intensive in their use of headquarter services, as predicted by Antras and Helpman (2004), but also in industries where manufactured inputs constitute the primary factor of production.[6] What is more interesting, however, is that a majority of the multinationals operating in Turkey choose to do so in a partially integrated setting with a domestic partner, regardless of their industry. Figure 1.1 depicts the distribution of foreign equity participation in the pooled sample of plant-year observations, which points to a

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the total foreign equity participation at the plant level.

[4] Although the period of analysis is 1993-2001, I use data starting from 1990 for plants with 25+ employees and 1991 for plants with 10+ employees to compute the capital stock series. Inclusion of plant identification codes enables me to construct a panel and follow the plants over time. Construction of the capital stock series and variables used in the analysis is explained in the Data Appendix, which also describes the cleaning procedure of the data used for the analysis. Table A1 reports the number of plants that were in the raw data before cleaning.

[5] In addition, multinationals are big players in their industries. Despite their small number in the overall population of plants, multinationals have employed 381 employees on average in a year compared to 117 in wholly owned domestic plants. This discrepancy is more pronounced in value added terms, with MNEs creating almost ten times as much value added as domestic plants. See Table 1.3.

[6] A similar finding is reported by Corcos et al. (2010), who find that intrafirm trade and outsourcing coexist in virtually all the manufacturing industries in their database of French multinationals, which roughly includes one hundred industries at the NACE Rev1 3-digit level.

non-trivial distribution of the equity share owned by multinationals. There is a sizable variation in plant-level FDI which stretches from very low stakes in the single digits to complete integration cases. In unreported figures, I find this pattern to be fairly robust to the type of industry and plant size. Both of the facts that vertical integration exists in all sectors and that it mostly occurs through partial integration are unaccounted for in previous theoretical models.

A more arresting picture emerges when we examine how the distribution of foreign equity participation changes over time. Define the “age” of an MNE to be the n^{th} consecutive year that a multinational carries out joint production with a domestic partner; for example, age 1 is the time of acquisition by the multinational with at least 1 percent equity share and the first year that joint production takes place, age 2 is the second year of joint production, and so on. Figure 1.2 shows how the extent of integration evolves with the age of the MNE.[7] As joint production continues into future years, the weight of the distribution moves to the right, suggesting that MNEs have higher extent of integration with age. Note the drop in the fraction of MNEs under minority foreign control and the rise in the fraction of MNEs under majority control with age. As an alternative way to see these dynamics, I plot the mean foreign equity participation against the age of the MNE in Figure 1.3.[8] While average foreign equity participation is around 52 percent at age 1, it jumps to 60 percent by age 3, and rises further to 65 percent by age 7. Hence, multinationals typically increase their equity participation at their subsidiaries conditional on continued joint production

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[7] Note that the sample used to construct this figure includes those MNEs that would be classified as “greenfield FDI,” i.e. plants which have always had 100 percent foreign equity participation. Hence the abundance of observations at the far right end of the distribution. These MNEs are included in the figure to give an idea about how the prevalence of partial integration compares to the case of complete integration. In the sample, only around 25% of all MNEs are fully integrated.

[8] In the figure, predicted foreign equity participation is a univariate fractional-polynomial estimate. I exclude greenfield FDI plants when constructing Figure 1.3, as these plants typically do not show any variation in their degree of foreign ownership. Inclusion of these plants does not change the main point of Figure 1.3, but makes the jump from age 1 to age 2 less pronounced.

and this adjustment mostly occurs at the earlier ages of the MNE. These trends are again robust to type of industry and plant size (employment).

Table 1.2 provides a summary of the (logs of) key variables used in the empirical analysis, including their standard deviations decomposed into a between- and a within-sector component. In line with previous evidence (see, for instance, Corcos et al. (2010)), I find substantial variation in productivity and factor intensities overall. More importantly, almost all of this variation is due to firm-level heterogeneity *within* sectors, and not between them. Panel (a) reveals that 82.8% of the variation in TFP, 90.9% of the variation in skill intensity, and 97.3% of the variation in capital intensity come from within-sector differences in the covariates, which indicate that the sector is a poor indicator of factor intensities. These figures are slightly higher than the ones reported for the French data by Corcos et al. (2010), and they support the authors' observation that the firm is the correct unit of analysis in order to study the determinants of internalization identified by the theory.

There are three empirical regularities that emerge from the Turkish data. First, the majority of multinationals operate in a partially integrated setting with a domestic partner regardless of industry characteristics, which implies that partial integration is a more prevalent form of foreign direct investment than complete integration. Moreover, there is significant heterogeneity in the degree of integration among MNEs. Second, the average share of ownership by foreign direct investors increases over time conditional on continued joint production. This suggests that multinationals follow a dynamic policy of integrating with their supplier and choose high levels of equity participation if they find themselves in a long lasting contractual relationship. This pattern could also arise if more highly integrated firms are more likely to survive. Lastly, there is significant within-sector heterogeneity; the variation in productivity and factor intensities across firms cannot be explained by sector-specific characteristics.

1.3 Optimal Integration

In this section, I modify the model in Antras and Helpman (2004), henceforth AH, to incorporate partial integration in the study of foreign direct investment.

There are two countries, North and South, and a single factor of production, labor. Preferences are as in AH, so that the world population consists of a unit measure of consumers with identical preferences given by:

$$U = x_0 + \frac{1}{\mu}\sum_{j=1}^{J} X_j^{\mu},\ 0 < \mu < 1,$$

where x_0 represents consumption of a homogeneous good, μ is a parameter, and aggregate consumption in sector j is a CES function,

$$X_j = \left[\int x_j(i)^{\alpha} di\right]^{1/\alpha},\ 0 < \alpha < 1,$$

of the consumption of different varieties $x_j(i)$. I retain the AH assumption that varieties within a sector are more substitutable for each other than they are for x_0 or for varieties from a different sector; i.e. $\alpha > \mu$. These preferences imply that final goods producers face the following inverse demand function for each variety i in sector j:

$$p_j(i) = X_j^{\mu-\alpha} x_j(i)^{\alpha-1} \tag{1.1}$$

There is a perfectly elastic supply of labor in each country, and wages are given by w_N and w_S in the North and the South, respectively. Assume $w_N > w_S$. Output is produced using a combination of two inputs that are specific to the variety, $h_j(i)$ and $m_j(i)$, where the headquarter services input $h_j(i)$ can be produced only in the North.

The manufactured components $m_j(i)$ can be produced in either country. Essentially, however, every final good producer needs to contract with a manufacturing plant operator for the provision of the variety-specific components (Antras and Helpman, 2004). This means that an input that is crafted to be used in a certain variety has no valuable use in the production of some other variety. Accordingly, output is produced following the Cobb-Douglas function:

$$x_j(i) = \theta \left[\frac{h_j(i)}{\eta_j}\right]^{\eta_j} \left[\frac{m_j(i)}{1-\eta_j}\right]^{1-\eta_j}, \; 0 < \eta_j < 1, \tag{1.2}$$

where θ is a match-specific productivity parameter that is unknown to both the final good producer and the manufacturing supplier at the time of the match.[9] The parameter, η_j, controls the headquarter intensity of the production and is sector-specific.

A major assumption built into the model is that there exists a nondegenerate distribution of productivities for a final good producer across different suppliers. I interpret θ as a measure of how complementary the two sides to the match are and as reflecting the cost-saving advantages to the final good producer of monitoring and supervising the supplier. This will show variation across suppliers due to plant-specific factors such as location, industry, organizational form, or skill composition. The match-specific productivity is unknown in the first period and is revealed to both sides only after continued joint production in the second period. As in Jovanovic (1979), θ is distributed independently across suppliers, which means that the "informational capital" generated through joint production is completely match-specific. Hence, the final good producer's previous experience with other suppliers carries no information about its productivity with new suppliers.

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[9] Note that the match-specific parameter should in fact be denoted as θ_i; I drop the subscript to simplify notation.

The distribution of θ in the population is known and I follow the common assumption regarding firm productivities: i.e. $\theta \sim Pareto(b,\, \gamma)$, where $b > 0$ is the scale parameter and $\gamma > 2$ is the shape parameter.[10] Accordingly, the cdf is given by:

$$G(\theta) = 1 - \left(\frac{b}{\theta}\right)^{\gamma}, \;\; \theta \geq b$$

In order to draw the match-specific parameter with a manufacturing supplier, the final good producer pays a fixed cost of entry $w_N f_E$. Upon payment of this fixed cost, the final good producer matches with a supplier with probability one and receives a noisy signal about the true value of its joint productivity with its supplier. If the match persists, the final good producer decides on the organizational form of the match ("the firm"), which determines the additional *fixed organizational costs* to be incurred. Following AH, I interpret the fixed organizational costs as the sum of all costs that pertain to the search for a supplier in the South and to the management of the firm, which entails "supervision, quality control, accounting, and marketing" among other things.

I assume in addition that the fixed organizational costs are increasing in the final good producer's ownership share. This assumption reflects the idea, for instance, that a multinational firm may be required to hire a larger team of management and devote more time to establish a firm in which it has majority share. Due to economies of scale in operation, however, a multinational may not incur as high fixed costs once it achieves effective control of the firm. Hence, the fixed organizational costs are denoted as $w_N \delta^{\phi}$, where $\delta \in (0,\, 1)$ is the share of the multinational at the firm and $\phi \in (0,\, 1)$ is an exogenous parameter.

I focus specifically on vertical integration as the organizational form of the firm in

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[10] $\gamma > 2$ is required for the distribution to have finite variance.

this paper. I assume that the multinational has already made its decision to obtain the manufactured input from a vertically integrated supplier in the South; i.e. foreign direct investment. AH establish that there always exist high productivity final good producers that choose to acquire manufactured inputs via FDI. The crucial question I ask is: where does the multinational draw its boundaries in controlling/owning the manufacturing plant operator in any given period? In other words, is there an optimal level of integration, $\delta^* \in (0, 1)$, for each period given the multinational's characteristics?

I adopt the incomplete contracts setting due to Antras (2003), where ownership of the suppliers entitles final good producers to some residual rights of control. Following the property-rights approach to the boundaries of the firm, input suppliers and final good producers cannot sign enforceable contracts specifying the purchase of a certain type of intermediate input for a certain price (Antras, 2003). As such, the division of the firm's revenue is determined by an ex post bargaining procedure following the production of the inputs. As in AH, ex post bargaining takes place under all organizational forms and is modeled as a generalized Nash bargaining game over potential revenue, which is given by:

$$R_j(i) \quad = \quad p_j(i)x_j(i) = X_j^{\mu-\alpha} x_j(i)^{\alpha}$$

In the Nash bargaining procedure, the outside option of the manufacturing supplier is always zero since its input is completely variety-specific. The final good producer's outside option, however, depends positively on the share of the firm it controls. Specifically, δ determines the fraction of the manufactured input that the final good producer has residual rights over. In the ex post bargaining, the final good producer can seize its share of the manufactured input, δ, once production has already taken place, and sell an amount $\delta x(i)$.[11] This translates into a fraction δ^α of the revenue if the final good producer carries out production on its own. Let $\beta \in (0, 1)$ denote the fraction of the ex post gains from entering a production relationship that go to the final good producer. Given this definition of residual rights, the share of the revenue that the final good producer captures is given by $\beta_V = \delta^\alpha + \beta(1-\delta^\alpha)$ as a result of generalized Nash bargaining, which reflects the final good producer's outside option plus its share of ex post gains. The share of the revenue for the manufacturing supplier is $(1-\beta)(1-\delta^\alpha)$, or equivalently, $1-\beta_V$, where $\beta_V = \delta^\alpha + \beta(1-\delta^\alpha)$.

The final element of the model is an upfront payment in each period by the manufacturing supplier to participate in the match. The upfront payment could be either positive or negative and is included in the contract that is offered to the potential supplier by the multinational. The contract offer follows the decision for the level of integration. As in AH, I assume an infinitely elastic supply of manufacturing suppliers so that their profits from the relationship inclusive of the upfront payment are equal to their ex ante outside option, which is set to zero for simplicity.

The time line of the model is as follows:

1. Period 1 starts. The final good producer enters the industry and pays the fixed cost of entry, $w_N f_E$.
2. At the same time, an unmatched supplier of manufactured inputs and the final good producer form a pair and jointly draw a random match parameter θ from a known distribution with cumulative distribution function $Prob\{\theta \leq s\} = G(s)$. The value of θ is unknown to both sides of the match at this point.
3. After the match is formed, the final good producer and the supplier receive a signal y, which is a random draw from the uniform distribution over the range

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[11] Note that restricting δ to be strictly less than one ensures that the supplier chooses to produce a positive amount of the manufactured input in each period.

$(0,\, \theta]$.[12] [13] Following the realization of the noisy signal, the final good producer may choose to exit the match or offer a contract to the supplier. If the final good producer leaves, it can seek out a new supplier, draw a new match parameter, θ', and receive a noisy signal on it, y', the next period.

4. If the final good producer stays, it negotiates a multi-period contract with the supplier. The contract sets forth the share of the firm that the multinational will own this period, δ_1, with the understanding that this can be updated when the uncertainty is resolved. The contract also specifies an upfront payment, t, that is to be paid by the supplier for each period that the match survives and that can be updated. Note that t could be positive or negative and the supplier has an outside option of zero in each period.
5. If the parties to the match cannot reach an agreement, the match breaks up. The final good producer can then seek out a new supplier and draw a new match parameter, θ', in the next period. If the multi-period contract is accepted, the match survives into the next period.
6. Upon acceptance of the contract, the final good producer acquires its negotiated stake, δ_1, as specified in the contract. The final good producer and the supplier then independently choose their quantities, h and m respectively, to maximize their own payoffs.
7. Output for the first period is sold and the resulting revenue is divided following

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[12] I let the signal be a random draw from the uniform distribution for purposes of tractability. In particular, this setup yields the Pareto distribution to be "conjugate"; that is, the posterior distribution of the parameter of interest belongs to the same family as the prior distribution. The model could be easily extended to the case where the signals are also distributed Pareto - in this case, the posterior distribution will belong to the Gamma family of distributions when the shape parameter is unknown, and to the Pareto family when the scale parameter is unknown.

[13] Notice that the lower boundary on the range of the signal is known, while the upper boundary is not. One can also imagine a case where the lower boundary is unknown as well, e.g. some range $[\theta_1,\, \theta_2]$. This could be handled similarly where the prior joint distribution of θ_1 and θ_2 are bilateral bivariate Pareto, which gives rise to a posterior joint distribution in the same family of distributions.

a generalized Nash bargaining procedure. Period 1 ends.

8. Period 2 starts. In the case of survival, the true value of θ is revealed to both sides of the match as a result of continued joint production. The final good producer has the option to terminate the contract at this point or update it. If the multi-period contract is updated, the final good producer picks its optimal stake this period, δ_2, which will apply in all subsequent periods as well.
9. The final good producer and the supplier choose their quantities noncooperatively to maximize their own payoffs.
10. Output for this period is sold and the resulting revenue is shared following a generalized Nash bargaining procedure. Period 2 ends.

The current model can characterize what happens to the likelihood of divestment over time (i.e. a break up of the match) endogenously. It is still of interest, however, to study an exogenous impact that may dissolve a match, which ensures that there exists a set of domestic suppliers that remain unmatched in each period. I assume that a firm in production is subject to adverse liquidity shocks with the hazard of separation occurring at the exogenous rate λ. Once joint production starts, the firm could receive a liquidity shock in any of the future periods.

Before describing the equilibrium under uncertainty, I study the per-period problem that the final good producer and the manufacturing supplier face. In the case that parties reach agreement, one can write the revenue in each period, using (1.2), as:

$$R(i) = X^{\mu-\alpha}\theta^{\alpha}\left[\frac{h(i)}{\eta}\right]^{\alpha\eta}\left[\frac{m(i)}{1-\eta}\right]^{\alpha(1-\eta)}, \tag{1.3}$$

where I have dropped the subscript, j, to focus attention on a single industry. In the case of disagreement, the outside option of the supplier remains zero but that of the final good producer depends on its share of the firm, δ.

Following the final good producer's choice of δ in each period, the parties to the match independently choose the quantities of their inputs. Given the noncontractibility of the supply of inputs, each input supplier maximizes its own payoff. The final good producer's problem is to pick the amount of headquarter services to maximize $\beta_V R(i) - w_N h(i)$, and the manufacturing supplier's problem is to pick the amount of intermediate inputs to maximize $(1-\beta_V)R(i) - w_S m(i)$. Substituting the expression in (1.3) for $R(i)$ and taking first order conditions, the Nash equilibrium quantities are:

$$h^*(i) = \eta \left(X^{\mu-\alpha}\theta^\alpha \alpha\right)^{\frac{1}{1-\alpha}} \left(\frac{\beta_V}{w_N}\right)^{\frac{1-\alpha(1-\eta)}{1-\alpha}} \left(\frac{1-\beta_V}{w_S}\right)^{\frac{\alpha(1-\eta)}{1-\alpha}} \tag{1.4}$$

$$m^*(i) = (1-\eta) \left(X^{\mu-\alpha}\theta^\alpha \alpha\right)^{\frac{1}{1-\alpha}} \left(\frac{\beta_V}{w_N}\right)^{\frac{\alpha\eta}{1-\alpha}} \left(\frac{1-\beta_V}{w_S}\right)^{\frac{1-\alpha\eta}{1-\alpha}} \tag{1.5}$$

These quantities reflect the optimal decisions of the sides to the match after uncertainty is resolved; that is, at stage 9 of the game. When the input suppliers are making their input decisions prior to the resolution of the uncertainty, at stage 6, they will be picking their quantities conditional on the information that they receive about the true joint productivity. The optimal quantities under uncertainty are then given by the first order conditions to each supplier's program, which maximize own per-period *expected* payoffs. Since both input suppliers are assumed to update their beliefs about θ in a Bayesian fashion, the expected payoffs substitute $E[\theta^\alpha|y]$ in place of θ in (1.3).

The ratio of headquarter services to manufactured inputs is given by:

$$\frac{h^*(i)}{m^*(i)} = \frac{\eta}{1-\eta}\frac{\delta^\alpha(1-\beta)+\beta}{1-\delta^\alpha(1-\beta)-\beta}\frac{w_S}{w_N}, \tag{1.6}$$

since $\beta_V = \delta^\alpha(1-\beta)+\beta$. Notice that taking headquarter intensity and wages as fixed, $h^*(i)/m^*(i)$ depends only on δ. Hence, the model generates within-sector heterogeneity in factor use due to the level of integration. The optimal intensity of headquarter services is independent of θ due to the symmetry between the two input suppliers' (lack of) information about θ in each period. In the first period, they both observe the same signal, y, which returns the same conditional expectation about θ, while in the second period, the true value of θ is revealed to both sides. This informational symmetry prevents the sides to the match from learning more about θ through each other's input choices. Given this, the final good producer's optimal level of integration will be changing as the firm endures to the extent that it is affected by the resolution of the uncertainty. In particular, the production line will be getting more intensive in the use of headquarter services if δ increases following the removal of uncertainty in equilibrium. I show this result in the next section.

Using the first order conditions in (1.4) and (1.5) along with (1.3) gives the total per-period value of the firm as measured by total operating profits:

$$\pi(\delta,\, \theta,\, X,\, \eta) = X^{\frac{\mu-\alpha}{1-\alpha}}\theta^{\frac{\alpha}{1-\alpha}}\psi(\delta,\, \eta) - w_N\delta^\phi \tag{1.7}$$

where

$$\psi(\delta,\, \eta) = \alpha^{\frac{\alpha}{1-\alpha}}\left(\frac{\beta_V}{w_N}\right)^{\frac{\alpha\eta}{1-\alpha}}\left(\frac{1-\beta_V}{w_S}\right)^{\frac{\alpha(1-\eta)}{1-\alpha}}(1-\alpha\eta\beta_V-\alpha(1-\eta)(1-\beta_V)) \tag{1.8}$$

$$\beta_V = \delta^\alpha(1-\beta)+\beta$$

and $w_N\delta^\phi$ reflects the (per-period) fixed costs of integration. Recall that $\phi > \alpha$ is a parameter that describes the marginal fixed cost of acquiring an ownership stake at the firm. I assume that this marginal fixed cost decreases with the level of integration as the final good producer is required to commit a greater amount of resources initially to take control of the firm. Accordingly, $\phi \in (0, 1)$. Profits are strictly increasing in θ and strictly decreasing in w^N and w^S as expected.

Following AH, I consider an industry with high headquarter intensity η such that operating profits excluding organizational costs are increasing in the final good producer's share of the revenue.[14] This setup highlights the importance of the input by the final good producer and lays the basis for the observation that most foreign direct investment takes place in high technology intensive industries. Since I focus specifically on vertical integration in the South, this is equivalent to the setup in AH where $\psi(\beta_V, \eta)$ is increasing in β_V regardless of where production takes place. The intuition here is that in a high headquarter intensity sector, "the marginal product of headquarter services is high, making underinvestment in $h(i)$ especially costly and integration especially attractive" (Antras and Helpman, 2004).

In solving any given period's subgame, the upfront payment specified in the multi-period contract, t, ensures that the final good producer effectively maximizes the total value of the firm in every period.[15] Given the structure of the profits in the stage game, is there an optimal level of integration δ^* that maximizes (1.7)? Moreover, is δ^* unique? This is the question that the final good producer needs to answer at stage 8 of the game after both parties to the match learn the true value of θ (the same question needs to be answered also in the first period at stage 6, when θ is

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[14] Where deemed useful, I comment on how the model can accommodate low headquarter intensity sectors (see, for example, the proof of Proposition 1) and provide intuition for comparison purposes.

[15] See Antras and Helpman (2004) for a proof of this assertion.

still unknown). It is equivalent to asking whether the firm's operating profits, (1.7), are concave in δ^α; for if not, then the optimal level of integration happens either at extremes (e.g. in the case of linearity) or at multiple points.

Proposition 1 There exists a unique optimal value for the level of integration, $\delta^* \in (0, 1)$, that maximizes the total operating profits of the multinational firm at the stage game.

Figure 1.4, panel (a), shows the relationship between the firm's operating profits and its degree of integration for various values of headquarter intensity. Firstly, the optimal level of integration lies strictly away from the end points for a range of headquarter intensities. For different values of η, profits are maximized at an intermediate level of integration. Secondly, notice that the optimal level of integration is increasing in η. For industries that are relatively more intensive in the use of headquarter services (i.e. $\eta > 0.5$), both the optimal integration level and the absolute level of profits are rising in η.[16] The reason for this lies at the heart of the hold-up problem, whereby a larger share of the manufactured input's ownership should be given to the side whose investment has greater impact on the joint surplus, following the optimal allocation of property rights. In high η industries, the marginal product of the input from the headquarters is much greater than that of the input from the manufacturing supplier. Therefore, the underinvestment in the manufactured input that is caused by a higher degree of integration is more than offset by the rise in total revenues driven by increased employment of headquarter services. Consequently, the share of the revenue that the final good producer captures from the relationship is increasing in the intensity of headquarter services. I refer to this dependence of the optimal

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[16] Notice that the absolute level of profits for $\eta = 0.35$ is actually higher than that for $\eta = 0.5$. The upper envelope of operating profits as a function of δ seems to be U-shaped, with the bottom of the U being reached at an intermediate level of η. This is because the hold-up problem in physical investments is most severe when both sides to the match make large contributions.

degree of integration on η as the "Antras effect."

A second important result from the stage game concerns how δ^* changes with match-specific productivity. As seen from (1.3), the revenues of the firm are strictly increasing in θ. Given a higher level of productivity, a final good producer is inclined towards capturing a greater share of the revenue. However, this decreases the share that is left to the manufacturing supplier, causing underinvestment in the manufactured input. The downward pressure on the revenue level caused by the supplier's underinvestment can potentially outweigh the gains from a productivity increase. Yet, in an industry with high headquarter intensity, the marginal product of the manufacturing input is relatively low. This enables the final good producer to choose a higher stake at the firm without distorting the incentives of its supplier by too much.

Proposition 2 The optimal level of integration is increasing in the match-specific productivity level; that is, $\partial\delta^*(\theta)/\partial\theta > 0$.

I refer to this dependence of the optimal degree of integration on θ as the "match quality effect." Figure 1.4, panel (b), relates operating profits to δ for a range of joint productivities in the same industry. While the Antras effect highlights the role that sector-specific headquarter intensity plays in determining δ^*, the match quality effect emphasizes within-sector heterogeneity along joint productivities. Given a non-degenerate distribution of θ, the stage games produce a non-degenerate distribution of δ^* among the MNEs. Producers show variation in their level of integration not only along headquarter intensity, but also their joint productivities within similar industries. Which one of these effects is more instrumental in determining δ^* is essentially an empirical question. Another important implication of Proposition 2 is that the optimal ratio of investments in headquarter services and manufacturing inputs, given by(1.6), is higher for those MNEs with a higher match quality in any given industry. Within-sector heterogeneity in productivity translates into factor intensity heterogeneity for the MNEs due to the variation in their optimal degree of foreign ownership.

1.4 Equilibrium Under Uncertainty

In serving a host country market, the multinational seeks to maximize the expected present value of its profits. Given the structure of the multi-period contract, this will be equivalent to maximizing the total profit stream of the whole relationship (the integrated firm) associated with a match. The problem for the multinational is to determine the optimal path of integration with a manufacturing supplier to achieve this goal. This includes the option that the final good producer might withdraw from the partnership in order to seek a new match at any period in the relationship. I solve the problem by working backward, starting in period 2.[17]

From stage 8 on, the final good producer knows the true value of θ, which will be its joint productivity with the supplier in this and all future periods. Let $J(\theta)$ denote the expected present value of profits to a firm who has a known match quality θ and is behaving optimally. Note that having realized its true productivity, the final good producer could calculate its optimal level of investment, δ_2^*, and stipulate this level in the contract to be updated. Therefore, θ is a sufficient statistic for the firm's expected present value at any period in time, which allows me to write the value function in terms of θ only.

Let r be the firm's discount rate. If the contract is updated, then the value of

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[17] The solution concept here is similar to the discussion in Ljungqvist and Sargent (2004), who work with a simplified version of Jovanovic's model in its original context of labor markets. I also work with a simple discrete time version of Jovanovic's model; however, the current model differs significantly from the original in certain respects, such as its contracting structure and probability distributions.

the firm is given by $\pi(\theta) + \frac{1}{r+\lambda} J(\theta)$, where[18]

$$\pi(\theta) = X^{\frac{\mu-\alpha}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \psi(\delta_2, \eta) - w_N \delta_2 \tag{1.9}$$

is the per-period profit of the firm at the outcome of the stage game in period 2. Recall that λ is the exogenously given separation rate due to adverse liquidity shocks.

If the contract is terminated, no production will take place this period as the final good producer would have no provision of the manufactured inputs. The final good producer could then start searching for a new manufacturing input supplier next period and draw a new match parameter. Let Q be the present value of profits of a final good producer who withdraws from a match and behaves optimally. Since the search for a new supplier involves drawing a new value of θ independent of the previous matches, Q will be a constant under the assumptions of an infinite horizon and constant discount rate (Jovanovic, 1979).[19]

The Bellman equation that characterizes the value of the game to the final good producer in period 2 is then given by: $J(\theta) = max\{\pi(\theta) + \frac{1}{r+\lambda} J(\theta),\, \frac{1}{r} Q\}$. I depict this equation in Figure 1.5. The value of continued joint production is rising in the match parameter while the value of withdrawal is constant. As is clear from the figure, the optimal policy is one that updates the contract for values of θ above a certain level and terminates it below this threshold level. The solution to the Bellman equation in period 2 is given by:

$$J(\theta) \;=\; \begin{cases} \pi(\theta) + \frac{1}{r+\lambda} J(\theta) & for\ \theta \geq \underline{\theta} \\ \frac{1}{r} Q & for\ \theta \leq \underline{\theta} \end{cases} \tag{1.10}$$

where the threshold level $\underline{\theta}$ satisfies:[20]

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[18] I suppress the other arguments of the per-period profit function for notational simplicity.

[19] In the current model, the constancy of Q implies that if a final good producer withdraws from a match with a supplier, it will never choose to carry out joint production with this particular supplier in the future.

[20] Notice that (1.10) implies $J(\theta) = \frac{r+\lambda}{r+\lambda-1} \pi(\theta)$ for $\theta \geq \underline{\theta}$.

$$\frac{r+\lambda}{r+\lambda-1}\pi(\underline{\theta}) = \frac{1}{r}Q \tag{1.11}$$

The final good producer's optimal policy in period 2 implies that, in equilibrium, only those matches that have high enough productivities will continue joint production in future periods. If the true value of θ is revealed to be below $\underline{\theta}$, the firm will be dissolved since continuing the relationship indefinitely at a low θ yields a lower expected present value of profits than the alternative matches. This aspect of the model can explain the often mentioned case of "cherry-picking" in foreign direct investment, whereby multinational firms invest only in the high productivity plants in the host economy. Since the multinational can sample from a large pool of potential suppliers and it locks itself in a relationship with the same supplier, its optimal policy is to wait until it finds itself in a match with high enough productivity. In equilibrium, only those multinationals that realize a certain threshold level of productivity persist in the industry.

The multinational's optimal policy in period 2 implies that matches break up only between the first and second periods. If the multinational decides to remain in the relationship in period 2, then it will continue joint production indefinitely. Hence, divestment is negatively correlated with the age of the multinational and the model reproduces the empirical observation that most plant closures by multinationals occur in the early stages of the partnership.

Given the optimal policy of contract updating in period 2, I now turn to the final good producer's decision making in period 1 in the presence of uncertainty. Having received a noisy signal on the match parameter, y, the final good producer follows Bayesian updating to calculate the posterior probability distribution of θ. The following lemma describes the properties of the posterior distribution.

Lemma 1: Let y denote a random draw from a uniform distribution over the range $(0,\, \theta]$. The $Pareto(b,\, \gamma)$ distribution has density:

$$f(\theta) = \begin{cases} \frac{\gamma b^{\gamma}}{\theta^{\gamma+1}} & if\, \theta \geq b \\ \\ 0 & otherwise \end{cases}$$

where $b > 0$ and $\gamma > 2$. Let $\tilde{\gamma} = \gamma + 1$ and $\tilde{b} = max(y,\, b)$. The posterior density of θ is defined by:

$$f(\theta|y) \propto \begin{cases} \frac{1}{\theta^{\tilde{\gamma}+1}} & if\, \theta \geq \tilde{b} \\ \\ 0 & otherwise \end{cases}$$

which takes the same form as the prior. Hence $\theta|y$ is $Pareto(\tilde{\gamma},\, \tilde{b})$ with $E(\theta|y) = \frac{\tilde{\gamma}\tilde{b}}{\tilde{\gamma}-1}$ and $Var(\theta|y) = \left[\frac{\tilde{\gamma}}{\tilde{\gamma}-2} - \left(\frac{\tilde{\gamma}}{\tilde{\gamma}-1}\right)^2\right]\tilde{b}$.

Proof: See Leonard and Hsu (1999).

Lemma 1 expresses the posterior expected value of θ in terms of the parameters of the distribution and the signal. In order for the signal to be informative about θ, I assume for the remaining analysis that the lower bound for the signal is b, so that $\tilde{b} = y$.[21] This setup leads the firm to infer that the true value of its θ is increasing in the value of the signal that it receives, as the posterior mean is given by: $\tilde{\theta} = E(\theta|y) = \frac{\tilde{\gamma}}{\tilde{\gamma}-1}y$. Notice that since y is uniformly distributed, the posterior mean is also distributed uniformly, characterized by the parameters $\hat{b}$ and $\hat{\gamma}$, where $\hat{b} = \frac{\tilde{\gamma}}{\tilde{\gamma}-1}b$ and $\hat{\gamma} = \frac{\tilde{\gamma}}{\tilde{\gamma}-1}\theta$.[22] I denote the distribution of the posterior mean by $G(\tilde{\theta}|\hat{\gamma},\, \hat{b})$.

Let $V(\tilde{\theta})$ be the value to a final good producer who has received signal y and

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[21] One can interpret this by assuming, for instance, that the firm receives a signal above a certain value in expectation of the productivity gains from a takeover. Note that when $y < b$, the posterior mean becomes $\tilde{\gamma}b/(\tilde{\gamma}-1)$, which is independent of y, and therefore the signal becomes uninformative.

[22] The support of a uniform distribution is defined by its upper and lower bounds.

is behaving optimally in period 1. If the final good producer chooses to remain in the match, the outcome of the game in period 1 yields a per-period profit of $\pi(\tilde{\theta})$, where[23]

$$\pi(\tilde{\theta}) = X^{\frac{\mu-\alpha}{1-\alpha}} E\left[\theta^{\frac{\alpha}{1-\alpha}} | y\right] \psi(\delta_1, \eta) - w_N \delta_1 \tag{1.12}$$

In the case that the match breaks up, the final good producer receives a per-period profit of zero and it can seek out a new supplier next period. If it survives, the true value of θ is revealed. Then $V(\tilde{\theta})$ satisfies:

$$V(\tilde{\theta}) = max\left\{\pi(\tilde{\theta}) + \frac{1}{r+\lambda}\int J(\theta')dP(\theta'|\tilde{\gamma}, \tilde{b}), \frac{1}{r}Q\right\} \tag{1.13}$$

In (1.13), $P(\theta'|\tilde{\gamma}, \tilde{b})$ is the conditional distribution of joint productivities for the next period when the true θ is revealed. As with the contract updating policy in period 2, (1.13) implies an optimal policy for the final good producer that continues the match above a certain level of $\tilde{\theta}$, and withdraws from it below this threshold.[24] The solution to the Bellman equation for the first period is given by:

$$V(\tilde{\theta}) = \begin{cases} \pi(\tilde{\theta}) + \frac{1}{r+\lambda}\int J(\theta')dP(\theta'|\tilde{\gamma}, \tilde{b}) & for\ \tilde{\theta} \geq \underline{\tilde{\theta}} \\ \frac{1}{r}Q & for\ \tilde{\theta} \leq \underline{\tilde{\theta}} \end{cases} \tag{1.14}$$

where $\underline{\tilde{\theta}}$ satisfies:

$$\pi(\underline{\tilde{\theta}}) + \frac{1}{r+\lambda}\int J(\theta')dP(\theta'|\tilde{\gamma}, \tilde{b}) = \frac{1}{r}Q \tag{1.15}$$

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[23] The following equations are written with some abuse of notation. Notice that equation (1.12) is actually defined in terms of $E\left[\theta^{\frac{\alpha}{1-\alpha}}|y\right]$, which is not the same as $\tilde{\theta} = E(\theta|y)$. To be more precise, one can calculate $E\left[\theta^{\frac{\alpha}{1-\alpha}}|y\right]$ as $\frac{\tilde{\gamma}}{\tilde{\gamma}-\alpha/(1-\alpha)}y^{\alpha/(1-\alpha)}$ by using the density function $f(\theta)$ in Lemma 1. Notice that just like $E(\theta|y)$, $E\left[\theta^{\frac{\alpha}{1-\alpha}}|y\right]$ is determined by $\tilde{\gamma}$ and y. Likewise, taking α as given, the distribution of the posterior expectation is uniform and characterized by similar parameters.

[24] To see this, notice that both $\pi(\tilde{\theta})$ and $\frac{1}{r+\lambda}\int J(\theta')dP(\theta'|\tilde{\gamma}, \tilde{b})$ are increasing in $\tilde{\theta}$ while $\frac{1}{r}Q$ is constant.

It is possible to show (see Appendix) that $\pi(\underline{\theta}) > \pi(\underline{\tilde{\theta}})$; that is, the final good producer requires a higher level of profits in period 2 to stay in the match compared to the level of profits it would accept in period 1 to continue joint production. The reason for the increase in the "reservation profits" is the resolution of the uncertainty over the joint productivity parameter. Since the final good producer knows that the firm's total profits will be determined by the true value of θ in period 2 and thereafter, it becomes more selective in establishing a long-term relationship with a supplier. An immediate implication of this result is that $\underline{\theta} > \underline{\tilde{\theta}}$, because the per-period profit function $\pi(.)$ is strictly increasing in θ. Therefore, the final good producer's optimal policy implies divestment whenever the true productivity level with the supplier turns out to be lower than the threshold value of the posterior mean.

The increase in the reservation productivity level of the final good producer explains the argument that foreign direct investors tend to retain high-productivity firms under their ownership and sell low-productivity firms to uninformed agents since they gain crucial information about the productivity of the firms under their control (Loungani and Razin, 2001). Note, however, that in order to gain this crucial information, the final good producer should commit to at least one period of joint production with its supplier. What happens following this learning stage is a selection process which eliminates low quality matches. As a result, multinational producers lie at the high end of the productivity distribution for a universe of plants in host economies.[25]

I now study whether there exists a unique solution to the final good producer's

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[25] This mechanism implies a lemons problem in the market for corporate stocks when foreign owners are divesting. It would not be surprising to see a decline in the value of a firm when corporate control is handed from foreign owners back to the initial owners of the firm.

dynamic problem. The final good producer's optimal policy consists of a threshold strategy in each of the two periods of the model. If the final good producer leaves the match at either of these periods, it can match with a new supplier and receive a noisy signal on its joint productivity with the new partner. The expected present value from a new match is given by:

$$Q = \int V(\tilde{\theta}) dG(\tilde{\theta}|\hat{\gamma},\, \hat{b}) \tag{1.16}$$

The final good producer's optimal policy is characterized by the equations (1.10), (1.14), and (1.16), which give rise to a single Bellman equation in V:

$$\begin{aligned} V(\tilde{\theta}) \quad = \quad & max\left\{\pi(\tilde{\theta}) + \frac{1}{r+\lambda}\int max\left\{\frac{r+\lambda}{r+\lambda-1}\pi(\theta),\, \frac{1}{r}\int V(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\, \hat{b})\right\} dP(\theta|\tilde{\gamma},\, \tilde{b}),\right. \\ & \left. \frac{1}{r}\int V(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\, \hat{b})\right\} \end{aligned} \tag{1.17}$$

The following result establishes the solution to the final good producer's dynamic problem and is proved in the Appendix.

Theorem 1 There exists a unique, bounded, and continuous solution for V in (1.17).

What does the learning process imply about the optimal level of integration? Recall that the final good producer designs a multi-period contract in period 1 (stage 4) which specifies its share of the manufactured input in the first period and gives the right to update this share when the uncertainty is resolved (stage 8). I am interested in how this share evolves as the match endures. Within the property-rights framework of the multinational firm, I expect the resolution of the uncertainty to lead to a more efficient allocation of residual rights as joint production reveals the optimal mix of headquarter services and manufactured inputs. The multi-period contract should be updated to reflect this allocation of rights over the manufactured input.

Consider a final good producer in period 1 that has received a signal such that its posterior expected value of θ, say $\tilde{\theta}_t$, lies between $\underline{\theta}$ and $\tilde{\underline{\theta}}$. In equilibrium, this marginal producer will start production with its supplier in the first period but it will divest and withdraw from its match if the true value of its θ eventually turns out to be less than $\underline{\theta}$. For the producer to survive with its current match into future periods, its true θ should turn out to be greater than $\underline{\theta} > \tilde{\theta}_t$. This implies that the true joint productivity with the supplier should surpass the posterior expected value, which is calculated from the signal, for surviving firms. Recalling the earlier result that $\partial\delta^*(\theta)/\partial\theta > 0$, the marginal producer will increase its optimal level of integration with the supplier in the case that the match survives. It is then intuitive to see the following proposition:

Proposition 3 The optimal level of integration for an average firm in its second period is higher than the optimal level of integration for an average firm in its first period. In other words, the optimal degree of foreign ownership is rising over time for an average multinational.

Proposition 3 explains the empirical regularity demonstrated in Section 2 that foreign equity participation rises with the age of the MNE. The intuition is fairly straightforward and depends on the selection of high productivity matches into future periods. Low productivity matches dissolve if the true value of their θ is not higher than their posterior mean. High productivity matches survive into the second period and the multi-period contract is updated to reflect the revelation of the true value of productivity. This selection mechanism leads us to the following proposition:

Proposition 4 The optimal ratio of investments in headquarter services and manufactured inputs, h^*/m^*, rises with the age of the integrated firm.

Proposition 4 is relatively easy to see from equation (1.6). Notice that (1.6) depends only on δ, and positively. Since the optimal level of integration is increasing over time for an average multinational, we immediately have that h^*/m^* is higher in the second period than in the first period. Hence, the model predicts that production gets more intensive in the use of headquarter services as the integrated firm continues production in future periods. In the second period, there is a greater transfer of headquarter services that are produced in the North to the production plant in the South. Therefore, the model generates transfer of technology that is driven by the degree of foreign ownership and explains the empirical finding that multinational plants get more headquarter-intensive over time.[26]

The inner workings of the dynamic model essentially depend on a selection mechanism whereby low productivity matches dissolve as the uncertainty over match quality is resolved. This selection mechanism determines the rise in the threshold levels of joint productivity from period 1 to period 2 and leads to the optimal reallocation of property rights within the firm. According to the model, the probability of a match being dissolved in period 2 is given by $Prob\{\theta' < \underline{\theta}|\tilde{\theta}\} = P(\underline{\theta}|\tilde{\gamma}, \tilde{b})$, which is obviously negatively correlated with $\tilde{\theta}$, the posterior expected value for joint productivity. I summarize this selection mechanism in the following proposition:

Proposition 5 The probability of a match being dissolved subsequently is negatively correlated with the current level of joint productivity.

The dynamic model can thus explain the major empirical regularities identified in Section 2 in addition to a set of well-known facts in the literature. It also presents some strong implications about the evolution of the degree of foreign ownership and

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[26] See, for instance, the discussion in Arnold and Javorcik (2009) for how factor intensity and use of imported inputs evolves at multinationals over time.

productivity and how they interact. I turn next to a rigorous empirical analysis of this interaction.

1.5 Empirical Evidence

The theoretical model described above delivers some testable implications about the relationship between the level of foreign ownership and the joint productivity (“match quality”) of the multinational parent and the manufacturing supplier. In order to test the implications of the model, I measure joint productivity at the MNE by total factor productivity (TFP). This section first discusses the construction of the joint productivity measure and then lays out the econometric strategy to test the model alongside presenting my findings using plant-level data from Turkish manufacturing industry.

1.5.1 Estimating Joint Productivity

In the model, output is produced according to the Cobb-Douglas production function:

$$x_j(i) = \theta \left[\frac{h_j(i)}{\eta_j}\right]^{\eta_j} \left[\frac{m_j(i)}{1-\eta_j}\right]^{1-\eta_j}, \; 0 < \eta_j < 1,$$

where θ indicates joint productivity, $h_j(i)$ is the headquarter services input that is imported from the North, and $m_j(i)$ is the manufactured component at the plant in the South. Both the headquarter firm and the manufacturing supplier employ physical capital, labor, and some intermediate inputs to provide h and m. While I do not observe the quantities of inputs that are used in the production of h, I do observe the inputs used by the supplier firm to produce m. More specifically, I assume that m is produced following a Cobb-Douglas function of the form:

$$m_j(i) = k_{i,j}^a l_{i,j}^b n_{i,j}^c e_{i,j}^d \tag{1.18}$$

where k represents physical capital, l represents labor, n represents raw material inputs, and e represents energy consumption. Substituting (1.18) into the final production function gives:

$$x_j(i) = \theta \left[\frac{h_j(i)}{\eta_j}\right]^{\eta_j} \left[\frac{k_{i,j}^a l_{i,j}^b n_{i,j}^c e_{i,j}^d}{1-\eta_j}\right]^{1-\eta_j}$$

which suggests the following specification of the Cobb-Douglas production function in logs:

$$logx_j(i) = \beta_0 + \beta_1 logh_j(i) + \beta_2 logk_j(i) + \beta_3 logl_j(i) + \beta_4 logn_j(i) + \beta_5 loge_j(i) + log\theta + \varepsilon_j(i)$$

where $log\theta$ is the productivity shock that is observed by the producer but not by the econometrician, and ε are unobservable shocks to efficiency. Productivity shocks $log\theta$ are assumed to follow a first-order Markov process. Since I cannot differentiate between h and n in my data set, I choose to follow a value-added estimation approach. Letting $v_j(i)$ represent value added, i.e. gross output net of both imported and domestic intermediate inputs, I can write the production function as:

$$logv_j(i) = \beta_0 + \beta_k logk_j(i) + \beta_l logl_j(i) + log\theta + \varepsilon \tag{1.19}$$

The parameters of the value-added equation (1.19) are consistently estimated using the two-step procedure suggested by Levinsohn and Petrin (2003) and predicted levels of productivity are recovered from:

$$\hat{\theta} = exp(logv - \hat{\beta}_k logk - \hat{\beta}_l logl)$$

The Levinsohn and Petrin (2003) procedure relies on firms' intermediate inputs to proxy for productivity shocks that are correlated with firms' inputs of production. In my estimations, I use raw materials to proxy productivity shocks in order to satisfy the monotonicity condition.[27] I estimate the parameters of (1.19) at the ISIC Rev. 2 three digit industry level; coefficient estimates are reported in Table 1.9.[28]

Table 1.2 reports the mean values of some key variables used in the empirical analysis by type of ownership and year. The average TFP value for the multinationals is more than twice that for domestic plants in most of the years in the sample. The average TFP at multinationals throughout the sample period is around 5.3 compared to 1.3 at domestic plants, a difference that is statistically significant. This finding confirms the model's prediction that, in equilibrium, only the most productive plants are controlled by multinational investors. Accordingly, multinational plants in Turkey are much larger compared to domestic plants, both in terms of the number of workers they employ and the value of output they produce. They are also more capital intensive on average and have much higher value added. Hence, there is a sizable premium to being multinational, which is well documented in the literature. What remains to be understood, however, are the determinants of the extent of ownership at multinationals, to which I turn next.

1.5.2 Match Quality and the Level of Foreign Ownership

This subsection answers two questions that are central to my model: i) What determines the level of foreign ownership at subsidiaries of multinational firms; and ii) how does joint productivity affect the level of ownership? Theory suggests that there are two primary factors that determine the answer to my first question. The

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[27] An alternative methodology for TFP calculation is Olley and Pakes (1996), who suggest using investment decisions to proxy productivity shocks. However, there is a large number of zero observations for the investment series in the Turkish data, as can be seen from Table 1.8, which reports the percentage of non-zero observations of potential proxy variables for the ten largest manufacturing sectors.

[28] I estimate industry categories 313 (beverages) and 314 (tobacco) together, as well as 361 (pottery, china, earthenware) and 362 (glass products), to increase the sample size for the estimation at the industry level. For the same concern, the production function is not estimated for the industries of 353 (petroleum refineries) and 354 (other petroleum), which have a total of 367 plant-year observations.

first is the industry-level intensity of the production line in headquarter services, η, which I refer to as the "Antras effect." The second is the match-specific joint productivity, θ, which I call the "match quality effect." Antras (2003) and Antras and Helpman (2004) proxy η by industry-level data on capital- and skill-intensity, respectively, and I compute these values for the Turkish manufacturing data for its 85 industries defined at the ISIC four digit level.[29] I compute θ as described in the previous section and estimate variants of the following Tobit type-one model:

$$y^*_{it} = \alpha + \beta_\theta ln(\theta)_{it} + \beta_{K/L} ln(K/L)_{gt} + \beta_{S/L} ln(S/L)_{gt} + \mu_t + \varepsilon_{it} \tag{1.20}$$

$$y_{it} = \begin{cases} y^*_{it} & if\, 0 < y^*_{it} \leq 100 \\ 0 & if\, y^*_{it} \leq 0 \end{cases} \tag{1.21}$$

where i indexes plants, g indexes industries, and t indexes time. In (1.20), y^*_{it} is a latent variable indicating the optimal level of foreign equity participation, but in the data I simply observe y_{it}. I assume $\varepsilon \sim N(0, \sigma^2)$ with variance σ^2 constant across observations, and μ_t are year dummies.

Table 1.4 reports the estimates of the model in (1.20). In all columns, I report standardized "beta" coefficients, which makes it easy to analyze and compare the size of the coefficients. To judge the goodness of fit for the different models, I follow Wooldridge (2002) and calculate R^2 as the square of the correlation coefficient between y_i and $\hat{y}_i$, where $\hat{y}_i$ is the Tobit estimate of $E(y|\mathbf{x} = \mathbf{x}_i)$ with $\mathbf{x}$ being the vector of explanatory variables. The results indicate that match quality is a highly significant determinant of the degree of foreign ownership. Joint productivity

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[29] I conducted the following analysis at the ISIC three-digit level as well, and my results are unchanged. My analysis with 85 industries is an improvement over Antras (2003), who worked at the 2-digit SIC level with 28 industries, and Yeaple (2006), who worked with 51 industries from BEA data, but falls short of a similar exercise conducted by Nunn and Trefler (2008), who work with 370 industries from the US Census data. Unlike these studies, however, I am interested in determining firm-level outcomes as opposed to the industry-level.

alone can explain more of the variation in foreign equity participation as compared to sectoral capital and skill intensity (see columns (1) and (2)). I find that while sectoral skill intensity is a significant determinant of foreign equity participation, sectoral capital intensity is not. Comparing the sizes of the coefficients in column (3) indicates that joint productivity has a larger effect than industry-level factor intensities. Hence, the "match quality effect" outweighs the "Antras effect" in determining the degree of integration at multinational subsidiaries.

These findings are consistent with a high degree of within-industry heterogeneity in factor use. In their study of intrafirm trade using French data, Corcos et al. (2010) find factor intensity to be an important determinant of firms' sourcing decisions when measured at the firm level, but not at the industry level, which they attribute to substantial within-industry heterogeneity. In order to determine whether match quality still matters when this heterogeneity is taken into account, I estimate (1.20) with firm-level capital and skill intensity. Indeed, columns (4) and (5) show that both variables are highly significant determinants of foreign equity participation. I find that match quality retains its significance with an economically large effect even after controlling for firm-level heterogeneity in factor intensities: a one standard deviation increase in joint productivity leads to a 0.223 standard deviation increase in foreign equity participation.

One of the major propositions that comes out of my model is that, conditional on acquisition taking place, the level of foreign ownership is increasing in the joint productivity of the final good producer and the manufactured input supplier; i.e. $\partial\delta/\partial\theta > 0$. In order to quantify the impact of joint productivity on the level of foreign ownership, I estimate the pooled Tobit model:

$$(1.22) \quad y_{it}^{*} = \alpha + \beta_{\theta} ln(\theta)_{it} + \beta_{K/L} ln(K/L)_{it} + \beta_{S/L} ln(S/L)_{it} + \gamma' \mathbf{X}_{it} + \varepsilon_{it},$$

where y_{it}^{*} is defined by (1.21) and $\mathbf{X}_{it}$ is a vector of firm-level controls.[30] The pooled Tobit model has two distinct advantages. First, it does not maintain strict exogeneity of the explanatory variables; while ε_{it} are assumed to be independent of the covariates, the relationship between the current error term and the covariates in the other time periods is unspecified. This means that we can safely estimate explanatory variables that are affected by feedback from previous periods. Second, ε_{it} are allowed to be serially dependent, so that y_{it}^{*} can be dependent after conditioning on the explanatory variables (Wooldridge, 2002).

Table 1.5 reports the estimates from the model in (1.22), which also control for year and sector effects.[31] I report marginal effects conditional on foreign acquisition; i.e. $E(\partial y/\partial x|0 < y \leq 100)$. Column (1) indicates that a 10 percent increase in joint productivity is associated with around a 17 percent increase in foreign equity participation when I do not control for additional covariates. This is an economically significant effect and it points to substantial variation in the degree of foreign ownership simply due to "match quality." When additional covariates are included in columns (2) and (3), the estimated effect is 18 percent and 14 percent, respectively. These figures show that multinationals acquire sizable shares of equity at those of their subsidiaries that they perceive as highly productive partnerships. Controlling for unobserved plant effects in column (4) does not change the major finding of a positive relationship between joint productivity and foreign equity participation,

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[30] My choice of controls is informed by existing studies which predict the *type* of foreign ownership at the plant level (see, for instance, Barbosa and Louri (2002)). It is important to note that there is a subtle difference between the determinants of the level of foreign ownership and the determinants of foreign acquisition per se. Most of the existing literature has focused on the latter, predicting what factors increase the likelihood of a domestic plant being taken over. The focus of the current study, however, is on the former, which will not necessarily share the factors that predict acquisition.

[31] If foreign investors own larger equity fractions in sectors that are more productive than the others, then failing to control for sector effects might drive the relationship reported in Table 1.5. Controlling for sector effects ensures that this relationship is driven by *within-industry* variation.

although it returns much lower coefficients across the board.[32]

It is possible to have a nonzero correlation between $ln(\theta)_{it}$ and ε_{it} in (1.22) if the specification does not include relevant time-varying factors correlated with TFP, or if TFP is mismeasured.[33] An additional concern is reverse causality, whereby the degree of foreign ownership might impact productivity through intrafirm activities. An oft mentioned argument is that equity investment decisions precede physical investment decisions, for instance if majority foreign ownership is required to transfer technology to the affiliate (Lipsey and Sjoholm, 2006). If such physical investment affects TFP concurrently, then $ln(\theta)$ is potentially endogenous in (1.22).[34] I therefore turn to an instrumental variables (IV) Tobit model to establish the causal link from joint productivity to the degree of foreign ownership.

I implement the IV Tobit model in a two-step procedure following Smith and Blundell (1986) and Wooldridge (2002), in which residuals from first stage estimation are included in (1.22) and a standard Tobit is estimated at the second step. I estimate the first stage by ordinary least squares including the (log of) price cost-margin

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[32] Column (4) reports estimates from a random effects Tobit model to control for unobserved individual effects since unconditional fixed effects estimates are biased as is well known. Controlling for individual effects comes at a cost, though, because the random effects Tobit estimator requires strict exogeneity conditional on the unobserved effects. This assumption is unlikely to be satisfied in the present context as theory emphasizes the link between firm-specific characteristics and firm-level outcomes.

[33] I experimented with three additional methods to check the robustness of my results against the construction of the TFP measure. First, I used electricity use as a proxy for unobserved productivity shocks instead of raw materials in the Levinsohn-Petrin procedure. Second, I estimated equation (1.19) assuming there are two types of labor, skilled and unskilled, instead of one. Data on the number of non-production and production workers are used to represent skilled and unskilled labor, respectively. I estimated the production function with two types of labor first using electricity usage as a proxy, and then using raw materials. My results are robust to these alternative methods and they are available upon request.

[34] While the differences in the level of productivity between MNEs and domestic firms are well documented, the evidence from the few studies on whether there is a causal effect of foreign ownership on productivity is inconclusive. Using data from the British and Italian manufacturing industries, respectively, Harris and Robinson (2002) and Benfratello and Sembenelli (2006) find that foreigners acquire the most productive plants (cherry-picking) and that foreign ownership has no effect on productivity. In contrast, Arnold and Javorcik (2009) find that foreign acquisitions do lead to productivity improvements in Indonesian manufacturing, and Aitken and Harrison (1999) find that foreign equity participation is positively correlated with plant productivity, as measured by (log) output, in Venezuela. In a review of the literature, Navaretti and Venables (2004) argue: "... the evidence reported up to now supports a statistical association between foreign ownership and productivity, but not a causal link."

(PCM) at the plant level, which serves as the identifying exclusion restriction. The PCM is calculated as {(value added - total wages)/gross value of production} for each plant-year observation. The PCM captures the multinational's marginal costs and price-setting behavior and thus directly reflects its market power and profitability, which cannot be accounted for by physical inputs to production. These in turn are positively associated with firm-level productivity, which renders PCM a good proxy for $ln(\theta)$. In the data, the simple correlation between (log) PCM and (log) TFP is 0.39. Barbosa and Louri (2002) find, using plant level data from Portugal, that PCM does not affect multinationals' ownership preferences, which provides support for the exogeneity condition of the instrument.

Estimates from the IV Tobit model are reported in columns (5)-(7) of Table 1.5.[35] First stage results indicate that PCM is a highly significant predictor of joint productivity; a 10 percent increase in PCM is associated with around a 5 percent increase in TFP. Accounting for endogeneity does not affect my major findings and estimates at the second stage. Column (5) shows that a 10 percent increase in joint productivity leads to an 18 percent increase in foreign equity participation. Including further controls in columns (6) and (7), this estimate becomes 14 percent and 12 percent, respectively. Table 1.5 additionally reports the results of the Wald test of exogeneity for the two-step procedure, which indicate that endogeneity is a valid concern except for column (5). As a result, these estimates point to a robust and economically large effect of joint productivity on the degree of foreign ownership. Comparing the size of the estimates for all covariates, joint productivity is only second to plant size in determining foreign equity participation. As expected, capital and skill intensity as well as plant size unambiguously impact the degree of foreign

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[35] As a robustness check, I estimated the IV Tobit model using maximum likelihood as well. My results are unchanged using this alternative method.

ownership positively.

1.5.3 Match Quality and Selection

Why does the average degree of foreign ownership rise over time? In the model, multinationals enter a relationship with input suppliers if they receive a high enough productivity draw and they determine their level of equity participation depending on the noisy signal on this draw. Because they lock themselves in a long-lasting relationship upon the resolution of the uncertainty over joint productivity, multinationals choose higher shares of equity in a high productivity partnership. They are also predicted to increase their equity share if true productivity turns out to be better than what is implied by the noisy signal. If, on the other hand, they find themselves to be in a low productivity partnership after uncertainty is resolved, then they dissolve the match and engage in divestment. As low productivity matches dissolve with learning, divestment occurs at those partnerships with lower levels of foreign equity participation, thus producing the trend in Figure 1.3. This subsection tests whether the described selection mechanism is also at work empirically by using nonparametric and semi-parametric survival analysis.

I define divestment as constituting any reduction in foreign equity participation that exceeds 1 percentage point, including cases of plant closure by the multinational parent.[36] A reduction in foreign equity participation means the sale of equity shares back to the domestic supplier or a third party, which indicates that the multinational parent is unwilling to commit resources in line with its original stake as it perceives itself to be in a low productivity match. In the data, the median age (defined as the number of years that the newly established MNE has operated) of divestment is

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[36] The reason for choosing 1 percent for the definition is to sidestep any coding errors in the data and to capture the fact that any change in excess of 1 percent can have significant implications for the subsidiary, if for instance, the multinational parent decreases its stake from 51 percent to 49 percent.

3 years. I start by modeling the “hazard” of divestment by a strictly empirical and nonparametric approach that leaves out covariates that could affect the hazard rate, which is the well-known Kaplan-Meier estimator. Let T be the time until divestment occurs and a_m be the age of the MNE in year $m = 1$, ..., M; e.g. a_1 is the first year of production for the MNE. Then the survivor (no divestment) function at age a_m is given by:

$$S(a_m) = P(T > a_m) = \Pi_{r=1}^{m} P(T > a_r | T > a_{r-1}) \tag{1.23}$$

Now for each $r = 1$, ..., M, define N_r to be the number of MNEs in the “risk set” for interval r. That is, N_r is the number of MNEs that did not engage in divestment in the time interval $[a_{r-1}, a_r)$, so they are subject to the hazard of divestment during this period (age). Similarly, define D_r to be the number of MNEs that engaged in divestment in interval r. A consistent estimator of (1.23) at age a_m is then given by (Wooldridge, 2002):

$$\hat{S}(a_m) = \Pi_{r=1}^{m} \left[(N_r - D_r)/N_r\right]$$

The Kaplan-Meier estimator imposes minimal restrictions and assumes that the probability of divestment depends only on time. In the present context, it highlights the role that learning over time plays in determining survival/divestment. Figure 1.6 depicts the evolution of the Kaplan-Meier estimates of divestment. I divide MNEs into four groups of 25 percentile units according to their average productivity.[37] The figure displays the cumulative probability of divestment by age for the MNEs ranked by their percentile of productivity. The cumulative divestment functions for the four groups diverge over time, with the MNEs in the bottom 25^{th} and second 25^{th}

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[37] As a robustness check, I conducted the following nonparametric and semi-parametric analyses using the initial values of productivity at the MNEs as well. My results are unchanged with this alternative variable.

percentiles subject to higher divestment hazard throughout. MNEs in these two groups have around a one-third probability of divestment beyond age seven. A log-rank test for the equality of the divestment functions for these four groups returns a χ^2 value of 13.22 with an associated p-value of 0.004. When I control for time-invariant sector and/or year effects, the log-rank test essentially returns a p-value of 0. Coupled with Figure 1.6, these test statistics provide strong evidence that low productivity matches dissolve earlier than high productivity matches.

An important assumption of the Kaplan-Meier estimator is that all MNEs in the sample behave the same regardless of whether they have engaged in divestment or not. If those MNEs that experienced no divestment during the sample period behave differently from those that did, then the Kaplan-Meier estimator may return biased results. Additionally, there could be other factors that influence the probability of divestment, such as plant size, which are not controlled for in the non-parametric approach. In order to address these issues, I turn to a Cox proportional hazard model. Cox (1972) suggests a semi-parametric method of analyzing the impact of covariates on the hazard rate while handling censored cases (MNEs for which no divestment took place) and individual heterogeneity. Let the hazard function be given by:

$$\lambda(T_i) = exp(-\mathbf{x}_i'\beta)\lambda_0(T_i) \tag{1.24}$$

where λ_0 is the "baseline" hazard, which reflects individual heterogeneity, and $\mathbf{x}$ is a vector of covariates. Cox's partial likelihood estimator provides consistent estimates of β without specifying the form and the estimation of λ_0 individually. Since interest is on how match quality impacts the probability of divestment, the Cox model provides the best tradeoff between the purely non-parametric model and the more restrictive parametric models.

Table 1.6 presents the estimates of the model in (1.24) with different sets of controls. I report hazard ratios; a ratio above 1.0 means higher odds of divestment and hazard ratios below 1.0 are associated with decreased hazard of divestment. All estimations are stratified by sector and year, which allow for equal coefficients of the covariates across these pairings, but generate baseline hazards unique to each stratum. Hence, I guard against sectoral and economy-wide shocks in a given year that may render the baseline hazards for these pairs non-proportional.[38]

I find strong evidence that lower levels of productivity increase the probability of a match being dissolved between the multinational parent and its supplier. Columns (1) and (2) report the estimated effect of an MNE's time-invariant average productivity on the probability of divestment.[39] One unit decrease in average productivity in log terms is associated with between 35 percent and 27 percent higher hazard of divestment. Considering that one standard deviation of average productivity is about 1.42 in log terms, these estimates imply economically large and significant differences between the survival prospects of MNEs that lie at the opposite ends of the productivity distribution. For instance, using the more conservative estimate from column (2), an MNE at the 25^{th} percentile ($ln\overline{TFP}_i = -0.59$) is predicted to have about 44 percent higher hazard of divestment compared to an MNE at the 75^{th} percentile ($ln\overline{TFP}_i = 1.05$).

In columns (3)-(6), I check whether using a time-variant measure of joint productivity affects my results. Since the model implies that current levels of productivity affect subsequent divestment, year-to-year shocks to TFP can potentially influence

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[38] This could be a concern in the Turkish data as Turkey experienced two drastic financial crises in 1994 and 2001, which were accompanied by devaluation of the Turkish Lira and the contraction of nominal GDP by almost a quarter in both years.

[39] Using the time-invariant value of average productivity helps attenuate the yearly idiosyncratic shocks to TFP and can represent a more accurate estimate of the match-specific joint productivity that the multinational learns over time.

the estimated hazard. While joint productivity is still highly significant, a one unit decrease is now associated with between 20 percent and 14 percent higher hazard of divestment (columns (3) and (4), respectively). Controlling for firm-level random effects in column (5) decreases this estimate to 12 percent. The random effects Cox model has the advantage of accounting for within-firm correlation in the divestment hazard. Column (6) indicates that with the addition of further controls, firm-level TFP no longer affects the hazard of divestment significantly. These results suggest that divestment at MNEs occurs primarily at the cross-section through a process of learning about fixed match quality rather than at a longitudinal level through MNEs reacting to changes in year-to-year productivity. This is supported by the likelihood ratio tests of shared frailty in columns (5) and (6), which find a significant firm-level frailty effect. Table 1.6 also shows that a smaller plant size and lower skill intensity at the plant level increase the probability of divestment. Perhaps surprisingly, capital intensity has no effect on the prospects of survival, except in column (6). Lastly, the proportional hazard tests provide strong support for the model specification in all columns, except for column (6).

1.6 Conclusion

Using an almost exhaustive database of Turkish manufacturing plants, I conducted a detailed examination of the degree of vertical integration among multinationals operating in Turkey and uncovered some empirical regularities that are unknown in the literature. Motivated by these and earlier findings, I developed a multi-period model of foreign direct investment under uncertainty. I showed that there exists a nondegenerate distribution of foreign ownership in integrated firms regardless of industry and that the degree of foreign ownership rises over time. The multi-period model developed in this paper is also able to explain several empirical findings in the literature and can generate “cream-skimming.” An important point that emerges from the model is that the relative use of factors in production, and thus the amount of intrafirm trade, are directly linked to the level of integration with the parent foreign company. This implies that technology transfer within integrated firms is determined by the degree of foreign ownership and it takes place only gradually via intrafirm trade conditional on survival.

My empirical analysis on the relationship between productivity and the degree of foreign ownership has revealed the importance of within-sector heterogeneity in explaining the distribution of foreign equity participation across plants. I find that a 10 percent increase in plant-level TFP is associated with between 12 and 18 percent increase in foreign equity participation. While factor shares in the production technology are also important in predicting the degree of foreign ownership, the heterogeneity in plant-level productivities can better explain the investment decisions of multinationals. I also find that MNEs with lower levels of productivity are more likely to engage in divestment. As a result, my empirical analysis lends support to the selection mechanism described in the theoretical model. Further empirical analysis of how the degree of foreign ownership impacts intrafirm trade would be most welcome.

1.7 Appendix A

The Appendix contains some intermediate results and proofs of the propositions and theories that are mentioned in the body of the text.

1.7.1 Proof of Proposition 1

The proof consists of two parts. In the first part of the proof, I show that there exists a solution $\delta^* \in (0,\, 1)$ to the final good producer's problem. In the second part, I show that this optimal level of integration is unique. In order to simplify the analysis, I show these results for the optimal fraction of revenues that accrue to the final good producer, β_V^*. Recall that $\beta_V = \delta^\alpha(1-\beta)+\beta$. Since the choice of the level of integration, δ, uniquely determines the division rule of the surplus, β_V, it will be sufficient to pin down an optimal $\beta_V \in (0,\, 1)$. One can then back out $\delta^* \in (0,\, 1)$ from $\delta = [(\beta_V^* - \beta)/(1-\beta)]^{1/\alpha}$.[40]

Existence:

I rewrite the final good producer's problem of maximizing per-period profits in terms of β_V (I suppress the other arguments for notational simplicity):

$$\underset{\beta_V}{max}\, \pi(\beta_V) = X^{\frac{\mu-\alpha}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \psi(\beta_V) - w_N \left(\frac{\beta_V - \beta}{1-\beta}\right)^{\frac{\phi}{\alpha}} \tag{1.25}$$

where

$$\psi(\beta_V) = \alpha^{\frac{\alpha}{1-\alpha}} \left(\frac{\beta_V}{w_N}\right)^{\frac{\alpha\eta}{1-\alpha}} \left(\frac{1-\beta_V}{w_S}\right)^{\frac{\alpha(1-\eta)}{1-\alpha}} \left(1 - \alpha\eta\beta_V - \alpha(1-\eta)(1-\beta_V)\right).$$

The first order condition to this program yields:

$$\begin{aligned} \frac{\partial \pi(\beta_V)}{\partial \beta_V} &= \left[\frac{\alpha^\alpha X^{\mu-\alpha}\theta^\alpha}{w_N^{\alpha\eta} w_S^{\alpha(1-\eta)}}\right]^{\frac{1}{1-\alpha}} \left[\frac{\alpha \beta_V^{\frac{\alpha\eta}{1-\alpha}-1}(1-\beta_V)^{\frac{\alpha(1-\eta)}{1-\alpha}-1}}{(1-\alpha)}\right] \\ &\quad \times \left[\beta_V^2(2\eta-1) + \beta_V(2\eta(\alpha-\alpha\eta-1)) + \eta(1-\alpha+\alpha\eta)\right] \\ &\quad - \frac{\phi w_N}{\alpha(1-\beta)} \left(\frac{\beta_V-\beta}{1-\beta}\right)^{\frac{\phi-\alpha}{\alpha}} \\ &= 0 \end{aligned} \tag{1.26}$$

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[40] Notice also that the first order condition that defines the optimal level of integration, $\partial\pi(\delta)/\partial\delta = 0$, can be written as $(\partial\pi(\beta_V)/\partial\beta_V)(\partial\beta_V/\partial\delta) = 0$. The partial derivative of β_V with respect to δ is always non-zero, so that δ^* is defined by $\partial\pi(\beta_V)/\partial\beta_V = 0$.

For operating profits to have at least one local maximum $\beta_V \in (0,\, 1)$, we require $\partial\pi(\beta_V)/\partial\beta_V > 0$ as $\beta_V \to \beta$ (this is the case when $\delta \to 0$) and $\partial\pi(\beta_V)/\partial\beta_V < 0$ as $\beta_V \to 1$ (this is the case when $\delta \to 1$). First consider the case when $\beta_V \to 1$. The second term in (1.26) is clearly negative and the first term converges to zero when $\frac{\alpha(1-\eta)}{1-\alpha} - 1 > 0$. If $\frac{\alpha(1-\eta)}{1-\alpha} - 1 < 0$, then the sign of the quadratic equation in β_V in the square brackets becomes important as the first term in the expression tends to infinity. However, notice that the quadratic equation goes to $-1 + \eta(1 + \alpha - \alpha\eta)$ as $\beta_V \to 1$. Let $g(\eta) = -1 + \eta(1 + \alpha - \alpha\eta)$. It is easy to check that $g(\eta)$ is increasing in η and $g(0) = -1$ and $g(1) = 0$. Since η takes on values in the open interval $(0,\, 1)$, $g(\eta)$ is always negative.

Next consider $\beta_V \to \beta$. The second term in the first order condition vanishes since $\phi > \alpha$. The sign of the first order condition is then determined by the quadratic expression $\beta^2(2\eta - 1) + \beta(2\eta(\alpha - \alpha\eta - 1)) + \eta(1 - \alpha + \alpha\eta)$, which is required to be positive to show existence. For high enough values of η, this expression is positive for almost all $\beta \in (0,\, 1)$. Since I focus on high headquarter intensity industries in this paper, the existence of δ^* follows without much restriction on β.[41] For low headquarter intensity industries, however, the model requires the bargaining power parameter β to be low enough for vertical integration to arise. In particular, assume η is less than $\frac{1}{2}$ for low headquarter intensity industries; one can check that for $\eta < \frac{1}{2}$, β should also be less than $\frac{1}{2}$ for integration to arise in equilibrium. Figure 1.7 demonstrates the permissible set of β's for two industries, one with relatively high headquarter intensity and the other with relatively low headquarter intensity.

The intuition here comes from the tradeoff faced by the final good producer between maximizing the level of profits versus maximizing its share of the revenue when

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[41] Only very high values for β may reverse the sign of the quadratic expression in β.

it decides on the level of integration. By picking a higher degree of ownership, the final good producer grabs a bigger fraction of the revenue, but causes its manufacturing supplier to underinvest, which leads to a lower overall level of profits. As the headquarter intensity of the production line increases, the relative importance of the manufacturing supplier's input goes down. This means that the supplier's underinvestment has minimal effect on the overall level of profits when η is high, thereby tilting the final good producer's tradeoff in favor of a higher share of the revenue.

Notice that the final good producer always receives at least a fraction β of the revenue. In low η industries, its input is of relatively low importance, so a high bargaining power β already compensates it for its investment. Any additional increase in the final good producer's share of the revenue will lower overall profits. In such industries, one needs the manufacturing supplier to have the upper hand in the ex post bargaining stage, i.e. $1-\beta$ to be high, for vertical integration to occur. In high η industries, however, the relatively high importance of its input leads the final good producer to claim a larger fraction of the revenue even if it has a high bargaining power to start with. Hence, the permissible set of β's enlarges with headquarter intensity.

Uniqueness:

I now prove that the optimal level of integration is unique. A sufficient condition for this result is that operating profits are strictly quasi-concave in δ. To get this result, I again work with β_V and I show the strict concavity of the profit function in δ. Note that β_V is a strictly concave function of δ, since $\beta_V = \delta^{\alpha}(1-\beta)+\beta$ and $\alpha \in (0,\, 1)$, and profits are strictly increasing in β_V by the model assumptions. Hence, one needs only to show that profits are concave in β_V to establish strict concavity in

δ.[42]

Since $\phi > \alpha$, the costs of organizational form in (1.25) are convex. Subtracting a convex function from a concave function returns another concave function; I therefore check whether $X^{\frac{\mu-\alpha}{1-\alpha}}\theta^{\frac{\alpha}{1-\alpha}}\psi(\beta_V)$ in (1.25) is concave in β_V. The second order condition to the final good producer's problem is given by:

$$\begin{aligned} \frac{\partial^2\pi(\beta_V)}{\partial\beta_V^2} = \; & \frac{\alpha}{(1-\alpha)^2}\left[\frac{X^{\mu-\alpha}\theta^\alpha\alpha^\alpha}{w_N^{\alpha\eta}w_S^{\alpha(1-\eta)}}\right]^{\frac{1}{1-\alpha}}\left[\beta_V^{\frac{\alpha\eta}{1-\alpha}-2}(1-\beta_V)^{\frac{\alpha(1-\eta)}{1-\alpha}-2}\right] \\ & \times[\beta_V^3(1-2\eta)\alpha+\beta_V^2(1+\alpha\eta-\alpha)(4\alpha\eta-1) \\ & +\beta_V(1+\alpha\eta-\alpha)(2-3\alpha-2\alpha\eta)\eta+(1+\alpha\eta-\alpha)(\alpha+\alpha\eta-1)\eta] \\ & -\frac{\phi w_N(\phi-\alpha)}{\alpha^2(1-\beta)^2}\left(\frac{\beta_V-\beta}{1-\beta}\right)^{\frac{\phi-\alpha}{\alpha}-1} \end{aligned} \tag{1.27}$$

where the first term is the second derivative of $X^{\frac{\mu-\alpha}{1-\alpha}}\theta^{\frac{\alpha}{1-\alpha}}\psi(\beta_V)$ with respect to β_V.

In order for operating profits to be concave in β_V, it is sufficient for the value of the cubic equation in β_V that is expressed in the square brackets to be negative.[43] The sign of this expression is determined by the values of the parameters in the model. In Figure 1.8, I plot out the cubic equation for various values of α and η. As can be seen from the figure, the cubic equation is everywhere less than zero whenever $\alpha < \frac{1}{2}$, regardless of what value η takes. When $\alpha > \frac{1}{2}$, the curvature of the cubic equation is reversed; as a result, the value of the equation becomes only slightly positive when

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[42] This is relatively easy to see. Let D be a convex set and $f : D \to \mathbb{R}$ be strictly concave. Let B contain $f(D)$ and $g : B \to \mathbb{R}$ be concave and strictly increasing. Consider any a, $b \in D$ and $t \in [0, 1]$. Let $d = ta + (1-t)b$. The strict concavity of f means that:

$$f(d) = f\left(ta + (1-t)b\right) > tf(a) + (1-t)f(b)$$

Then $g(f(d))$ is strictly concave since:

$$g\left(f(d)\right) > g\left(tf(a) + (1-t)f(b)\right) \geq tg\left(f(a)\right) + (1-t)g\left(f(b)\right)$$

where the first inequality follows from g being strictly increasing and the second (weak) inequality from its concavity.

[43] Note that this is more restrictive than necessary. The second term in (1.27) is unambiguously negative since $\phi > \alpha$. Negativity of the first term ensures that $\partial^2\pi(\beta_V)/\partial\beta_V^2 < 0$. However, the second order condition could still be negative when the first term is positive, depending on the relative sizes of the two terms.

evaluated at the extreme end values of β_V. This may occur, for instance, when both α and η are sufficiently high. However, recall that β_V is the share of revenue that accrues to the final good producer, which has a lower bound of β, and $1 - \beta_V$ is the share of revenue that accrues to the manufacturing input supplier. As a result, one can comfortably conjecture that the value of β_V in equilibrium will be away from the end points of 0 and 1. This establishes the concavity of the profit function in β_V. (Recall that α governs the elasticity of substitution between any two varieties within a sector through the CES function for aggregate consumption.)

1.7.2 Proof of Proposition 2

In order to show the result, I again work with β_V instead of working with δ directly. Since $\frac{\partial \delta^*}{\partial \theta} = \left(\frac{\partial \delta^*}{\partial \beta_V(\delta)}\right)\left(\frac{\partial \beta_V(\delta)}{\partial \theta}\right)$ and β_V rises monotonically in δ^*, it is sufficient to sign the partial derivative $\partial \beta_V(\delta)/\partial \theta$.

The final good producer's optimal share of revenues is implicitly defined by the first order condition in (1.26). Define the function $g(\beta_V, \theta) = \frac{\partial \pi(\beta_V)}{\partial \beta_V}$. Using the implicit function theorem:

$$\frac{\partial \beta_V}{\partial \theta} = -\frac{\partial g(\beta_V, \theta)/\partial \theta}{\partial g(\beta_V, \theta)/\partial \beta_V}$$

Notice that $\partial g(\beta_V, \theta)/\partial \beta_V$ is simply the second order condition given by (1.27). I show in the proof of Proposition 1 that (1.27) is negative. Now consider $\partial g(\beta_V, \theta)/\partial \theta$. This is given by:

$$\begin{aligned}\frac{\partial g(\beta_V, \theta)}{\partial \theta} &= \frac{\alpha}{1-\alpha}\left[\frac{1}{\theta}\frac{\alpha^\alpha X^{\mu-\alpha}}{w_N^{\alpha\eta} w_S^{\alpha(1-\eta)}}\right]^{\frac{1}{1-\alpha}}\left[\frac{\alpha \beta_V^{\frac{\alpha\eta}{1-\alpha}-1}(1-\beta_V)^{\frac{\alpha(1-\eta)}{1-\alpha}-1}}{(1-\alpha)}\right] \\ &\quad \times \left[\beta_V^2(2\eta - 1) + \beta_V(2\eta(\alpha - \alpha\eta - 1)) + \eta(1 - \alpha + \alpha\eta)\right]\end{aligned}$$

Since $\psi(\beta_V, \eta)$ is assumed to be increasing in β_V in high headquarter intensity industries, we have[44]:

$$\begin{aligned}\frac{\partial \psi(\beta_V, \eta)}{\partial \beta_V} &= \left[\frac{\alpha^{\alpha}}{w_N^{\alpha\eta} w_S^{\alpha(1-\eta)}}\right]^{\frac{1}{1-\alpha}} \left[\frac{\alpha \beta_V^{\frac{\alpha\eta}{1-\alpha}-1}(1-\beta_V)^{\frac{\alpha(1-\eta)}{1-\alpha}-1}}{(1-\alpha)}\right] \\ &\quad \times \left[\beta_V^2(2\eta-1) + \beta_V(2\eta(\alpha-\alpha\eta-1)) + \eta(1-\alpha+\alpha\eta)\right] > 0\end{aligned}$$

It is then straightforward to see that $\frac{\partial g(\beta_V, \theta)}{\partial \theta} > 0$. Hence, the partial derivative $\partial \beta_V / \partial \theta$ is positive as a result of the implicit function theorem, which establishes that δ^* is strictly increasing in θ.

1.7.3 Proof of Intermediate Result

In the body of the paper, I made the assertion that the level of profits required by the final good producer to stay in the match rises from the first period to the second; i.e. $\pi(\underline{\theta}) > \pi(\tilde{\underline{\theta}})$. I now show formally why this holds.

Using (1.10) and (1.11) in equation (1.15), and adding and subtracting like terms where necessary, we get:

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[44] To see this result, note that the quadratic term in β_V in square brackets goes to $(\beta_V - 1)^2$ as $\eta \to 1$; i.e. for high enough values of headquarter intensity, the quadratic expression is positive.

$$
\begin{aligned}
\frac{r+\lambda}{r+\lambda-1}\pi(\underline{\theta}) &= \pi(\tilde{\underline{\theta}}) + \frac{1}{r+\lambda}\int_{-\infty}^{\infty} J(\theta')dP(\theta'|\tilde{\gamma},\tilde{b}) \\
\frac{r+\lambda}{r+\lambda-1}\pi(\underline{\theta}) &= \pi(\tilde{\underline{\theta}}) + \frac{1}{r+\lambda}\int_{-\infty}^{\underline{\theta}} \frac{1}{r}QdP(\theta'|\tilde{\gamma},\tilde{b}) \\
&\quad + \frac{1}{r+\lambda}\int_{\underline{\theta}}^{\infty} \frac{r+\lambda}{r+\lambda+1}\pi(\theta')dP(\theta'|\tilde{\gamma},\tilde{b}) \\
\frac{r+\lambda}{r+\lambda-1}\pi(\underline{\theta}) &= \pi(\tilde{\underline{\theta}}) + \frac{\pi(\underline{\theta})}{r+\lambda-1}\int_{-\infty}^{\underline{\theta}} dP(\theta'|\tilde{\gamma},\tilde{b}) \\
&\quad + \frac{1}{r+\lambda-1}\int_{\underline{\theta}}^{\infty} \pi(\theta')dP(\theta'|\tilde{\gamma},\tilde{b}) \\
(r+\lambda)\pi(\underline{\theta}) &= (r+\lambda-1)\pi(\tilde{\underline{\theta}}) + \pi(\underline{\theta})\int_{-\infty}^{\underline{\theta}} dP(\theta'|\tilde{\gamma},\tilde{b}) \\
&\quad + \int_{\underline{\theta}}^{\infty} \pi(\theta')dP(\theta'|\tilde{\gamma},\tilde{b}) \\
(r+\lambda-1)\left[\pi(\underline{\theta}) - \pi(\tilde{\underline{\theta}})\right] &= \pi(\underline{\theta})\int_{-\infty}^{\underline{\theta}} dP(\theta'|\tilde{\gamma},\tilde{b}) + \int_{\underline{\theta}}^{\infty} \pi(\theta')dP(\theta'|\tilde{\gamma},\tilde{b}) - \pi(\underline{\theta}) \\
(r+\lambda-1)\left[\pi(\underline{\theta}) - \pi(\tilde{\underline{\theta}})\right] &= \pi(\underline{\theta})\int_{-\infty}^{\underline{\theta}} dP(\theta'|\tilde{\gamma},\tilde{b}) + \int_{\underline{\theta}}^{\infty} \pi(\theta')dP(\theta'|\tilde{\gamma},\tilde{b}) \\
&\quad - \int_{-\infty}^{\underline{\theta}} \pi(\underline{\theta})dP(\theta'|\tilde{\gamma},\tilde{b}) - \int_{\underline{\theta}}^{\infty} \pi(\underline{\theta})dP(\theta'|\tilde{\gamma},\tilde{b}) \\
\pi(\underline{\theta}) - \pi(\tilde{\underline{\theta}}) &= \frac{1}{r+\lambda-1}\int_{\underline{\theta}}^{\infty} \left[\pi(\theta') - \pi(\underline{\theta})\right] dP(\theta'|\tilde{\gamma},\tilde{b}) \\
\pi(\underline{\theta}) - \pi(\tilde{\underline{\theta}}) &> 0
\end{aligned}
$$

The last line can be easily seen as the right hand side of the equation is certainly positive due to the fact that $\pi(.)$ is an increasing function of θ.

1.7.4 Proof of Theorem 1

I check Blackwell's sufficient conditions to establish the existence of an appropriate operator and show its properties. Let T denote the operator which defines V as the fixed point of the equation (1.17), so that $V = TV$.

First, T transforms bounded and continuous functions into other bounded and continuous functions. Boundedness follows since the profit function in terms of the posterior expected value of productivity, $\pi(\tilde{\theta})$, is bounded. To see this, note that from equation (1.7), the profit function is bounded from below trivially by the fixed cost (when $\theta = 0$). The support of θ is $(0, \infty)$, but as θ rises, Proposition 2 implies that the optimal level of integration, and thus the final good producer's share of revenue,β_V, should also rise. From (1.8), one can see that this negates the initial effect on profits from the rise in θ. As β_V tends to 1, operating profits collapse to zero. Continuity follows in a more straightforward manner as the profit function is continuous in $\tilde{\theta}$.

Second, consider $V(\tilde{\theta}) \geq W(\tilde{\theta})$ from the set of bounded and continuous real-valued functions on θ. Then:

$$\begin{aligned}
TV &= max\left\{\pi(\tilde{\theta}) + \frac{1}{r+\lambda}\int max\left[\frac{r+\lambda}{r+\lambda-1}\pi(\theta),\, \frac{1}{r}\int V(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\, \hat{b})\right] dP(\theta|\tilde{\gamma},\, \tilde{b}),\right.\\
&\qquad \left.\frac{1}{r}\int V(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\, \hat{b})\right\}\\
&\geq max\left\{\pi(\tilde{\theta}) + \frac{1}{r+\lambda}\int max\left[\frac{r+\lambda}{r+\lambda-1}\pi(\theta),\, \frac{1}{r}\int W(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\, \hat{b})\right] dP(\theta|\tilde{\gamma},\, \tilde{b}),\right.\\
&\qquad \left.\frac{1}{r}\int W(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\, \hat{b})\right\}\\
&= TW
\end{aligned}$$

This establishes the monotonicity of T. For Blackwell's other sufficient condition, we have:

$$\begin{aligned}
T(V+c) &= max \\
&\left\{\pi(\tilde{\theta}) + \frac{1}{r+\lambda}\int max\left[\frac{r+\lambda}{r+\lambda-1}\pi(\theta),\, \frac{1}{r}\int\left\{V(\tilde{\theta}')+c\right\}dG(\tilde{\theta}'|\hat{\gamma},\,\hat{b})\right]dP(\theta|\tilde{\gamma},\,\tilde{b}),\right. \\
&\left.\frac{1}{r}\int\left\{V(\tilde{\theta}')+c\right\}dG(\tilde{\theta}'|\hat{\gamma},\,\hat{b})\right\} \\
&= max \\
&\left\{\pi(\tilde{\theta}) + \frac{1}{r+\lambda}\int max\left[\frac{r+\lambda}{r+\lambda-1}\pi(\theta),\, \frac{1}{r}\int V(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\,\hat{b}) + \frac{c}{r}\right]dP(\theta|\tilde{\gamma},\,\tilde{b}),\right. \\
&\left.\frac{1}{r}\int V(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\,\hat{b}) + \frac{c}{r}\right\} \\
&= max \\
&\left\{\pi(\tilde{\theta}) + \frac{1}{r+\lambda}\int max\left[\frac{r+\lambda}{r+\lambda-1}\pi(\theta),\, \frac{1}{r}\int V(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\,\hat{b})\right]dP(\theta|\tilde{\gamma},\,\tilde{b}),\right. \\
&\left.\frac{1}{r}\int V(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\,\hat{b})\right\} + \frac{c}{r} \\
&= TV + \frac{c}{r}
\end{aligned}$$

Hence, T is a contraction operator with modulus $1/r$ which gives us that the functional equation in (1.17) has a unique fixed point in the space of bounded and continuous functions.

1.7.5 Proof of Proposition 3

Since the optimal level of integration is strictly increasing in the level of productivity due to Proposition 2, we need only to show that the average productivity in the second period is greater than in the first period. The rest of the proof closely follows Ljungqvist and Sargent (2004).

The mean values of productivity in period 1 and in period 2 are calculated using Bayes rule. The probability that a previously unmatched multinational offers a contract to its supplier in the first period is given by $\int_{\underline{\tilde{\theta}}}^{\infty} dG(\tilde{\theta}|\hat{\gamma},\,\hat{b})$. The probability that a previously unmatched multinational offers a contract in the first period *and* updates it in the second period is given by: $\int_{\underline{\tilde{\theta}}}^{\infty}\int_{\underline{\theta}}^{\infty} dP(\theta|\tilde{\gamma},\, \tilde{b})dG(\tilde{\theta}|\hat{\gamma},\, \hat{b})$. Following Bayes rule, average productivity in period 1 and period 2 is respectively given by:

$$\overline{\tilde{\theta}}_1 = \frac{\int_{\underline{\tilde{\theta}}}^{\infty} \tilde{\theta} dG(\tilde{\theta}|\hat{\gamma},\, \hat{b})}{\int_{\underline{\tilde{\theta}}}^{\infty} G(\tilde{\theta}|\hat{\gamma},\, \hat{b})}$$

$$\overline{\theta}_2 = \frac{\int_{\underline{\tilde{\theta}}}^{\infty}\int_{\underline{\theta}}^{\infty} \theta dP(\theta|\tilde{\gamma},\, \tilde{b})dG(\tilde{\theta}|\hat{\gamma},\, \hat{b})}{\int_{\underline{\tilde{\theta}}}^{\infty}\int_{\underline{\theta}}^{\infty} dP(\theta|\tilde{\gamma},\, \tilde{b})G(\tilde{\theta}|\hat{\gamma},\, \hat{b})}$$

Using the fact that $\tilde{\theta} = \int_{b}^{\infty} \theta dP(\theta|\tilde{\gamma},\, \tilde{b})$, one gets:

$$\begin{aligned}
\overline{\tilde{\theta}}_1 &= \frac{\int_{\underline{\tilde{\theta}}}^{\infty}\int_{b}^{\infty} \theta dP(\theta|\tilde{\gamma},\, \tilde{b})dG(\tilde{\theta}|\hat{\gamma},\, \hat{b})}{\int_{\underline{\tilde{\theta}}}^{\infty} G(\tilde{\theta}|\hat{\gamma},\, \hat{b})} \\
&= \frac{\int_{\underline{\tilde{\theta}}}^{\infty}\int_{b}^{\underline{\theta}} \theta dP(\theta|\tilde{\gamma},\, \tilde{b})dG(\tilde{\theta}|\hat{\gamma},\, \hat{b}) + \overline{\theta}_2 \int_{\underline{\tilde{\theta}}}^{\infty}\int_{\underline{\theta}}^{\infty} dP(\theta|\tilde{\gamma},\, \tilde{b})dG(\tilde{\theta}|\hat{\gamma},\, \hat{b})}{\int_{\underline{\tilde{\theta}}}^{\infty} G(\tilde{\theta}|\hat{\gamma},\, \hat{b})} \\
&< \frac{\int_{\underline{\tilde{\theta}}}^{\infty} \left\{\overline{\theta} P(\overline{\theta}|\tilde{\gamma},\, \tilde{b}) + \overline{\theta}_2 \left[1 - P(\overline{\theta}|\tilde{\gamma},\, \tilde{b}\right]\right\} dG(\tilde{\theta}|\hat{\gamma},\, \hat{b})}{\int_{\underline{\tilde{\theta}}}^{\infty} G(\tilde{\theta}|\hat{\gamma},\, \hat{b})} \\
&< \overline{\theta}_2
\end{aligned}$$

Thus, average productivity rises over time which leads to a greater degree of foreign ownership at the average integrated firm.

1.7.6 Proof of Proposition 4

In the text.

1.7.7 Proof of Proposition 5

In the text.

Table 1.1: Presence of Multinationals in Turkish Manufacturing

	1993	1994	1995	1996	1997	1998	1999	2000	2001
No. of MNEs	251	264	277	282	308	338	353	343	341
Total No. of Plants	5,682	5,982	6,466	6,888	7,322	7,855	7,557	7,385	6,950
MNE Presence (%)	4.42	4.41	4.28	4.09	4.21	4.30	4.67	4.64	4.91

(a) Multinational Presence by Year

		Plant-Year Obs:		*MNE Presence:*
ISIC Code	Sector	MNE	Total	(%)
311	Food	235	6,764	3.47
312	Other Food	116	1,978	5.86
313	Beverage	43	657	6.54
314	Tobacco	53	217	24.42
321	Textiles	175	10,605	1.65
322	Wearing Apparel	199	7,040	2.83
323	Leather	1	787	0.13
324	Footwear	3	693	0.43
331	Wood Products	10	1,128	0.89
332	Furniture	7	935	0.75
341	Paper Products	36	1,009	3.57
342	Printing and Publishing	11	1,166	0.94
351	Industrial Chemicals	74	602	12.29
352	Other Chemicals	294	1,831	16.06
353	Petroleum Refineries	8	63	12.70
354	Other Petroleum	67	229	29.26
355	Rubber Products	54	812	6.65
356	Other Plastic Products	103	2,564	4.02
361	Pottery, China, Earthenware	11	278	3.96
362	Glass Products	43	524	8.21
369	Non-metallic Mineral Products	156	3,649	4.28
371	Iron and Steel	46	1,697	2.71
372	Non-ferrous Metal	23	728	3.16
381	Fabricated Metal Products	147	5,032	2.92
382	Non-electrical Machinery	175	4,158	4.21
383	Electrical Machinery	285	2,809	10.15
384	Transport Equipment	293	2,821	10.39
385	Scientific and Optical Equipment	48	628	7.64
390	Other Manufacturing	41	683	6.00

(b) Multinational Presence by Sector

Notes: An MNE is defined as a plant with any level of foreign ownership share. MNE presence is the ratio of the number of MNE observations to the total number of observations. Industry classification follows the International Standard Industry Classification System (ISIC) Rev.2 at the 3-digit level.

Table 1.2: Summary Statistics on Firm-Level Variables

	Obs	Mean	Std Dev	Intra-sector Std Dev (%)
TFP	58,845	-0.631	1.247	0.828
Capital Intensity	59,137	-1.082	1.676	0.973
Skill Intensity	54,248	-1.557	0.954	0.909
Employment	59,127	4.010	1.119	0.971
Electric Use	59,077	-4.471	1.326	0.885

(a) Intra-Sector Heterogeneity

	TFP	Capital Intensity	Skill Intensity	Employment	Electric Use
TFP	1.000				
Capital Intensity	-0.075	1.000			
Skill Intensity	0.115	0.165	1.000		
Employment	0.272	0.114	0.049	1.000	
Electric Use	0.053	0.340	0.101	0.209	1.000

(b) Correlations Across Firm-Level Variables

Notes: All variables are in logs. Intra-sector Std Dev (%) refers, for each variable, to the ratio between the mean standard deviation within ISIC 3-digit sectors and the overall standard deviation. The calculation of TFP estimates are described in the text. Capital Intensity is the ratio of the stock of capital to employment in any given year. Skill Intensity is the ratio of non-production workers to production workers. Employment is the average number of workers at a plant over a given year. Electric Use is the yearly consumption of electricity per worker. Capital Intensity and Electric Use are in billions of Turkish Liras and deflated by 1990 prices.

Table 1.3: Summary Statistics (Means) by Year and Ownership

Year	TFP	Employment	Output	Value Added	Capital Intensity
Multinational Plants					
1993	4.7	419.0	2167.4	1018.1	2.4
1994	5.0	380.2	1698.8	792.0	2.6
1995	4.6	368.3	2007.2	896.1	2.5
1996	5.4	397.8	2051.3	933.8	2.7
1997	4.1	392.6	2175.8	1013.3	2.9
1998	6.0	369.4	1944.0	840.9	2.8
1999	6.2	352.3	1907.0	856.3	2.8
2000	5.7	371.5	2269.9	927.4	2.9
2001	5.9	378.8	2207.1	948.1	3.1
Domestic Plants					
1993	1.4	126.2	299.2	127.3	1.7
1994	1.3	117.2	272.0	112.3	1.7
1995	1.2	114.8	283.7	110.1	1.6
1996	1.2	116.3	270.9	101.4	1.7
1997	1.2	118.0	294.2	113.6	1.5
1998	1.2	115.4	282.0	110.0	1.6
1999	1.4	112.4	282.2	109.4	1.8
2000	1.4	114.7	298.4	106.0	1.5
2001	1.4	113.7	301.3	109.4	1.5

Notes: An MNE is defined as a plant with any level of foreign ownership share. Employment is the average number of workers at a plant over a given year. Output and Value Added are defined as in the text and in Data Appendix. Capital Intensity is the ratio of the stock of capital to employment in any given year. Output, Value Added, and Capital Intensity are in billions of Turkish Liras and deflated by 1990 prices. The calculation of TFP estimates are described in the text.

Table 1.4: The Determinants of the Level of Foreign Ownership, Sector- and Firm-Level Factors

	(1)	(2)	(3)	(4)	(5)
Dependent Variable: Foreign Equity Participation, $y_{i,t}$ (%)					
Joint Productivity,	0.266***		0.248***		0.223***
$ln\,TFP_{i,t}$	(0.113)		(0.110)		(0.109)
Sector-Level Capital Intensity,		0.009	0.013		
$ln\,(K/L)_{g,t}$		(0.257)	(0.149)		
Sector-Level Skill Intensity,		0.224***	0.187***		
$ln\,(S/L)_{g,t}$		(0.357)	(0.202)		
Firm-Level Capital Intensity,				0.249***	0.257***
$ln\,(K/L)_{i,t}$				(0.080)	(0.083)
Firm-Level Skill Intensity,				0.270***	0.232***
$ln\,(S/L)_{i,t}$				(0.124)	(0.128)
Year Effects	Yes	Yes	Yes	Yes	Yes
$-ln\,L$	20,178	20,660	19,895	19,702	19,016
$\hat{\sigma}$	157.316	159.725	153.120	148.876	143.284
R^2	0.031	0.019	0.033	0.053	0.079
Observations	58,845	59,137	58,845	54,248	53,966

Notes: This table reports estimates of (1.20). Standardized "beta" coefficients are reported; robust standard errors for the marginal effects after Tobit are given in parentheses and clustered at the sector level in column (2) and at the firm level in the remaining columns; *, **, *** indicate significance at the 10%, 5%, and 1% level, respectively. Sector- and Firm-Level Capital and Skill Intensity measures are defined at the ISIC 4-digit level. Variable definitions and the calculation of R^2 are described in the text. $-ln\,L$ is the negative of the log pseudolikelihood and $\hat{\sigma}$ is the estimated standard error of the fitted model.

Table 1.5: Tobit Results for the Effect of Joint Productivity on the Level of Foreign Ownership

	Tobit			RE Tobit	IV Tobit		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable: Foreign Equity Participation, $y_{i,t}$ (%)							
ln Joint Productivity	1.669*** (0.123)	1.809*** (0.135)	1.370*** (0.129)	0.158*** (0.044)	1.809*** (0.219)	1.384*** (0.218)	1.180*** (0.235)
ln Capital Intensity		1.023*** (0.092)	0.937*** (0.097)	0.511*** (0.046)		1.038*** (0.099)	0.922*** (0.107)
ln Skill Intensity		1.085*** (0.130)	1.146*** (0.132)	0.457*** (0.058)		1.144*** (0.141)	1.165*** (0.144)
ln Plant Size			1.469*** (0.119)	0.973*** (0.060)			1.601*** (0.142)
ln Electric Use			-0.126 (0.113)	0.027 (0.043)			-0.085 (0.119)
Model Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$-ln\, L$	19,364	18,438	17,994	13,060	14,925	14,199	13,874
$\hat{\sigma}$	146.159	135.031	129.700		144.419	132.426	127.473
Wald Test (p-value)					0.652	0.001	0.045
						First Stage	
Dependent Variable: *ln* Joint Productivity							
ln Price-Cost Margin					0.518*** (0.004)	0.532*** (0.004)	0.519*** (0.004)
R^2					0.538	0.590	0.666
Observations	58,845	53,966	53,917	53,917	44,826	41,001	40,972

Notes: This table reports estimates of (1.22). Marginal effects conditional on foreign acquisition are reported, except for the first stage in IV Tobit. Model effects include year and sector effects in all columns, and additionally unobserved effects in column (4). $-ln\, L$ is the negative of the log likelihood of the fitted model and $\hat{\sigma}$ is the estimated standard error of the fitted model. Wald Test is the test of exogeneity for two-step IV Tobit, p-value reported (see Wooldridge (2002)). Variable definitions and sources are described in the text. All standard errors are corrected for heteroskedasticity, clustered at the firm level. Coefficients are given in the first line; standard errors in parentheses; *, **, *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table 1.6: Cox Regression Results for the Hazard of Divestment

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable: Hazard Rate of Divestment						
Average Joint Productivity, $ln\,\overline{TFP}_i$	0.652***	0.733***				
	(0.048)	(0.059)				
Joint Productivity, $ln\,TFP_{i,\,t}$			0.793***	0.855***	0.878***	0.931
			(0.045)	(0.053)	(0.053)	(0.056)
Capital Intensity, $ln\,(K/L)_{i,\,t}$		0.952		0.951		0.812***
		(0.040)		(0.040)		(0.050)
Skill Intensity, $ln\,(S/L)_{i,\,t}$		0.877*		0.801***		0.745***
		(0.063)		(0.056)		(0.064)
Plant Size, $ln\,(L)_{i,\,t}$		0.811***		0.781***		0.641***
		(0.041)		(0.038)		(0.050)
Model Effects	Yes	Yes	Yes	Yes	Yes	Yes
Shared Frailty					Yes	Yes
$-ln\,L$	865.087	832.313	832.153	796.620	2,398.292	2,322.029
Proportional Hazards Test, χ^2	0.20	2.96	0.19	2.64	0.53	27.01
(p-value)	(0.657)	(0.565)	(0.667)	(0.620)	(0.465)	(0.000)
LR Test of Shared Frailty, χ^2					123.35	97.09
(p-value)					(0.000)	(0.000)
Observations	2,674	2,649	2,593	2,572	2,593	2,572

Notes: This table reports estimates of (1.24). Model effects control for sector and year effects in all columns. Shared frailty controls for firm-level effects. Hazard ratios are given in the first line; robust standard errors in parentheses; *, **, *** indicate significance at the 10%, 5%, and 1% level, respectively. Variable definitions are in the text. $-ln\,L$ is the negative of the log likelihood, and LR test of Shared Frailty tests for the existence of a significant firm-level frailty effect.

Figure 1.1: Distribution of Foreign Ownership in the Pooled Sample

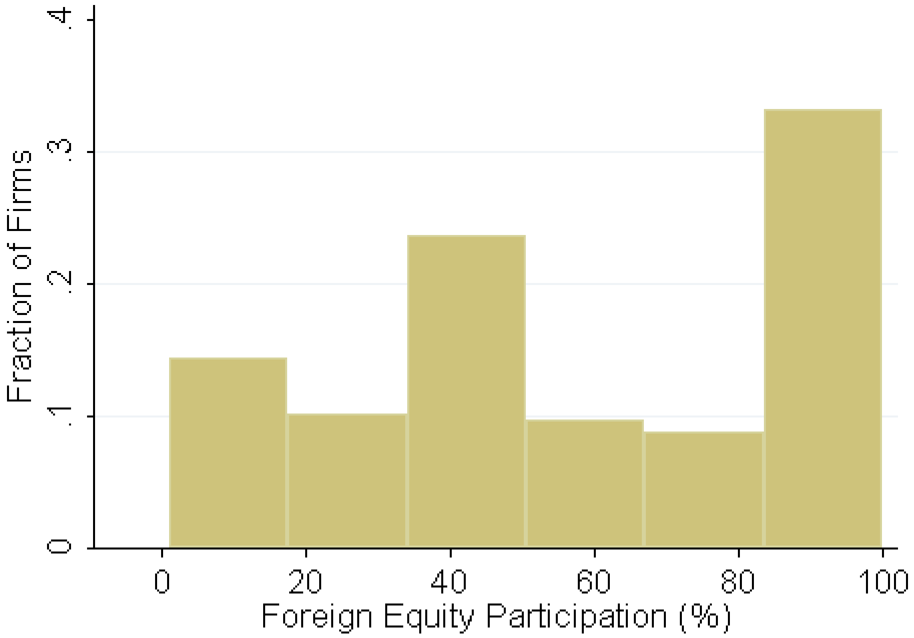
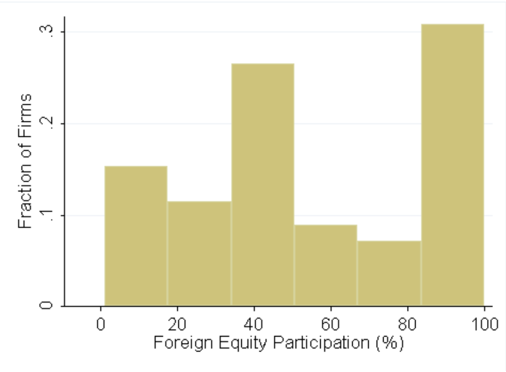
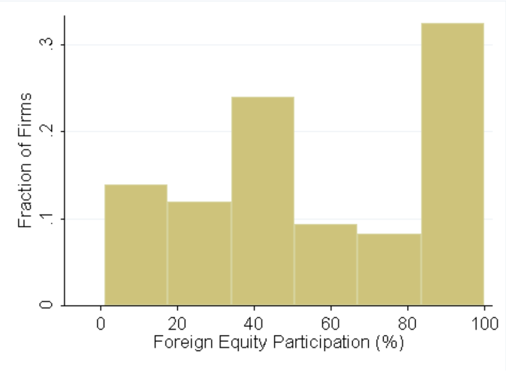


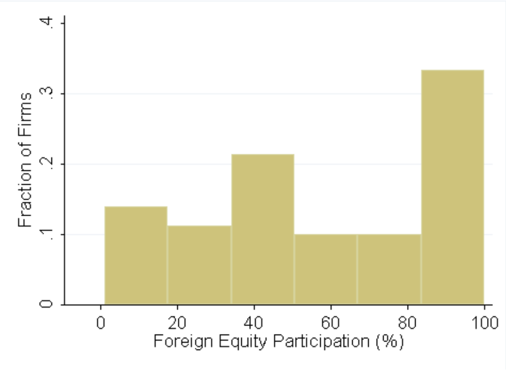
Figure 1.2: Distribution of Foreign Ownership by Age



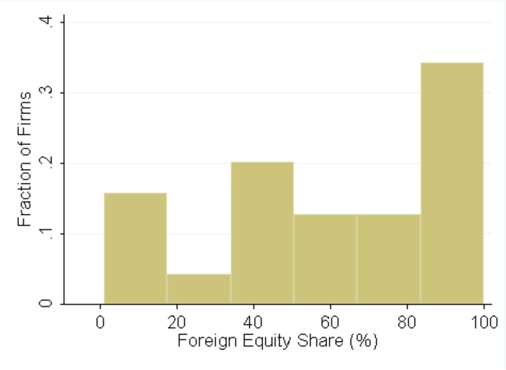
Age 1:



Age 3:



Age 5:



Age 7:

Figure 1.3: Average Degree of Foreign Ownership by Age

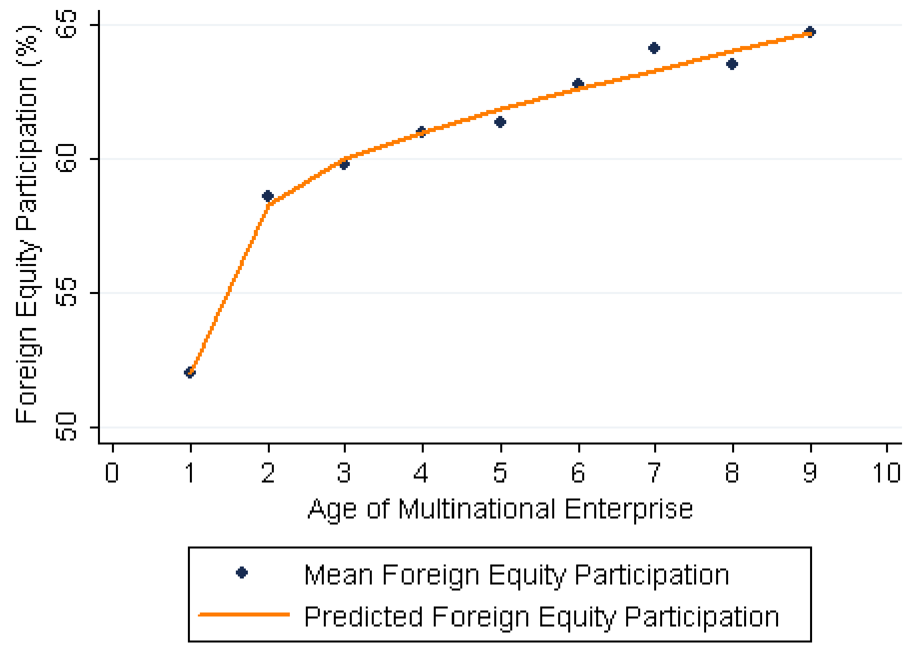
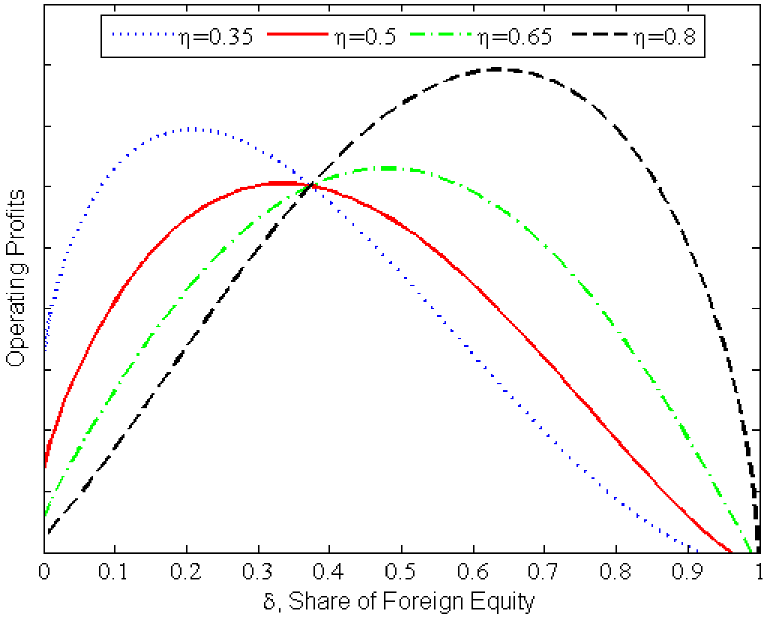
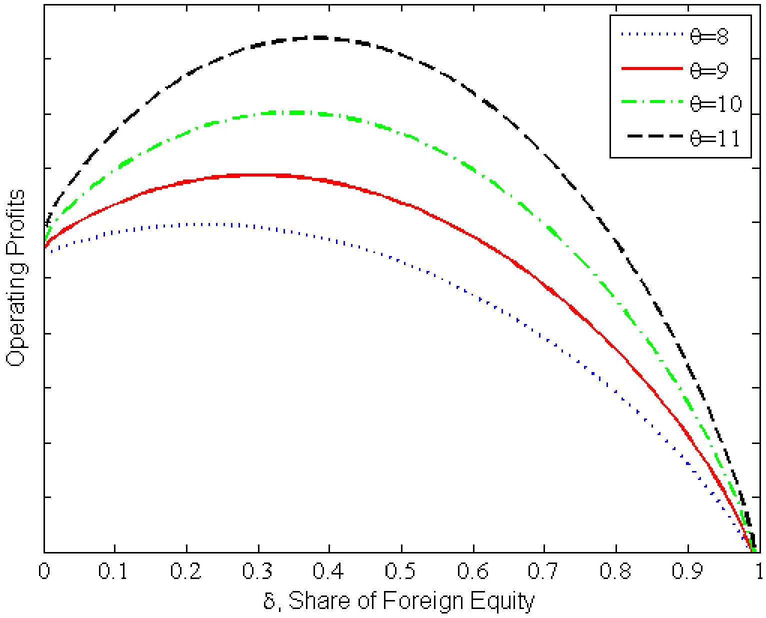


Figure 1.4: Operating Profits and the Level of Integration



(a) Different Headquarter Intensities

Notes: This figure simulates the behavior of the operating profits function in (1.7) for different values of headquarter intensity, η. The parameter values used in the simulation are: $\beta = 0.1$, $\alpha = 0.75$, $\mu = 0.4$, $\theta = 30$, $X = 10$, $\phi = 0.8$, $w_N = 1.1$, and $w_S = 1$.



(b) Different Match Qualities

Notes: This figure simulates the behavior of the operating profits function in (1.7) for different values of the match quality, θ. The parameter values used in the simulation are: $\beta = 0.1$, $\alpha = 0.7$, $\mu = 0.4$, $\eta = 0.7$, $X = 10$, $\phi = 0.8$, $w_N = 1.1$, and $w_S = 1$.

Figure 1.5: Optimal Policy in Period 2

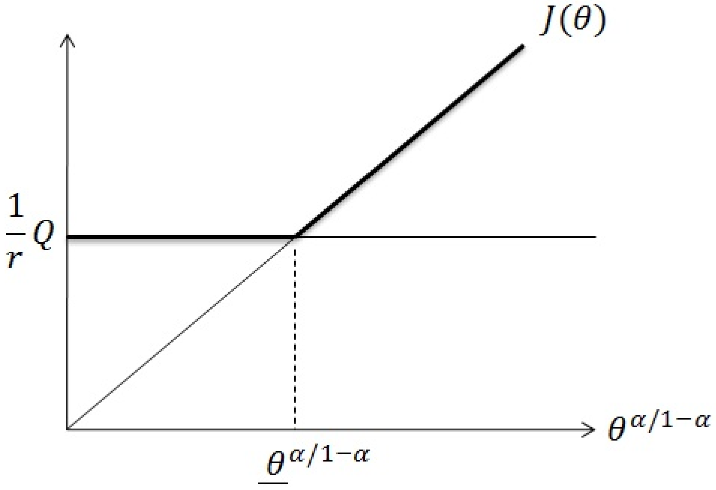
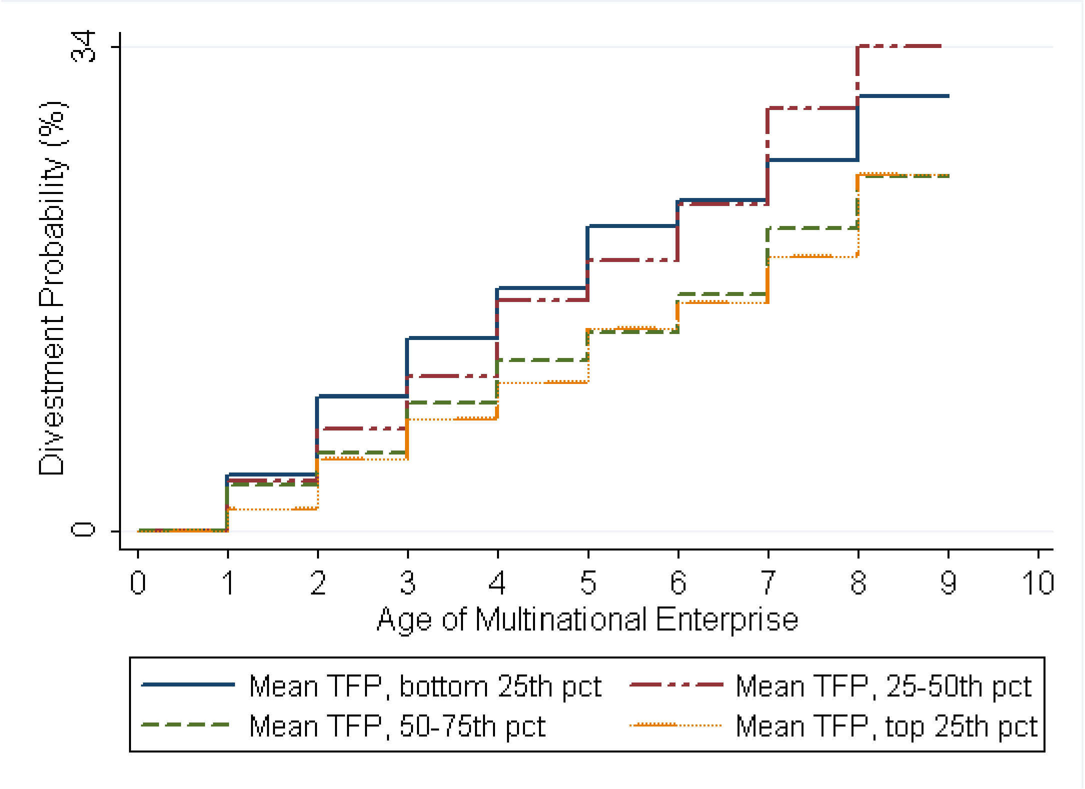


Figure 1.6: Kaplan-Meier Divestment Plot of MNEs by Level of Joint Productivity



Notes: This figure plots the Kaplan-Meier estimates of the divestment probabilities for multinationals in the Turkish manufacturing industry, 1993-2001, stratified by percentile rank of their mean total factor productivity (TFP) while under foreign ownership. Divestment is defined as any decrease in foreign equity participation exceeding one percent or complete shutdown of the multinational plant. The calculation of TFP estimates are described in the text.

Figure 1.7: The Permissible Set of β's for Various Headquarter Intensities

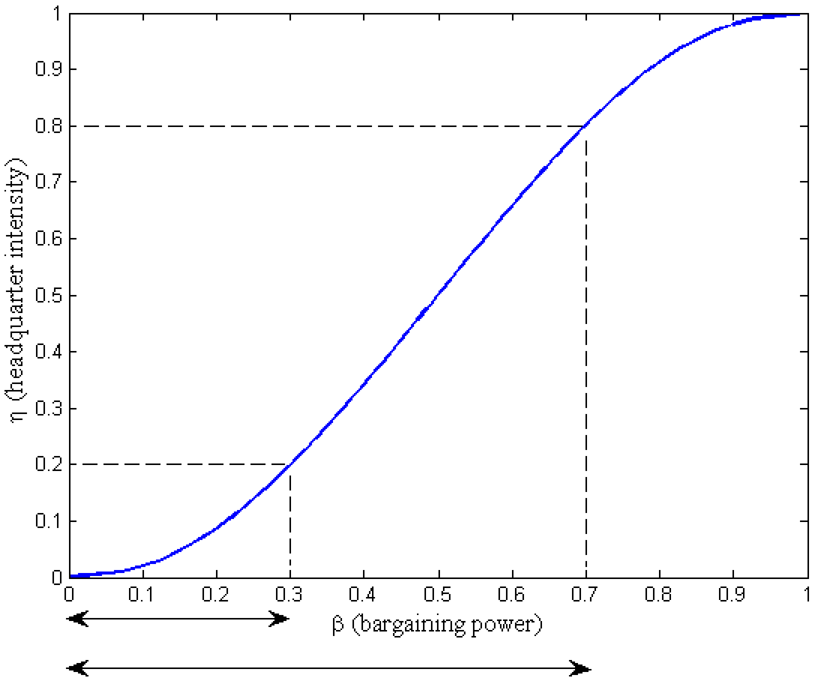
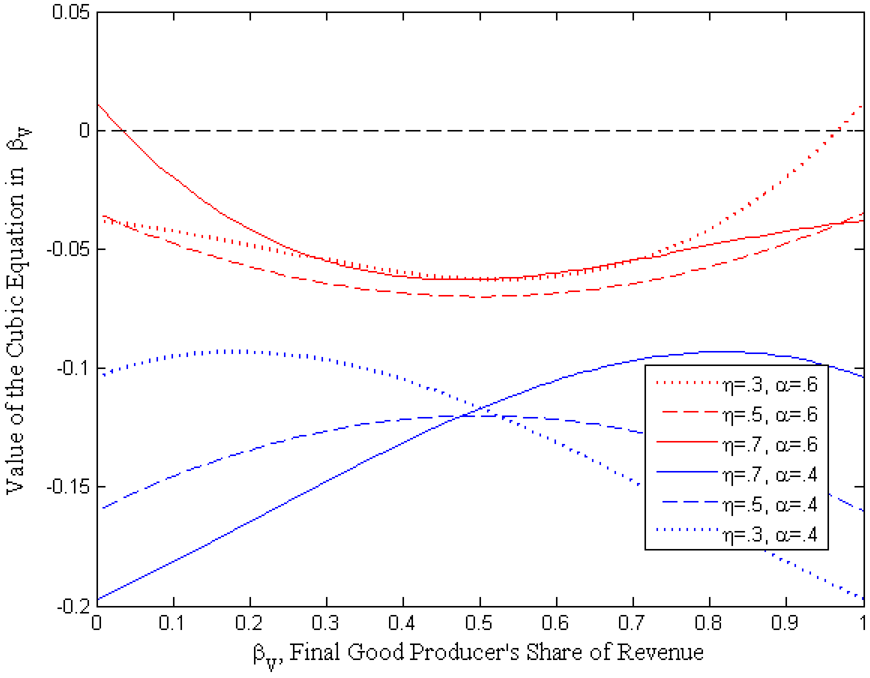


Figure 1.8: The Sign of the Cubic Equation in β_V for Different Parameter Values



1.8 Appendix B

In this section, I detail the construction of the variables used in the paper and the procedure followed to clean the data. Note that all variables in the data set are measured in 1990 prices (Turkish Liras). All data come from the Turkish Statistical Institute's Industrial Analysis Database unless stated otherwise.

Output is measured as the sum of the revenues from annual sales of the plant's final goods, revenues from contract manufacturing, and the change in inventories of final goods from year start to year end. I deflate output by the relevant three-digit output price deflator. Material inputs are measured as the sum of all intermediate inputs, except for fuel and electricity, and the change in inventories of material inputs from year start to year end. I deflate material inputs by the relevant three-digit input price deflator. Electricity is calculated as the sum of the value of electricity purchased and produced in-house minus the value electricity sold. Both electricity and fuel are deflated by their own price deflators. Labor is measured as the number of paid workers of the plant in a given year. This is reported for production and non-production workers four times during a given year (in February, May, August, and November) and the average of these four observations constitutes the average number of workers at the plant in a given year (i.e. the plant size).

Capital stock information is not reported in the database, so I calculate it using the reported investment data. The database includes information on investment in machinery and equipment, building and structures, transportation equipment, and computer and programming. All series are available since 1990, except for computer and programming, which is available since 1995. Since the disaggregated investment deflator is not available, I use the aggregate investment deflator to deflate all series. I use the perpetual inventory method in constructing the yearly capital stock for each of these series at the plant level.

Since initial capital stock is not reported, I impute it by assuming that plants are on their balanced growth path. I assume that capital stock is predetermined and evolves according to:

$$K_{t+1} = (1 - \delta)K_t + I_t \tag{1.28}$$

as current investment, reacting to realized productivity shocks, takes one period before it becomes productive. If plants are on their balanced growth path, then $K_1/K_0 = Y_1/Y_0 = 1 + g_{0,1}$, where $g_{0,1}$ is the initial output growth of the plant. It is then easy to show that initial capital stock is given by: $K_0 = I_0/(g_{0,1} + \delta)$. After calculating K_0, I apply the perpetual inventory method to construct the capital stock series implied by (1.28). I use depreciation rates of 5%, 10%, 20%, and 30% for building and structures, machinery and equipment, transportation equipment, and computer and programming, respectively. I observe zero initial investment for a small number of plants, for which I calculate initial capital stock at the year that they first report positive investment and then iterate back by dividing capital stock by $(1 - \delta)$ each year.

After calculating the capital stock series separately for machinery and equipment, building and structures, transportation equipment, and computer and programming, I aggregate the series to form the total capital stock series of the plant. The database provides information on imported machinery capital, and I follow the same approach outlined here to calculate these series.

Table 1.7 reports the number of MNEs and the total number of plants in the database before the cleaning procedure. I follow three rules to clean the data. First, plants that have “gaps” in the sample period are excluded from the analysis. Second, those observations which have a non-positive value for capital stock are excluded as well. Lastly, I exclude the outlier observations which could distort inference following the construction of the TFP measure by dropping the top 1 percent of the sample for which productivity is computed.

Table 1.7: Turkish Manufacturing Industry, 1993-2001

Year	No. of MNEs	Total No. of Plants	Foreign Presence (%)
1993	301	10,567	2.85
1994	312	10,127	3.08
1995	325	10,229	3.18
1996	326	10,590	3.08
1997	362	11,365	3.19
1998	416	12,321	3.38
1999	406	11,262	3.61
2000	414	11,114	3.73
2001	439	11,311	3.88

Table 1.8: Percent of Non-Zero Observations

ISIC	Sector	Investment	Fuels	Materials	Electricity
311	Food	56.8	84.4	100	99.9
312	Other Food	49.3	85.3	100	99.9
321	Textiles	63.9	71.9	99.8	99.9
322	Wearing Apparel	60.8	64.6	99.6	99.9
356	Other Plastic Products	69.9	62.3	100	100
369	Non-metallic Mineral Products	56.9	88.0	99.9	99.8
381	Fabricated Metal Products	63.0	72.9	99.9	99.9
382	Non-electrical Machinery	63.5	70.9	100	99.9
383	Electrical Machinery	69.5	77.2	99.9	99.7
384	Transport Equipment	67.4	74.8	100	99.9

Table 1.9: Levinsohn-Petrin Estimates of the Production Function, 1993-2001

ISIC	Sector	*Labor*		*Capital*		*N*
		Coeff.	S.E.	Coeff.	S.E.	
311	Food	.893	.029	.359	.075	6448
312	Other Food	.845	.047	.190	.113	1853
313, 314	Beverage and Tobacco	.894	.090	.098	.177	830
321	Textiles	.809	.023	.193	.042	10293
322	Wearing Apparel	.754	.036	.075	.102	6762
323	Leather	.884	.098	.191	.081	708
324	Footwear	1.022	.083	.226	.096	683
331	Wood Products	.851	.079	.011	.101	1074
332	Furniture	.964	.064	.292	.110	905
341	Paper Products	.826	.085	.265	.201	975
342	Printing and Publishing	.613	.103	.328	.156	1117
351	Industrial Chemicals	.698	.153	.419	.128	563
352	Other Chemicals	.950	.063	.262	.118	1767
355	Rubber Products	.952	.103	.545	.185	789
356	Other Plastic Products	.944	.071	.367	.081	2432
361, 362	Pottery, China, and Glass Prod.	.810	.098	.339	.176	778
369	Non-metallic Mineral Prod.	.932	.048	.937	.091	3558
371	Iron and Steel	.873	.070	.159	.107	1556
372	Non-ferrous Metal	.878	.104	.402	.195	683
381	Fabricated Metal Products	.910	.034	.337	.054	4870
382	Non-electrical Machinery	.948	.045	.204	.047	3990
383	Electrical Machinery	.898	.051	.148	.102	2734
384	Transport Equipment	.826	.050	.164	.093	2741
385	Scientific and Optical Equipment	.728	.108	.413	.220	613
390	Other Manufacturing	1.008	.109	.441	.180	665

CHAPTER II

Foreign Direct Investment and Wages: Does the Level of Ownership Matter?

2.1 Introduction

A large body of trade research is devoted to understanding the host-country effects of foreign direct investment (FDI), which has increased dramatically in recent decades. One of the key effects studied extensively in this regard is the impact that multinational activity has on average wages at plants subject to foreign acquisition. It is now well known that affiliates of multinational companies pay higher wages compared to their domestic counterparts even after controlling for sectoral, regional, and plant-level characteristics.[1] However, existing studies provide a range of estimates for the average wage effect of multinational status from 1 percent to 70 percent. Despite the similarity in the methodology and data sets employed in these studies, it remains to be understood why we observe such a large range of estimates at seemingly similar multinational plants and what the precise wage effects of multinational activity are. As Girma and Gorg (2007) note, even when controlling for observable and time invariant unobservable characteristics, there remains a fundamental problem in iden-

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[1] See, for example, Aitken et al. (1996), Feenstra and Hanson (1997), Doms and Jensen (1998), Figini and Gorg (1999), Taylor and Driffield (2005), Lipsey and Sjoholm (2006), Almeida (2007), Heyman et al. (2007), Girma and Gorg (2007), and Arnold and Javorcik (2009). See Table A1 in Almeida (2007) for a summary of the literature on the multinational wage premium using firm level data and the premium estimates.

tifying the performance differences that are attributable to multinationality *per se*. The current study identifies the causes of such divergent estimates and documents the causal impact of foreign ownership on wages using methodology that sidesteps earlier limitations.

Existing studies often estimate a firm-level wage model with a binary variable that indicates multinational status. Using binary variables in the estimation embodies the assumption that all multinational affiliates are identical with respect to the wages they pay. Since an indicator variable for ownership status censors the information on what share of the affiliate equity is controlled by the multinational parent, it is unable to capture any variation in the wages due to different levels of foreign equity participation. If the level of control that multinationals exercise at their affiliates affects the wages they pay, then estimation with a binary variable will fail to capture the heterogeneity in the wage premium across multinational affiliates. Moreover, an econometric issue arises if the wage premium varies with foreign equity participation. Rigobon and Stoker (2009) show that the least squares estimator is prone to severe bias when there are several regressors and a binary variable is used in place of a continuous regressor. Estimates also become sensitive to the level of thresholds in defining the multinational status of an affiliate. Thus, using a censored foreign ownership variable, as is the common practice in the literature, would lead to inconsistent estimates of the wage premium when wages vary with the level of foreign equity participation.

This study identifies the heterogeneity in the multinational wage premium that arises due to the level of foreign equity participation using a unique data set from Turkey. The distinguishing feature of these data is the observation of continuous levels of foreign ownership at the plant level with a considerable degree of ownership distribution across the plants. I build on the results by Rigobon and Stoker (2009) to show that using censored regressors may lead to severe bias not only in ordinary least squares estimation, but also in fixed effects estimation. More specifically, when the true relationship between foreign equity participation and average wages is linear, using a binary variable instead of a continuous regressor leads to inconsistent estimates of the wage premium even if plant level individual effects are accounted for. By artificially creating different thresholds for the foreign ownership variable, I illustrate the "variability" of wage premia across different definitions and the biases that ensue. Up to 14 percent of the wage premium attributed to a foreign owner may come from different levels of foreign equity participation even after controlling for plant level effects.

Two main results come out of the empirical analysis, which uses the census of Turkish manufacturing plants over the period 1993-2001.[2] First, using nonparametric and semiparametric regressions, I demonstrate that there is essentially a linear and increasing relationship between the level of foreign ownership and average wages. This monotonic relationship holds more strongly for non-production workers than production workers. Second, I find that a significant wage premium exists only for non-production workers when I produce estimates of the premium that control for plant level effects and the endogeneity of foreign ownership. I address the endogeneity of multinational activity by generating instruments from the panel data at hand in a generalized method of moments framework, which allows me to accommodate a large set of assumptions on the estimated wage model. My results indicate that a 10 percentage point increase in foreign equity participation is associated with a 4

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[2] Three earlier studies report estimates from matched employer-employee data in addition to firm-level estimates (see Heyman et al. (2007) for Sweden, and Martins (2004) and Almeida (2007) for Portugal). These estimates focus on whether foreign firms pay higher wages to identical workers. While it is desirable to have such data to control for worker heterogeneity, such employer-employee data do not exist for Turkey.

percent increase in the average wage of non-production workers, and that the level of foreign ownership does not affect the wages of production workers. Therefore, there is a significant degree of heterogeneity in the wage premia at multinational affiliates that comes from different levels of foreign equity participation. Moreover, the finding that there is no significant premium for production workers is novel in the literature.

Existing literature has identified how the level of foreign ownership is related to certain aspects of the firm, which may have an impact on average wages. Takii and Ramstetter (2005) find that higher foreign equity participation is associated with higher levels of productivity in Indonesian manufacturing. A similar finding is documented in the case of Venezuela by Aitken and Harrison (1999). This could arise because a majority foreign ownership share might be required for bringing in technologies from the parent firm, which in turn may lead to a high wage premium (Lipsey and Sjoholm, 2006). In a similar vein, Barbosa and Louri (2002) argue that a foreign partner will demand higher ownership in case of profitable affiliates and large intangible assets to be transferred. Indeed, Budd et al. (2005) find that the degree of multinational ownership appears to condition the degree of intrafirm profit sharing, and that affiliate wages are positively correlated with both parent and affiliate profits.

Although some existing studies consider the impact of the level of foreign ownership on the wage premium, there is no consensus in the literature on the subject. On the one hand, Martins (2004) finds no higher wage premia for firms that exhibit a stronger degree of foreign control in Portugal. On the other hand, Lipsey and Sjoholm (2006) and Aitken et al. (1996) find that majority-owned foreign plants pay higher wages for skilled workers in Indonesia and Venezuela, respectively. However, these studies do not address the endogeneity of foreign ownership explicitly. Few studies, notably Heyman et al. (2007), Girma and Gorg (2007), and Arnold and

Javorcik (2009), present estimates of the wage premium that tackle the issue of endogeneity by using matching techniques. Hence, the current study is the first in the literature to identify systematic heterogeneity in the wage premium due to different levels of foreign ownership while accounting for endogeneity explicitly. I find that foreign equity participation impacts average wages at every level and my results are not driven by those multinationals achieving majority control at their affiliates.

The rest of the paper is structured as follows. The next section discusses the empirical strategy of earlier studies and builds on the results from Rigobon and Stoker (2009) to demonstrate the problems with the use of binary regressors in the panel data context. Section 3 introduces the data to be used in the analysis. Section 4 presents my empirical strategy to test the implications of Section 2 and to identify the relationship between the level of foreign ownership and average wages. Section 5 includes my empirical results and presents a set of robustness checks. Concluding remarks appear in Section 6.

2.2 Censoring the Level of Foreign Ownership

The equity share that a multinational controls at an affiliate is often unobserved in plant-level data. When it is observed, the common practice is to designate a certain threshold and define a plant as "foreign-owned" if the multinational's equity participation exceeds that threshold.[3] In this section, I discuss three issues. First, I describe how the common practice of using different thresholds to define foreign ownership can hide the heterogeneity in the wage premium. Second, building on

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[3] In national and international accounting standards, FDI is typically defined as involving an equity stake of 10 percent or more at the plant level (Razin and Sadka, 2007), although different countries follow different recording practices. For instance, Sweden uses the 50% cut-off in defining foreign ownership (Heyman et al., 2007). While researchers typically use this cut-off to define majority control, it has been noted by the finance literature that shareholders can achieve effective control in many cases by holding a block that is much smaller than 50% of the firm (Razin and Sadka, 2007).

Rigobon and Stoker (2009), I derive the bias in the fixed effects estimate of the wage premium that arises from censoring a continuous regressor in a single variable regression. Lastly, I extend this result to the multivariate case and discuss how censoring the level of foreign ownership distorts the estimation of the wage premium.

Assume that the true empirical model that links wages to foreign ownership at the plant level is given by:

$$w_{i,t} = \alpha_i + m(x_{i,t}) + \gamma' \mathbf{y}_{i,t} + \varepsilon_{i,t}, \ \ i = 1, \ldots, N; \ t = 1, \ldots, T \tag{2.1}$$

where $w_{i,t}$ represents the potential wage, $x_{i,t} \in [0, 100]$ denotes foreign equity participation in percentages at plant i at time t, $m(.)$ is a function that relates $x_{i,t}$ to wages, α_i is a time-invariant plant effect, $\mathbf{y}_{i,t}$ is a vector of plant-level controls, and $\varepsilon_{i,t}$ is white noise. If the level of foreign ownership affects wages linearly, then the true model becomes:

$$w_{i,t} = \alpha_i + \beta x_{i,t} + \gamma' \mathbf{y}_{i,t} + \varepsilon_{i,t}, \ \ i = 1, \ldots, N; \ t = 1, \ldots, T \tag{2.2}$$

I confirm in the later sections that the estimated relationship between foreign equity participation and wages is indeed linear for the present study. I am interested in the wage premium due to the level of multinational activity, which is captured by β in (2.2). The inclusion of α_i in (2.2) enables the identification of β from within-plant variation in foreign control, thus sidestepping problems that might arise from selection of high-wage plants by multinationals.

Earlier studies estimate a wage premium by using a censored version of the foreign ownership variable mostly because their data prevented them from observing $x_{i,t}$ in its continuous nature. Specifically, they estimate:

$$w_{i,t} = a_i + bF_{i,t} + c' \mathbf{y}_{i,t} + \epsilon_{i,t}, \ \ i = 1, \ldots, N; \ t = 1, \ldots, T \tag{2.3}$$

where $F_{i,t}$ is a binary variable indicating foreign ownership, defined on a threshold, ϕ:

$$F_{i,t} = 1[x_{i,t} > \phi] \tag{2.4}$$

Implicit in this practice is the assumption that all foreign plants are identical. When this is not the case, Figure 2.1 depicts how censoring the level of foreign ownership hides the heterogeneity in the wage premium and leads to different estimates depending on the threshold.[4] In the figure, all domestic firms are assumed to pay the same wage, w_1, while wages are increasing in the level of foreign ownership for multinationals, as depicted by the function $m(x)$. Assume that we estimate this relationship with an equation such as (2.3), and we set $\phi = 0\%$. The variable of interest, $\hat{b}$, will capture an effect illustrated by l_1 in the figure, with every multinational predicted to pay w_2. As l_1 simply captures an average effect, it overstates the wage premium for multinationals with less than 50 percent ownership and understates it for those above this level. If we instead set $\phi = 50\%$, then $\hat{b}$ captures an effect illustrated by l_2, at which all multinationals are predicted to pay w_3. In this case, l_2 overestimates the wage premium for most multinationals and provides a higher estimate than l_1. Hence, censoring not only hides the heterogeneity in the wage premium due to the level of foreign ownership, but it also results in confounded estimates due to lack of knowledge on $m(x)$.[5]

Rigobon and Stoker (2009) derive the bias from using censored regressors for the OLS (ordinary least squares) estimator, and I build on their results for the case of 0-1 censoring as in (2.4). I show here that their results can be readily extended to

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[4] Figure 2.1 is hypothetical and intended for demonstrative purposes only.

[5] Note that if there were no heterogeneity in the wage premium, then $\hat{b}$ would return the same estimate independent of the value of ϕ and accurately capture the return to being a multinational.

the FE (fixed effects, or within-group) estimator. In order to motivate the result, I start the analysis with a single regressor. Let the true model be given by (2.2), excluding the vector of controls $\mathbf{y}_{i,t}$. The fixed effects transformation eliminates α_i from (2.2) and yields a single variable model in deviations from individual means:

$$w_{i,t} - \bar{w}_i = (x_{i,t} - \bar{x}_i)\beta + (\varepsilon_{i,t} - \bar{\varepsilon}_i) \tag{2.5}$$

where $\bar{w}_i = T^{-1}\sum_{t=1}^{T} w_{i,t}$, and $\bar{x}_i$ and $\bar{\varepsilon}_i$ are defined similarly. The FE estimator, which is unbiased in finite samples, is given by:

$$\hat{\beta}_{FE} = \frac{\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{i,t} - \bar{x}_i)(w_{i,t} - \bar{w}_i)}{\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{i,t} - \bar{x}_i)^2}$$

I am interested in the asymptotic bias that arises when one estimates the following model instead:

$$w_{i,t} = a_i + bF_{i,t} + \epsilon_{i,t}, \;\; i = 1, ..., N; \, t = 1, ..., T \tag{2.6}$$

where the $F_{i,t}$ is defined as above. The coefficient of interest is estimated by:

$$\hat{b}_{FE} = \frac{\sum_{i=1}^{N}\sum_{t=1}^{T}(F_{i,t} - \bar{F}_i)(w_{i,t} - \bar{w}_i)}{\sum_{i=1}^{N}\sum_{t=1}^{T}(F_{i,t} - \bar{F}_i)^2}$$

The bias that I am going to characterize is given by $plim\, \hat{b}_{FE} - \beta$, which will clearly be affected by the threshold ϕ. To see this formally, recall that $\hat{b}_{FE}$ is identical to the estimator obtained by an OLS estimation of the dummy variable model:

$$w_{i,t} = \sum_{j=1}^{N} a_j d_{i,j} + bF_{i,t} + \epsilon_{i,t} \tag{2.7}$$

where $d_{i,j} = 1$ if $i = j$ and 0 elsewhere. Following Rigobon and Stoker (2009), the probability limits of the OLS estimators of (2.7) are given by:[6]

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[6] The difference here from Rigobon and Stoker (2009) is the conditional expectations, since the true data generating process (DGP) is now given by the single variable version of (2.2) with time-invariant individual effects instead of a cross-sectional DGP. Remember that the interpretation of β comes from the conditional expectation on the structural equation (2.2) even though one uses the censored version of (2.5) or (2.7) in practice to estimate the parameters of the model.

$$\begin{aligned}
plim\, \hat{a}_{i,\,FE} &= E[w_{i,\,t}|F_{i,\,t}=0,\,\alpha_i] = \alpha_i + \beta E[x_{i,\,t}|F_{i,t}=0,\,\alpha_i] \\
plim\, \hat{b}_{FE} &= E[w_{i,\,t}|F_{i,\,t}=1,\,\alpha_i] - E[a_i|F_{i,\,t}=1,\,\alpha_i] \\
&= E[w_{i,\,t}|F_{i,\,t}=1,\,\alpha_i] - E[w_i|F_{i,\,t}=0,\,\alpha_i] \\
&= \alpha_i + \beta E[x_{i,\,t}|F_{i,t}=1,\,\alpha_i] - \alpha_i - \beta E[x_{i,\,t}|F_{i,t}=0,\,\alpha_i] \\
&= \beta\,\{E[x_{i,\,t}|F_{i,t}=1,\,\alpha_i] - E[x_{i,\,t}|F_{i,t}=0,\,\alpha_i]\}
\end{aligned}$$

The FE estimator $\hat{b}_{FE}$ measures β up to a positive scalar as in the OLS case, but differently, this scalar is now determined by the expectations conditional on α_i. The bias is:

$$plim\, \hat{b}_{FE} - \beta = \beta\,\{E[x_{i,\,t}|F_{i,t}=1,\,\alpha_i] - E[x_{i,\,t}|F_{i,t}=0,\,\alpha_i] - 1\}$$

What does this result tell us? If one is merely interested in whether foreign ownership causes a positive or negative wage premium, then using a censored regressor will provide a consistent answer as to the direction of this association. However, if the interest is in the size of the premium, then $\hat{b}_{FE}$ provides an estimate that is confounded by the difference $E[x_{i,t}|F_{i,t}=1,\,\alpha_i] - E[x_{i,t}|F_{i,t}=0,\,\alpha_i]$. This *within* difference depends not only on ϕ, but also on the conditional distribution of the uncensored variable $x_{i,\,t}$. For instance, if foreign owners acquire higher equity stakes at plants that are larger in size or that operate in certain industries, then we would expect the within difference to be larger in such plants and industries. Thus, the extent of the heterogeneity in foreign ownership directly impacts the wage premium estimate and 0-1 censoring might lead to misestimates by hiding this information.

In practice, one is typically interested in the parameters of a multivariate model, which calls into question the transmission of bias among the regressors. Assume that the true model is given by (2.2) in which the vector $\mathbf{y}_{i,\,t}$ consists of a single control $y_{i,\,t}$. The censored model is:

$$w_{i,\,t} = a_i + bF_{i,\,t} + cy_{i,\,t} + \epsilon_{i,\,t}, \;\; i = 1,\, ...,\, N;\, t = 1,\, ...,\, T \tag{2.8}$$

The FE estimator of b is again identical to the estimator obtained by OLS estimation of the dummy variable model:

$$w_{i,\,t} = \sum_{j=1}^{N} a_j d_{i,\,j} + bF_{i,\,t} + cy_{i,\,t} + \epsilon_{i,\,t} \tag{2.9}$$

Following Rigobon and Stoker (2009), denote the residual of $w_{i,\,t}$ regressed on $F_{i,\,t}$ as: $\Delta w_{i,\,t} = w_{i,\,t} - (1 - F_{i,\,t})\bar{w}_{0,\,t} - F_{i,\,t}\bar{w}_{1,\,t}$; where $\bar{w}_{1,\,t} = \sum_{i=1}^{N}\sum_{t=1}^{T} F_{i,\,t}w_{i,\,t} / \sum_{i=1}^{N}\sum_{t=1}^{T} F_{i,\,t}$ is the average of $w_{i,\,t}$ for $F_{i,\,t} = 1$, and $\bar{w}_{0,\,t} = \sum_{i=1}^{N}\sum_{t=1}^{T}(1 - F_{i,\,t})w_{i,\,t} / \sum_{i=1}^{N}\sum_{t=1}^{T}(1 - F_{i,\,t})$. Applying the same transformation to both sides of (2.2), one gets:

$$\Delta w_{i,\,t} = \beta \Delta x_{i,\,t} + \gamma \Delta y_{i,\,t} + \Delta \varepsilon_{i,\,t} \tag{2.10}$$

If one applies this transformation to the model in (2.9), both the censored variable $F_{i,\,t}$ and the individual dummies $d_{i,\,j}$ are removed, which yields the estimation equation:

$$\Delta w_{i,\,t} = c\Delta y_{i,\,t} + v_{i,\,t} \tag{2.11}$$

Rigobon and Stoker (2009) note that the bias in $\hat{c}$ of (2.8) is the same as that of (2.11), which arises due to the omission of $\Delta x_{i,\,t}$ from (2.10). The standard omitted variable bias formula then yields $plim\, \hat{c}_{FE} = \gamma + \beta\eta \equiv c$, where η is defined by:

$$\eta = \frac{Cov(\Delta y_{i,\,t},\, \Delta x_{i,\,t})}{Var(\Delta y_{i,\,t})} = \frac{(1-p)Cov(y_{i,\,t},\, x_{i,\,t}|F_{i,t} = 1,\, \alpha_i^*) + pCov(y_{i,\,t},\, x_{i,\,t}|F_{i,t} = 0,\, \alpha_i^*)}{(1-p)Var(y_{i,\,t}|F_{i,t} = 1,\, \alpha_i^*) + pVar(y_{i,\,t}|F_{i,t} = 0,\, \alpha_i^*)}$$

and p is the probability that $F_{i,t} = 1$. Again, the difference in the current result from that of Rigobon and Stoker (2009) for the OLS case is that the covariances and variances are now conditioned on individual effects, α_i^*, where the linear projection of $x_{i,t}$ on the additional regressor is expressed as: $x_{i,t} = \alpha_i^* + \eta y_{i,t} + r_{i,t}$.

Hence, the parameter η, which measures how within-deviations of foreign equity participation are proxied by the within-deviations of the additional regressor, determines the size of the bias in $\hat{c}$. As Rigobon and Stoker (2009) note, it is impossible to assess the bias in terms of size and direction if one has no information regarding the within-variation of $x_{i,t}$. The probability limits for the other coefficients in (2.8) are given by:

$$\begin{aligned} plim\,\hat{a}_{i,FE} &= E[w_{i,t}|F_{i,t}=0,\,\alpha_i] - cE[y_{i,t}|F_{i,t}=0,\,\alpha_i] \\ &= \alpha_i + \beta E[x_{i,t}|F_{i,t}=0,\,\alpha_i] + (\gamma - c)E[y_{i,t}|F_{i,t}=0,\,\alpha_i] \\ &= \alpha_i + \beta\,[E[x_{i,t}|F_{i,t}=0,\,\alpha_i] - \eta E[y_{i,t}|F_{i,t}=0,\,\alpha_i]] \end{aligned}$$

$$\begin{aligned} plim\,\hat{b}_{FE} &= E[w_{i,t}|F_{i,t}=1,\,\alpha_i] - E[w_{i,t}|F_{i,t}=0,\,\alpha_i] \\ &\quad +cE[y_{i,t}|F_{i,t}=0,\,\alpha_i] - cE[y_{i,t}|F_{i,t}=1,\,\alpha_i] \\ &= \alpha_i + \beta E[x_{i,t}|F_{i,t}=1,\,\alpha_i] + \gamma E[y_{i,t}|F_{i,t}=1,\,\alpha_i] \\ &\quad -\alpha_i - \beta E[x_{i,t}|F_{i,t}=0,\,\alpha_i] - \gamma E[y_{i,t}|F_{i,t}=0,\,\alpha_i] \\ &\quad -c\,\{E[y_{i,t}|F_{i,t}=1,\,\alpha_i] - E[y_{i,t}|F_{i,t}=0,\,\alpha_i]\} \\ &= \beta\,[E[x_{i,t}|F_{i,t}=1,\,\alpha_i] - E[x_{i,t}|F_{i,t}=0,\,\alpha_i] \\ &\quad -\eta\,\{E[y_{i,t}|F_{i,t}=1,\,\alpha_i] - E[y_{i,t}|F_{i,t}=0,\,\alpha_i]\}] \end{aligned}$$

The bias in $\hat{b}_{FE}$ thus depends on two extra terms compared to the single regressor case: how the additional regressor covaries with x, and the distribution of the additional regressor conditional on censoring and α_i. With additional regressors in the picture, it is possible to have a case where $\hat{b}_{FE}$ may actually have the *wrong* sign. This will be the case whenever we have: $\frac{E[x_{i,\,t}|F_{i,t}=1, \alpha_i] - E[x_{i,\,t}|F_{i,\,t}=0, \alpha_i]}{E[y_{i,\,t}|F_{i,\,t}=1, \alpha_i] - E[y_{i,\,t}|F_{i,\,t}=0, \alpha_i]} < \eta$. Hence, with 0-1 censoring, it is possible to end up not only with a biased estimate of the wage premium, but also with the wrong sign on it.

2.3 Panel Data on Turkish Manufacturing

Data on the Turkish manufacturing industry come from the Industrial Analysis Database by the Turkish Statistical Office (TurkStat), which covers all manufacturing plants in Turkey with more than ten employees, including plants controlled by foreign investors. For this study, I focus on the period 1993-2001. The inclusion of plant identification codes enables me to construct a panel and follow the plants over time. The total number of manufacturing plants varied between 10,567 in 1993 and 11,311 in 2001 (see Table 2.7). The percentage of foreign plants in the sample, defined as plants that have at least some level of foreign ownership, increased from 2.85 percent to 3.88 percent over the same period. The measure of foreign ownership in this study is the percentage of subscribed equity owned by the foreign investor, which varies between 0 and 100 percent. The average foreign equity participation at plants owned partially or fully by foreigners increased from 58.78 percent in 1993 to 64.33 percent in 2001.

Figure 2.2 depicts the distribution of foreign ownership shares for all plant-year observations for the subset of foreign plants in the sample. There is a substantial degree of heterogeneity in how much control multinational firms exercise. While most foreign plants seem to be majority owned, there is a significant number of plant-year observations with multinationals owning less than 50 percent of the plant's equity.

Moreover, one sees the full range of ownership shares with sizable densities in each bin of the distribution. Similar patterns can be seen when I reproduce Figure 2.2 for different industries or plant sizes (results not reported here). Informed by the analytical results in the previous section, I expect this pattern in the level of foreign ownership to bias estimates of the wage premium in a censored regression.

In addition to foreign ownership, the database contains yearly information on employment, inputs, output, value added, wages and compensation, sales, inventories, additions to fixed assets, energy use, sector, and location. Plant size is measured as the total number of paid workers at a plant in any given year. I observe the number of production and non-production workers and total payments to each group in the database. In all of the analyses, total yearly wages as reported by the plants are used in the calculation of the average plant wage and the average wage for production and non-production workers, excluding any additional benefits and compensation.[7]

A frequently mentioned source of possible selection bias is acquisitions of high-wage domestic plants by multinational firms, also known as cherry picking (see Lipsey and Sjoholm (2006) and Almeida (2007)). It could be the case that foreign plants acquire domestic establishments that are already highly productive and large in size and that therefore pay higher wages in general. Such selection bias would distort the results of the empirical investigation if plant effects are not controlled for. Figure 2.3 provides the average yearly wage for plants that experienced a takeover in the sample period by type of ownership and compares these values to the average wage in the overall sample.

Figure 2.3 reveals that plants that experienced a takeover during the period 1993-

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[7] Numbers of paid workers are reported for production and non-production workers four times during a given year (in February, May, August, and November) and the average of these four observations constitutes the average number of workers at the plant in a given year (i.e. the plant size).

2001 were paying much higher wages to their workers compared to the plants in the overall sample. This holds for such plants regardless of whether they were under foreign or domestic ownership, which provides evidence to the oft-mentioned selection bias of high-wage plants by foreigners. In this case, least squares estimates will tend to capture the difference in levels between the traditionally high wage firms, which are most likely to be acquired, and the traditionally low wage firms that will almost always stay under domestic control. However, one can also see from Figure 2.3 that wages were higher at plants that experienced a takeover when they were under foreign ownership. This suggests that foreign ownership per se might have an impact on the average wage, even though the estimated premium after controlling for the individual firm effect is likely to be much smaller than least squares estimates.

2.4 Empirical Methodology

Two empirical findings characterize the activity of multinationals in Turkey with respect to the level of control they exercise and the plants they acquire. First, foreign investors choose to own any percentage of subscribed capital (equity) when they engage in FDI, allowing them to exercise various degrees of control at the acquired plant. Second, regardless of the equity share they eventually own, they target domestic plants which already pay wages that are much higher than the average. In this section, I outline a three-step empirical strategy to analyze the link between foreign ownership and wages in light of these two regularities. I first describe how the predictions of Section 2 on censoring are tested and then turn to provide estimates of the foreign ownership premium that control for plant-level effects and endogeneity.

2.4.1 Defining Different Thresholds

Observing foreign equity participation at the plant level allows me to define multinational status using different thresholds. In order to analyze how these different thresholds affect the wage premium, I estimate the following censored equation:

$$ln\, w_{ijt} = \beta_0 + \beta_1 FDIPlant_{ijt} + \alpha' \mathbf{X}_{ijt} + Sector + Region + Time + \varepsilon_{ijt} \tag{2.12}$$

where $FDIPlant_{ijt} = 1[x_{ijt} > \phi]$ indicates multinational status, x_{ijt} is foreign equity participation and varies between 0 and 100 percent, ϕ is the threshold level, and i, j, and t index plant, sector, and year, respectively. In equation (2.12), w_{ijt} is the average yearly plant wage and $\mathbf{X}_{ijt}$ is a vector of plant-specific characteristics such as size and skill intensity. Sector dummy variables at the two digit level of the ISIC Rev. 2, regional dummy variables, which classify each plant belonging to one of the seven geographical regions in Turkey, and time dummy variables control for sector, region and year specific wage effects, and ε_{ijt} is a random plant-specific error component. In all my specifications, I estimate the equation of interest for three dependent variables: the average plant wage, the average wage for production workers, and the average wage for non-production workers.

I estimate equation (2.12) by OLS and FE using four possible values of ϕ that are arbitrarily chosen: 0%, 15%, 30%, and 50%. The goal of this exercise is to demonstrate the bias in OLS and FE estimations that arises from using different thresholds in the definition of a multinational plant. Varying estimates of β_1 due to the threshold level ϕ would indicate that the multinational wage premium depends on this arbitrary definition of multinational status. In light of the analytical results in section 2, this would suggest that the level of foreign equity participation is innately tied to average wages. If this were not so, i.e. the level of foreign equity participation does not affect average wages, then we would see identical estimates and statistical (in)significance of β_1 regardless of the threshold level. This counterfactual case would correspond to the absence of heterogeneity in the foreign ownership wage premium.

2.4.2 Nonparametric and Semiparametric Analysis

In my second round of estimations, I examine whether the true relationship between foreign equity participation and wages is linear. I first estimate this relationship non-parametrically using the locally weighted scatterplot smoothing (Lowess) estimator of Cleveland (1979). Consider a regression of wages on foreign equity share, given by the model:

$$w_i = m(x_i) + \varepsilon_i, \quad i = 1, ..., N \tag{2.13}$$

where the error term ε_i is i.i.d. Lowess is a standard local regression estimator, whereby one lets $m(x_i)$ be linear in the neighborhood of a data point x so that $m(x_i) = m + \beta(x_i - x)$. Cleveland (1979) suggested that one minimize:

$$\sum_{i=1}^{N} \{w_i - m - \beta(x_i - x)\}^2 K\left(\frac{x_i - x}{h}\right) \tag{2.14}$$

with respect to m and β, where $K(.)$ is a kernel weighting function. This can be achieved by performing a weighted least squares regression of w_i against $z_i' = (1, (x_i - x))$ with weights $K_i^{1/2}$ (Pagan and Ullah, 1999). The weighted least squares regression estimates for each observation i are then used to predict the value of the dependent variable to trace out the non-parametric relationship between w and x. For implementing Lowess, I use the tricubic kernel as my weighting function, which places less weight on points near the end of the sample, and I use a bandwidth of 0.8, which uses eighty percent of the sample for each regression.[8] Despite its com-

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[8] I also experimented with a bandwidth of 0.5 for both my nonparametric and semiparametric estimates, which left my results unchanged.

putational intensity, Lowess is preferable over kernel regression as it uses a variable bandwidth, robustifies against outliers, and uses a local polynomial estimator to minimize boundary problems (Cameron and Trivedi, 2005).

I implement Lowess in two different ways. The first set of Lowess regressions is run on the pooled cross-section sample of plant-year observations using average plant wage and foreign equity participation. In the second set of Lowess regressions, I include plant level fixed effects in the model in (2.13). Accordingly, I transform my data into within-plant deviations before estimating the non-parametric model, which allows me to control for plant-specific effects. This means that the weighted least squares estimates are identified from the within-plant variation in each local regression. Hence, I am able to identify whether changes in the level of ownership at a multinational plant over time affect the level of wages at the same plant or not.

One can question whether the relationship identified by the nonparametric analysis is driven by some omitted variables. In order to overcome this concern, I next turn to a semiparametric analysis where additional controls enter the true model parametrically and are additively separable from the nonparametric component. Consider the partially linear model:

$$w_i = m(x_i) + \alpha' \mathbf{X}_i + \varepsilon_i, \quad i = 1, ..., N \tag{2.15}$$

where $\mathbf{X}_i$ is a vector of plant characteristics. I implement the difference-based semiparametric estimator of Yatchew (1997), whereby $m(.)$ is assumed to have a bounded first derivative. Yatchew (1997) suggests ordering the data such that $x_1 < x_2 < ... < x_N$ and taking the first difference of (2.15). The transformed equation is then estimable by ordinary least squares. First-differencing equation (2.15) allows inference to be carried out on α' as if there were no nonparametric component in the model. But once α' is estimated, a variety of nonparametric techniques could be applied to estimate $m(.)$ as if α' were known (Lokshin, 2006), that is, after constructing the differences $w_i - \hat{\alpha}'\mathbf{X}_i$. In my estimations, the nonlinear function $m(.)$ is estimated by the Lowess procedure outlined earlier, using a bandwidth of 0.8. Additionally, a significance test on x_i can be carried out, which tests the null hypothesis that the regression function has the known parametric form $g(x,\, \delta) + \alpha'\mathbf{X}_i$, where δ is an unknown parameter, against the alternative semiparametric form $m(x_i) + \alpha'\mathbf{X}_i$, where $m(.)$ is unknown. Lokshin (2006) provides details on the test.

2.4.3 Estimating the Foreign Equity Participation Premium

If there is evidence that censoring x_i returns biased estimates and that the true relationship is linear, then I can expect the regressions with continuous observations to provide more accurate estimates of the foreign ownership wage premium. In this subsection, I focus on quantifying the impact of foreign equity participation on average wages. For this purpose, I estimate the premium by running a set of regressions on the subset of plants that have been under multinational control at any point in the sample period. In this framework, I can test whether increases in foreign equity share translate into higher wages at the plant level.

Two considerations are in place here. First, cherry-picking of high paying domestic firms by foreign investors and the presence of unobservable firm characteristics require the inclusion of plant-level fixed effects to the econometric specification. Second, the assumption that foreign equity participation is independent of the idiosyncratic error term can be easily violated. While it is relatively easy to handle endogeneity that arises from unobserved heterogeneity, it is much harder to handle dynamic endogeneity whereby current and past levels of wages may affect the level of foreign ownership. In addition, endogeneity bias will arise if the level of foreign ownership responds simultaneously to idiosyncratic shocks and in the case of measurement error. This naturally calls for an instrumental variable estimation; yet, it is extremely difficult (if not impossible) to come up with a valid instrument in such plant level studies.

At this point, I take advantage of the panel data at hand to use exogenous regressors in other time periods to instrument for endogenous regressors in the current time period. Consider the dynamic model:

$$ln\, w_{ijt} = \gamma ln\, w_{ij,t-1} + \beta_1 FEP_{ijt} + \alpha' \mathbf{X}_{ijt} + \delta_i + \varepsilon_{ijt}, \;\; t = 2, ..., T \tag{2.16}$$

where δ_i denote time independent plant-level effects and we assume foreign equity participation, FEP_{ijt}, to be endogenous. It is assumed that $|\gamma| < 1$ and ε_{ijt} are serially uncorrelated. In order to tackle the endogeneity problem, one can first-difference the model in (2.16) to purge δ_i, which in addition renders lagged values of $ln\, w_{ijt}$ and x_{ijt} to be valid instruments in the transformed equation. Consistent and efficient estimation can then be achieved by GMM estimators that use all available lags at each period as instruments for the equations in first differences (Arellano and Bond, 1991). Blundell and Bond (1998) extend the Arellano-Bond estimator to include more instruments that are available by assuming that first differences of instrumenting variables are uncorrelated with the fixed effects, which greatly improves efficiency and reduces the finite sample bias. However, the estimator can easily generate a large number of instruments given the availability of lags and additional moment conditions, which will lead to an overfit of the endogenous variables that tends to distort inference in finite samples.[9] In order to guard against problems due to a large num-

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[9] The problem arises because a high number of instruments means a poorly estimated optimal weighting

ber of instruments, I estimate (2.16) both using all available lags (and differences) as instruments and with a restricted set of instruments (to two most immediate lags).

I implement the "system GMM" estimator of Blundell and Bond (1998) in a two-step procedure and apply the finite-sample correction of Windmeijer (2005) to the standard errors. Traditionally, researchers using these GMM estimators have focused on results for the one-step estimator, partly because simulation studies suggested very modest efficiency gains from using the two-step version (Bond, 2002). The two-step estimator also tends to return standard errors that are severely downward biased when the number of instruments is large. However, Windmeijer (2005) finds that the two-step efficient GMM estimator with the corrected variance estimate leads to more accurate inference compared to the one-step estimator. For this reason, I report estimates of the two-step procedure with the Windmeijer correction, but I also conducted the estimation with the one-step estimator as a robustness check. The results for the one-step estimator are very similar to the results reported here and available upon request in an additional appendix.

2.5 Results

2.5.1 Estimates with Different Thresholds

In my first set of regressions, I estimate equation (2.12) using a binary variable that specifies whether a plant is classified as foreign (i.e. $FDIPlant$ takes on the value of unity) depending on the level of foreign equity participation.[10] Table 2.1

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matrix in the GMM estimator. See Roodman (2008) for a discussion of how 'instrument proliferation' can lead to serious problems when implementing these GMM estimators.

[10] In each regression, I control for a set of plant-level characteristics. These are: log plant size (as measured by the total number of employees); skill intensity (given by the ratio of skilled workforce to total plant size); ratio of production workers to total plant size; log value added per worker (data on value added provided by TurkStat); log electricity used or log inputs; sector, year, and region dummies. Sector and region dummies are replaced by plant-level effects for FE regressions. I also estimated all reported specifications controlling for log inputs instead of log electricity and my results do not change. The full set of results for the OLS and FE regressions with various thresholds, including the estimates for the controls and regression diagnostics, can be found in Tables A3 and A4 in the Appendix.

documents the differences in the estimates of the wage premium when various thresholds are used. The threshold value used to define $FDIPlant$ is given in rows (a)-(d), while columns (1)-(3) present OLS estimates and columns (4)-(6) present FE estimates for the three wage variables of interest. For example, the figure in row (b) and column (1) indicates that the OLS estimate of the average plant wage premium to multinational status is 51 percent when a plant is defined as foreign if it has at least 15 percent foreign equity participation. Controlling for plant-level effects, however, reduces the estimate of the premium to 11 percent in row (b) and column (4) when the same threshold is applied.[11] It is immediate from this discrepancy that foreign investors acquire plants that already pay high wages, justifying the motivation to focus on a wage model with plant-specific effects.

Estimates from Table 2.1 indicate that the wage premium typically increases as the threshold level ϕ gets higher. This holds true of all the OLS estimates, for which the discrepancies between the estimated premia are greater across various thresholds. The average plant wage premium is estimated to be 48 percent (row (a), column (1)) when there are no thresholds, while it is estimated to be 57 percent (row (d), column (1)) when $\phi = 50\%$. This implies that 9 percent of the average plant wage premium is purely attributable to using different thresholds. When I repeat the same exercise for production and non-production workers, I see similar discrepancies between the estimated premia. The estimated premium ranges from 17 to 22 percent for production workers (column (2)) and from 37 to 45 percent for non-production workers (column (3)), suggesting a greater degree of heterogeneity in the premium

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[11] If foreign investors acquire plants that already pay higher wages than the rest of the domestic plants, then we should expect to see a modest wage premium to becoming multinational. This result is consistent with the results by Lipsey and Sjoholm (2006), Almeida (2007), and Heyman et al. (2007), who find a lower premium when they control for plant level effects. Almeida (2007) shows that foreign acquisitions have small effects, typically less than 2%, on average wages at the acquired firms when "cherry-picking" is taken into account.

for the latter group of workers.

The problems with inference on a censored variable become more apparent in the FE estimates of Table 2.1, columns (4)-(6). While the discrepancies between the premium estimates for different thresholds are smaller, column (5) shows that the statistical significance of the estimate can be affected by the threshold value. In column (5), the wage premium to production workers is consistently positive, yet it is significant only when $\phi = 15\%$ (row (b)). Moreover, while the OLS estimates demonstrate a higher premium when the threshold increases, the FE estimates in columns (5) and (6) do not display such monotonicity. Similar to OLS results, however, there is greater heterogeneity in the wage premium of non-production workers even after controlling for plant level effects. Column (6) indicates that the premium estimate for this group ranges from 18 to 25 percent. Hence, Table 2.1 shows that using different thresholds yields inconclusive evidence on whether there really exists a wage premium at foreign plants for all groups of workers, and even if so, how large this premium is.

As a further test of how different definitions of a foreign plant affect average plant wages, I divide the sample of plants in the data into four categories depending on the percentage of equity owned by the foreign investor. I assign a value of one to a plant that has foreign equity participation from the range of intervals that I specify and run a regression where I include these intervals simultaneously as independent variables.[12] The heterogeneity in the wage premium due to the level of foreign control is more pronounced in this set of regressions, reported in Table 2.2. Column (1) indicates that the average wage premium at a plant with at least 50 percent foreign equity participation is 58 percent, while it is 42 percent for a plant with foreign equity

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[12] The intervals are 0-15%, 16-30%, 31-50%, and 51-100%.

participation in the interval 31-50 percent, and 32 percent for a plant in the 15-30 percent interval. Controlling for plant-level effects, the estimated wage premia are 15 percent for plants with at least 50 percent foreign equity, and around 8 percent for other foreign plants (column (4)), which suggests that obtaining majority control creates an impact.

However, when I run the same regression for production and non-production workers separately, I see that the effect of equity participation can be nonmonotonic. In column (6), the estimated wage premia for non-production workers for the intervals 15-30 percent, 31-50 percent, and 51-100 percent are, 20 percent, 14 percent, and 28 percent, respectively. Hence, even after controlling for plant-level effects, up to 14 percent of the estimated wage premium can be explained by different levels of foreign equity participation. Consistent with earlier findings, column (5) shows that whether or not there is a wage premium for production workers is affected by the definition of multinational status. I find that there exists a premium (around 7 percent) for this group of workers only at plants that have at least 50 percent foreign equity participation.

These results indicate that the methodology followed in classifying a plant as foreign may significantly impact the estimated effect of foreign ownership on average wages. Censoring the foreign ownership variable in an arbitrary way hides the heterogeneity in the wage premium due to the level of foreign equity participation. Moreover, this heterogeneity may exist only for a certain group of workers, and such information will be lost when econometric analysis is carried out with binary data.

2.5.2 Nonparametric and Semiparametric Estimates

The results from the previous section suggest a monotonic and positive relationship between foreign equity participation and average wages, however there is also some evidence indicating nonlinearities. In order to see the true shape of the relationship, Lowess plots of equation (2.13) are presented in Figures 4 and 5, which use the subset of plants that have been under foreign ownership at some point in the sample period. Figure 2.4 depicts the relationship between foreign equity participation at the plant level versus (log) average wages in the pooled sample. Panel (a), which shows the relationship for the average plant wage, indicates an upward sloping Lowess plot line that is almost exactly the same as the linear fit. In panels (b) and (c), a similar relationship is observed for the (log) average wage of production workers and non-production workers, respectively. In all of the panels, the nonparametric fit displays an upward trend. One can also see from panels (b) and (c) that there is a larger dispersion of wages at all levels of foreign equity participation for non-production workers compared to production workers.

If foreign investors acquire higher fractions of equity at domestic plants that pay higher wages to start with, then this sort of a selection mechanism could drive the relationship in Figure 2.4. To guard against such selection, Figure 2.5 presents the Lowess estimates that control for plant level effects. I plot average wages against the deviations from the within-plant mean value of foreign equity participation.[13] Panel (a) shows that higher levels of foreign equity participation are associated with higher average plant wages, even when the multinational status of a plant is unchanged. This

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[13] Notice that most of the deviations from within-plant mean equity participation are positive and away from zero. This means that not only do levels of foreign ownership change at a plant over the sample period, but also that most of these changes constitute increases in the foreign ownership level. This highlights the importance of using uncensored versions of the foreign ownership variable, as the information from changes to the level of foreign ownership within the firm is lost when censored variables are used.

means that it is not simply being foreign that brings a premium with it, but also that the size of this premium increases with the level of foreign equity paticipation. Similar to the finding in Figure 2.4, the Lowess estimates with fixed effects are roughly in line with the linear fit. Panels (b) and (c) show that the monotonic and positive relationship holds likewise for average production and non-production worker wages.

It is possible that the observed relationship between average wages and foreign equity participation is driven by some omitted factors. For instance, Aitken and Harrison (1999) find that foreign equity participation is positively correlated with plant productivity as measured by (log) output. If foreign plants pay their workers competitively, then this positive correlation should also be reflected in average wages. Figure 2.6 shows the Lowess estimates of $m(x_i)$ in equation (2.15) using the difference based semiparametric estimator of Yatchew (1997), which control for additional plant characteristics such as (log) value added per worker. The coefficient estimates from the difference-based semiparametric regression of (2.15) for the three different groups of workers are reported in Table 2.11 in the Appendix, along with the significance test of the nonparametric variable under the V-stat.

Panels (a) and (c) of Figure 2.6 confirm the earlier findings that average plant wages and average wages for non-production workers increase monotonically with foreign equity participation. The significance tests reported in Table 2.11 indicate that foreign equity participation is highly significant for average plant and average non-production worker wages, with both tests delivering a p-value of zero (V-stats are 21.064 and 9.402, respectively). While the significance test for average production worker wages also returns a p-value of zero (V-stat is 5.850), panel (b) of Figure 2.6 casts doubt on a linear relationship for this group of workers. The estimated Lowess plot line in panel (b) is fairly flat and shows only a slight upward trend at the high end of the foreign ownership distribution. Compared to the nonparametric estimates of Figures 4 and 5, this implies that any linear relationship between wages of production workers and the level of foreign ownership is driven by other plant characteristics, such as productivity or skill composition. These results suggest that the level of foreign ownership significantly impacts the wage premium for non-production workers but it has minimal impact for production workers. Accordingly, the monotonic relationship between average plant wages and level of foreign ownership is likely to be driven by the wage premium for non-production workers only.

2.5.3 Estimates with Uncensored Regressors

My earlier results suggest that the size of the wage premium is affected by the level of foreign ownership. This subsection presents accurate estimates of the wage premium from the model in (2.16) with uncensored regressors, which not only controls for plant level effects, but also accommodates the endogeneity of foreign ownership and control variables.

My preferred set of results from system GMM estimation are reported in Table 2.3, where I treat all right hand side variables as potentially endogenous. This specification generates GMM style instruments for all right hand side variables, which results in close to two hundred instruments in some cases. While a larger number of instruments tends to increase efficiency, using deeper lags as instruments may weaken the strength of the instruments. In addition, instrument proliferation undermines the Hansen test, which is typically used to check instrument validity. Estimates using all available lags for the instrument set are given in columns (1), (3), and (5), while estimates using the restricted subset of instruments to the two most immediate lags are given in columns (2), (4), and (6).[14]

The main result that comes out of Table 2.3 is that there exists a positive and significant relationship between foreign equity participation and average wages only for non-production workers. Column (5) indicates that a 10 percent increase in foreign equity participation leads to a 4 percent increase in the average non-production worker wage. Restricting the instrument set to lags three and four in column (6) yields an estimate of 5 percent. In the case where a plant goes from domestic ownership to being completely foreign owned (i.e. FEP goes from 0 to 100 percent), columns (5) and (6) predict the wage premium for non-production workers to be between 39 and 54 percent. Once we take into account the endogeneity of the foreign ownership variable, there is no longer an average plant wage premium due to the level of foreign ownership. This result contrasts with the FE estimates from Tables 1 and 2, which return a positive and significant foreign ownership premium for the average plant wage. Hence, simply controlling for unobserved heterogeneity at the plant level and failing to take into account other sources of endogeneity may generate considerably different results.[15]

My estimates reported in Table 2.3 confirm earlier findings that non-production workers are the primary beneficiaries of foreign ownership. Unlike previous studies, however, I do not find a significant wage premium for production workers, as seen from columns (3) and (4). In addition, my estimates for the hypothetical case for a plant being completely foreign owned yield larger estimates compared to earlier

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[14] Consistent estimation of equation (2.16) relies on the assumption that the idiosyncratic errors are serially uncorrelated. Test statistics for this assumption are given in Table 2.3 as *m1*, *m2*, and *m3* in terms of their p-values, which are tests proposed by Arellano and Bond (1991) to detect first-order, second-order, and third-order serial correlation in the *differenced* equation. Since the Arellano-Bond test statistics in Table 2.3 reveal second-order serial correlation, I restrict the instrument set to lags three and deeper.

[15] Note that the point I make here is not due to censoring, but due to endogeneity only. A fixed effects regression with the uncensored foreign ownership variable, not reported here, returns a significant estimate, while controlling for endogeneity via system GMM removes this significance.

findings and they provide an upper bound on the estimated premium. This is due to the continuous nature of my foreign investment variable. For example, column (5) suggests that a domestic plant at which a foreign investor owns 20 percent of the equity will see the average non-production worker wage to be only 8 percent higher. However, if the foreign investor owns 80 percent of the equity, then the estimated wage premium is 32 percent. While the plant would be classified as multinational under both cases, there is a significant difference between the wage premia depending on how much of the plant equity is foreign owned. As can be seen from Figure 2.1, most foreign plants in Turkey have a partial degree of foreign control; the wage premia across these plants will therefore be uneven. As a result, previous studies most likely capture some estimate that lies in the range reported here and thus hide the heterogeneity in the wage premium that arises due to different levels of control.

The coefficient estimates for the controls in Table 2.3 are as expected, except for (log) plant size, which seem susceptible to the specification of the instrument set. The composition of the instrument set also affects the test statistics I use to check instrument validity. The Hansen test statistics in Table 2.3 cannot reject the null hypothesis that the set of GMM instruments used in estimation is valid, although a large number of instruments tends to reduce the power of this test. I therefore report additionally the Sargan test of overidentifying restrictions and the Arellano and Bond (1991) test statistics for serial correlation. Both of these additional tests suggest that the sets of instruments used in the regressions are valid, although the Sargan test rejects their validity in columns (4) and (6) at the one percent confidence level.[16]

Higher levels of foreign ownership may lead to higher wage premia if plants with majority foreign control are inherently different than plants with minority control. This could arise, for instance, if majority foreign equity participation is required for bringing in technologies from the parent firm (Lipsey and Sjoholm, 2006). In addition, Arnold and Javorcik (2009) suggest that foreign owners may substitute expatriate staff for local managers and introduce pay scales linked to performance. Gaining majority control at a plant is likely to lead to such reshuffling of the plant's labor force, especially at the administrative level, and possibly more on the job training. In order to test for such "sheepskin effects," I estimate equation (2.16) with an additional control, which is a dummy variable indicating majority ownership. The results from this exercise are reported in Table 2.4, where all right hand side variables are assumed to be endogenous.

The main result that there exists a significant wage premium only for non-production workers is confirmed by Table 2.4. Having majority control is far from being statistically significant in all my regressions. Column (5) indicates that conditional on having majority control, a 10 percent increase in foreign equity participation is associated with a 7 percent increase in the average wage of a non-production worker. A plant that is completely owned by foreign investors is predicted to have a wage premium of 39 percent, which matches the estimate from the same column of Table 2.3. Column (6) in Table 2.4 predicts the same wage premium to be 53 percent. The test statistics for instrument validity cannot reject the null hypothesis

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[16] Roodman (2006) argues that the Sargan and Hansen tests should not be relied upon too faithfully as they are prone to weakness. While the Sargan test is not vulnerable to instrument proliferation as is the Hansen test, it requires homoskedastic errors for consistency, which is rarely the case in plant level studies. Arellano and Bond (1991) also report greater power for their own proposed tests in identifying whether serial correlation renders lagged instruments invalid when compared to the Sargan and Hansen tests.

of exogenous instruments at the five percent confidence level, except for the Sargan statistic in columns (4) and (6). These results show that the positive relationship between average wages of non-production workers and the level of foreign ownership is not driven by plants under majority foreign control.

Tables 3 and 4 document that average wages of production workers are unaffected by the level of foreign control. In order to check whether such a relationship is truly nonexistent, I estimate the model in (2.16) with a different dependent variable. Instead of using the average yearly wage, I use the average hourly wage for production workers to calculate the wage premium. Using hourly wage data has the advantage of controlling for overtime work and can better capture the competitive wage.[17] Additionally, one reason I don't find a significant wage premium for production workers might be if foreign plants employ a greater fraction of their production workers on temporary contracts. Table 2.A6 in the Appendix shows the results of this exercise.[18] Consistent with my earlier estimates, I find no significant premium for production workers in all of the specifications. However, I should note that both Sargan and Hansen test statistics strongly reject the validity of the instruments, which casts doubt on the reliability of these estimates.

The findings that only non-production workers benefit from multinational activity and that the wage premium depends on the level of foreign ownership can help identify which of the channels previously mentioned in the literature are at work. Arnold and Javorcik (2009) argue that while foreign owners do not alter the skill composition of labor at acquired plants, they are able to attract more experienced and

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[17] One reason we are observing higher wages at foreign plants might be that workers at foreign plants might be working longer hours on a given workday or might be taking leave on a less frequent basis than their counterparts at domestic plants.

[18] The dynamic specification for this wage series seems to be clear of first-order serial correlation as suggested by the Arellano-Bond test statistic *m2*. Therefore, I also present results from regressions that use second lags and deeper as their set of instruments.

motivated workers. My results suggest that multinationals attract such workers only for white collar jobs and that higher foreign equity participation is likely to reshuffle the labor force engaged in administrative work. Moreover, I interpret my findings as providing evidence for profit-sharing arguments at multinational plants. According to this branch of the literature, multinationals can afford to pay higher wages to their workers if foreign ownership is associated with higher productivity and profitability.[19] Aitken and Harrison (1999) and Takii and Ramstetter (2005) provide some evidence for the positive relationship between foreign equity participation and productivity, which seems to be the driver behind the wage premia observed at multinational plants. However, my results suggest that profit sharing within a multinational is limited to non-production workers.

Although some existing studies consider the impact of the level of foreign ownership on the wage premium, they do not find conclusive evidence. Using panel data from Indonesian manufacturing, Lipsey and Sjoholm (2006) find that while both majority- and minority-owned foreign plants pay higher wages than domestic plants, majority-owned plants pay higher wages for white-collar workers but lower wages for blue-collar workers. However, the authors argue that none of the differences between the foreign majority and minority wages are significant at the 5% level. A similar result is reported by Aitken et al. (1996), who find, using data from Venezuela, that skilled workers receive around 4 percent higher wages at majority-owned plants compared to minority-owned plants. Hence, the current study is the first in the literature to identify systematic heterogeneity in the wage premium due to different levels of foreign ownership.

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[19] See, for instance, Egger and Kreickemeier (2010).

Robustness Checks

System GMM estimates are usually sensitive to the assumptions made about the variables of interest and other controls with regard to their exogeneity. These assumptions determine how the right hand side variables enter the instrument matrix in the construction of the GMM estimator and thus directly affect the number of instruments created. I previously assumed that the control variables in (2.16), such as skill intensity and (log) value added per worker, are potentially endogenous. This results in a large number of instruments, which can lead to an overfitting of the variables of interest. In my first round of robustness checks, I therefore provide estimates for the model where additional controls are treated as exogenous, which greatly reduces the number of instruments used in estimation.[20] The results from the baseline model in (2.16) with exogenous controls are reported in Table 2.5. Note that foreign equity participation is still assumed to be endogenous.

Table 2.5 confirms the main findings from the previous section, but point estimates for some variables of interest differ significantly from those in Table 2.3. I again find that foreign equity participation significantly affects the average wages of non-production workers only, but with a higher premium. Columns (5) and (6) indicate that a 10 percent increase in foreign ownership leads to an increase in the average non-production worker wage by 5.4 and 6.9 percent, respectively. The results for the controls are generally similar to the ones in Table 2.3, except for plant size. Under the assumption of exogeneity, plant size is negatively associated with the average plant wage (columns (1) and (2)), yet it generates a positive and significant wage

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[20] Strict exogeneity rules out any feedback from current or past shocks to current values of the variable, which is often not a natural restriction in the context of economic models relating to several jointly determined outcomes (Bond, 2002). While one can imagine a case where the level of foreign ownership and the skill intensity of the employees at a plant are determined concurrently, it is not as straightforward to assume that the former variable will be determined at the same time as, for instance, plant size or inputs.

premium for non-production workers (columns (5) and (6)). The Arellano-Bond test statistics confirm the presence of second-order serial correlation, justifying the use of third lags and deeper for the instrument set. However, the Sargan and Hansen statistics for overidentifying restrictions point to weaker instrument validity. This is despite the finding that the coefficients for the lagged wage term in Table 2.5 are typically high, which corroborates the use of a system GMM estimator as opposed to the simpler difference estimator.

I repeat the same robustness exercise, this time including a dummy variable indicating majority control.[21] The results, reported in Table 2.6, confirm my earlier findings. Columns (5) and (6) predict that the wage premium at a plant with 100 percent foreign equity participation is 53 and 66 percent, respectively, which are much higher estimates compared to the results in Table 2.4. The Hansen and Sargan test statistics in Table 2.6 point to weaker instrument validity, although the Arellano-Bond test statistics validate the use of third lags and deeper. As a result, treating right hand side controls in the dynamic wage model as exogenous overestimates the wage premium and undermines instrument validity. This is also suggested by Table 2.13, which shows the results for the average hourly wage for production workers when controls are assumed to be exogenous. The estimates for FEP and $Log\,Wage_{t-1}$ are highly susceptible to instrument specification for this wage series, as demonstrated in the results across columns (1)-(4). Column (2) finds a marginally significant and positive effect of the level of foreign ownership on average hourly wages. However, both Sargan and Hansen test statistics strongly reject the validity of the instruments used in the estimation.

In a second round of robustness checks, I repeat all of the system GMM estima-

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[21] Differently from the other controls, however, majority control is assumed to be endogenous.

tions reported here using a one-step estimator, which is not subject to the critique of downward biased standard errors in small samples.[22] The one-step results confirm my earlier findings and provide similar estimates for the wage premium for non-production workers. The estimated coefficients on FEP are almost identical for non-production workers regardless of whether the instrument set uses all available lags or is restricted to the two most recent lags, and they suggest a wage premium of 5 percent for a 10 percenage point increase in foreign equity participation. Interestingly, the one-step results yield a negative and significant estimate for majority control when the indicator variable is estimated along with the baseline dynamic model.[23]

2.6 Conclusion

A large empirical literature has identified a persistent and significant difference between average wages at multinational firms compared to their domestic counterparts. There exists a wage premium to being multinational even after controlling for selection effects whereby foreign investors cherry-pick the plants they acquire. At the time of acquisition or subsequently, the individual characteristics and experiences of foreign investors are likely to impact the degree of control they want to exercise. The level of control that foreign owners choose at newly acquired plants may also have differential effects for its production and non-production workers. This requires that empirical studies that explore the relationship between wages and foreign ownership would be better equipped if they explicitly consider different levels of foreign

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[22] These results are available upon request in an additional appendix.

[23] As a further test of whether my results are driven by the variation in foreign ownership at a certain subset of foreign plants, I experimented with system GMM regressions of the dynamic wage model in (2.16) using only the subsamples of plants under minority and majority control separately. However, this exercise runs into the problem of cutting the sample of plants used in estimation by around a half. As a result, the number of plants (groups) used in the GMM estimation gets closer to the number of instruments generated, which severely distorts inference. In my estimations on each subsample, I frequently observe a Hansen test statistic of 1.0, which indicates the severity of this problem.

equity participation and account for the endogeneity of foreign ownership. Most of the previous literature worked with binary variables to indicate foreign ownership, which might mislead researchers' understanding of the impact of foreign ownership on wages. Estimation with censored variables on the right hand side returns biased results even after controlling for individual level effects. One implication is that one cannot readily compare estimates from country studies with each other, as the distribution of foreign ownership shares across firms and thresholds used in the definitions of foreign ownership are likely to vary across countries.

My results provide more accurate estimates of the effect of foreign ownership on wages by using continuous data for the variable under study at the same time as controlling for endogeneity. This allows me to identify the heterogeneity in the wage premium that arises due to different levels of foreign equity participation. I estimate that a 10 percentage point increase in the level of foreign ownership is associated with about a 4% increase in the average wage of a non-production worker. My results suggest that the identified wage premium at multinationals is primarily driven by higher pay for the non-production workers. I do not find a wage premium for production workers across a variety of empirical settings. In addition, failing to address the endogeneity of foreign ownership returns misestimates of the wage premium. A more informed choice of explanatory variables and econometric specification are thus crucial to better understand both the impact and the size of the foreign ownership wage premium. The heterogeneity identified in this paper also raises several issues for further research, especially theoretical models of foreign direct investment. Why are higher levels of foreign equity participation associated with higher wages? In addition, why is such a relationship only observed for non-production workers? Future research that investigates these questions would be welcome.

Table 2.1: OLS and FE Results: Wages and Multinational Status Defined at Various Thresholds
Dependent Variable: Log Average Yearly Wage

		OLS Estimates			FE Estimates		
		All Workers	Production Workers	Non-production Workers	All Workers	Production Workers	Non-production Workers
Foreign Equity Participation Threshold		(1)	(2)	(3)	(4)	(5)	(6)
0%	(a)	.4839	.1708	.3728	.1121	.0441	.1802
		(.0212)***	(.0164)***	(.0217)***	(.0214)***	(.0270)	(.0409)***
15%	(b)	.5064	.1839	.4046	.1144	.0468	.2142
		(.0228)***	(.0176)***	(.0233)***	(.0224)***	(.0280)*	(.0427)***
30%	(c)	.5246	.1946	.4133	.1165	.0376	.2001
		(.0242)***	(.0188)***	(.0251)***	(.0241)***	(.0288)	(.0461)***
50%	(d)	.5677	.2167	.4513	.1354	.0611	.2505
		(.0293)***	(.0235)***	(.0311)***	(.0307)***	(.0398)	(.0595)***

Notes: This table reports the coefficient estimates for the censored foreign ownership variable in the model in (2.12). The full set of results for the OLS and FE regressions are in the Appendix, Tables A3 and A4, respectively. All standard errors are corrected for heteroskedasticity, clustered at the plant level. Coefficients are given in the first line; standard errors in parentheses; *, **, *** indicate significance at the 10%, 5% and 1% level, respectively. All regressions include (log) plant size, skill intensity, ratio of production workers, (log) value added per worker, and (log) electricity as controls. OLS regressions include sector, region, and year dummies, and FE regressions include individual plant effects and year dummies as additional controls.

Table 2.2: OLS and FE Results: Wages and Multinational Status Defined at Various Intervals
Dependent Variable: Log Average Yearly Wage

	OLS Estimates			FE Estimates		
	All Workers	Production Workers	Non-production Workers	All Workers	Production Workers	Non-production Workers
	(1)	(2)	(3)	(4)	(5)	(6)
FDI dummy	.3231	.0864	.3033	.0775	.0625	.2008
(interval 15-30%)	(.0469)***	(.0376)**	(.0514)***	(.0342)**	(.0598)	(.0998)**
FDI dummy	.4191	.1440	.3220	.0850	.0131	.1351
(interval 31-50%)	(.0377)***	(.0294)***	(.0399)***	(.0268)***	(.0417)	(.0619)**
FDI dummy	.5846	.2221	.4656	.1530	.0662	.2817
(interval 51-100%)	(.0294)***	(.0236)***	(.0311)***	(.0320)***	(.0396)*	(.0603)***
Log Plant Size	.1977	.0628	.0962	.0138	-.0246	.0141
	(.0038)***	(.0042)***	(.0059)***	(.0056)**	(.0067)***	(.0099)
Skill Intensity	.0040	.0067	.0037	.0003	.0051	.0017
	(.0001)***	(.0002)***	(.0002)***	(.0001)***	(.0002)***	(.0002)***
Ratio of Production	.0008	.0083	.0116	-.0006	.0070	.0102
Workers	(.0003)**	(.0024)***	(.0037)***	(.0005)	(.002)***	(.0035)***
Log Value Added per	.2013	.0673	.0756	.0897	.0364	.0241
Worker	(.0037)***	(.0028)***	(.0035)***	(.0025)***	(.0029)***	(.0040)***
Log Electricity	.0093	.1091	.1363	.0043	.1223	.1524
	(.0013)***	(.0026)***	(.0041)***	(.0009)***	(.0026)***	(.0041)***
Model Effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.9151	0.8956	0.8416	0.8684	0.8847	0.8292
N	91,555	91,392	80,975	91,555	91,392	80,975

Notes: All standard errors are corrected for heteroskedasticity, clustered at the plant level. Coefficients are given in the first line; standard errors in parentheses; *, **, *** indicate significance at the 10%, 5% and 1% level, respectively. Model effects include sector, region, and year dummies for the OLS regressions, and individual plant effects and year dummies for the FE regressions. All regressions include a constant term. Reference category: FDI dummy (interval 0-15%).

Table 2.3: Two-Step System GMM Results: Wages and Foreign Ownership (Endogenous Controls)
Dependent Variable: Log Average Yearly Wage

	All Workers		Production Workers		Non-Production Workers	
	(1)	(2)	(3)	(4)	(5)	(6)
Log Wage $_{t-1}$	.6898	.7395	.3378	.3303	.3880	.4152
	(.0554)***	(.0630)***	(.0521)***	(.0646)***	(.0592)***	(.0749)***
Foreign Equity Participation	.0005	-.00008	.0013	.0007	.0039	.0054
(%)	(.0006)	(.0008)	(.0008)	(.0011)	(.0011)***	(.0013)***
Log Plant Size	.0078	.0445	.0477	.1432	-.0341	-.0333
	(.0277)	(.0338)	(.0528)	(.0649)**	(.0688)	(.0832)
Skill Intensity	.0031	.0039	.0082	.0084	.0040	.0047
	(.0009)***	(.0011)***	(.0019)***	(.0025)***	(.0023)*	(.0026)*
Ratio of Production Workers	.0028	-.0015	.0985	.1025	.0763	.0753
	(.0085)	(.0097)	(.0389)**	(.0475)**	(.0232)***	(.0198)***
Log Value Added per Worker	.1048	.0928	.1788	.2122	.1091	.0247
	(.0334)***	(.0480)*	(.0507)***	(.0745)***	(.0765)	(.0957)
Log Input	.0289	-.0037	.1065	.0431	.1668	.1893
	(.0287)	(.0372)	(.0450)**	(.0567)	(.0692)**	(.0870)**
m1 (Pr>z)	0.000	0.000	0.000	0.000	0.000	0.000
m2 (Pr>z)	0.017	0.018	0.117	0.144	0.015	0.017
m3 (Pr>z)	0.736	0.791	0.219	0.209	0.801	0.902
Sargan	0.036	0.032	0.122	0.001	0.109	0.005
Hansen	0.424	0.610	0.314	0.146	0.141	0.154
Number of Instruments	197	127	197	127	197	127
Instrument Set	lags 3+	lags 3 and 4	lags 3+	lags 3 and 4	lags 3+	lags 3 and 4
N	3513	3513	3484	3484	3233	3233

Notes: Year dummies and a constant term included in all models. Controls treated as *endogenous*. Robust standard errors in parentheses, clustered at the plant level and adjusted for Windmeijer's correction; *, **, *** indicate significance at the 10%, 5% and 1% level, respectively. m1, m2, and m3 are Arellano-Bond tests for first-order, second-order, and third-order serial correlation, asymptotically $N(0,1)$. Sargan and Hansen are tests of the overidentifying restrictions for the GMM estimators, asymptotically χ^2; p-value is reported. These tests use the minimized value of the corresponding two-step GMM estimators.

Table 2.4: Two-Step System GMM Results: Wages and Foreign Majority Ownership (Endogenous Controls)
Dependent Variable: Log Average Yearly Wage

	All Workers		Production Workers		Non-Production Workers	
	(1)	(2)	(3)	(4)	(5)	(6)
Log Wage $_{t-1}$	.6675	.7280	.3375	.3255	.3667	.4265
	(.0525)***	(.0627)***	(.0537)***	(.0646)***	(.0588)***	(.0723)***
Foreign Equity Participation	.0003	.0014	.0027	.0031	.0072	.0081
(%)	(.0011)	(.0014)	(.0021)	(.0027)	(.0025)***	(.0030)***
Majority Share Dummy	.0218	-.1042	-.1204	-.2354	-.3285	-.2766
	(.0809)	(.1030)	(.1711)	(.2261)	(.2055)	(.2410)
Log Plant Size	.0068	.0443	.0496	.1326	-.0458	-.0465
	(.0257)	(.0327)	(.0498)	(.0620)**	(.0713)	(.0816)
Skill Intensity	.0029	.0039	.0078	.0076	.0033	.0041
	(.0009)***	(.0010)***	(.0019)***	(.0025)***	(.0023)	(.0027)
Ratio of Production Workers	.0015	-.0028	.0970	.1019	.0768	.0760
	(.0085)	(.0098)	(.0390)**	(.0490)**	(.0249)***	(.0208)***
Log Value Added per Worker	.1187	.0889	.1780	.2299	.1185	.0285
	(.0307)***	(.0421)**	(.0494)***	(.0725)***	(.0756)	(.0893)
Log Input	.0298	-.0005	.0997	.0387	.1738	.1841
	(.0256)	(.0346)	(.0421)**	(.0568)	(.0666)***	(.0807)**
m1 (Pr>z)	0.000	0.000	0.000	0.000	0.000	0.000
m2 (Pr>z)	0.017	0.019	0.127	0.170	0.020	0.013
m3 (Pr>z)	0.681	0.789	0.203	0.190	0.746	0.879
Sargan	0.090	0.127	0.065	0.000	0.156	0.006
Hansen	0.384	0.651	0.188	0.094	0.180	0.230
Number of Instruments	224	144	224	144	224	144
Instrument Set	lags 3+	lags 3 and 4	lags 3+	lags 3 and 4	lags 3+	lags 3 and 4
N	3513	3513	3484	3484	3233	3233

Notes: Year dummies and a constant term included in all models. Controls treated as *endogenous*. Robust standard errors in parentheses, clustered at the plant level and adjusted for Windmeijer's correction. See notes to Table 2.3.

Table 2.5: Two-Step System GMM Results: Wages and Foreign Ownership (Exogenous Controls)
Dependent Variable: Log Average Yearly Wage

	All Workers		Production Workers		Non-Production Workers	
	(1)	(2)	(3)	(4)	(5)	(6)
Log Wage $_{t-1}$	.6181	.6496	.5095	.5114	.5124	.5317
	(.0988)***	(.0961)***	(.0566)***	(.0634)***	(.0755)***	(.0846)***
Foreign Equity Participation	.0014	.0011	.0016	.0008	.0054	.0067
(%)	(.0009)	(.0011)	(.0013)	(.0015)	(.0018)***	(.0020)***
Log Plant Size	-.0294	-.0280	.0249	.0274	.0466	.0467
	(.0149)**	(.0147)*	(.0186)	(.0195)	(.0242)*	(.0234)**
Skill Intensity	.0018	.0017	.0085	.0087	.0032	.0029
	(.0006)***	(.0006)***	(.0011)***	(.0011)***	(.0013)**	(.0013)**
Ratio of Production Workers	.0021	.0020	.0942	.0941	.1156	.1159
	(.0049)	(.0047)	(.0225)***	(.0220)***	(.0297)***	(.0274)***
Log Value Added per Worker	.1041	.1026	.0697	.0720	.0916	.0855
	(.0231)***	(.0225)***	(.0198)***	(.0208)***	(.0243)***	(.0241)***
Log Input	.0660	.0591	.0535	.0527	.0553	.0524
	(.0163)***	(.0162)***	(.0156)***	(.0168)***	(.0200)***	(.0198)***
m1 (Pr>z)	0.000	0.000	0.000	0.000	0.000	0.000
m2 (Pr>z)	0.040	0.042	0.021	0.021	0.011	0.014
m3 (Pr>z)	0.729	0.765	0.184	0.193	0.883	0.842
Sargan	0.007	0.001	0.089	0.002	0.000	0.000
Hansen	0.070	0.029	0.011	0.000	0.006	0.004
Number of Instruments	67	47	67	47	67	47
Instrument Set	lags 3+	lags 3 and 4	lags 3+	lags 3 and 4	lags 3+	lags 3 and 4
N	3513	3513	3484	3484	3233	3233

Notes: Year dummies and a constant term included in all models. Controls treated as *exogenous*. Robust standard errors in parentheses, clustered at the plant level and adjusted for Windmeijer's correction. See notes to Table 2.3.

Table 2.6: Two-Step System GMM Results: Wages and Foreign Majority Ownership (Exogenous Controls)
Dependent Variable: Log Average Yearly Wage

	All Workers		Production Workers		Non-Production Workers	
	(1)	(2)	(3)	(4)	(5)	(6)
Log Wage $_{t-1}$	.5892	.6574	.4669	.4815	.4510	.5045
	(.0840)***	(.0873)***	(.0599)***	(.0631)***	(.0768)***	(.0821)***
Foreign Equity Participation	.0013	.0018	.0044	.0042	.0087	.0106
(%)	(.0014)	(.0016)	(.0027)	(.0030)	(.0032)***	(.0034)***
Majority Share Dummy	.0171	-.0523	-.1861	-.2810	-.3358	-.4008
	(.1011)	(.1269)	(.2145)	(.2412)	(.2556)	(.2562)
Log Plant Size	-.0248	-.0267	.0239	.0269	.0454	.0393
	(.0151)	(.0147)*	(.0194)	(.0199)	(.0239)*	(.0234)*
Skill Intensity	.0020	.0017	.00837	.0085	.0038	.0033
	(.0005)***	(.0006)***	(.0012)***	(.0011)***	(.0013)***	(.0013)***
Ratio of Production Workers	.0023	.0020	.0941	.0957	.1216	.1173
	(.0046)	(.0045)	(.0227)***	(.0233)***	(.0322)***	(.0290)***
Log Value Added per Worker	.1097	.1018	.0703	.0812	.1050	.0922
	(.0214)***	(.0213)***	(.0202)***	(.0208)***	(.0242)***	(.0241)***
Log Input	.0664	.0559	.0560	.0511	.0606	.0559
	(.0138)***	(.0144)***	(.0163)***	(.0172)***	(.0206)***	(.0202)***
m1 (Pr>z)	0.000	0.000	0.000	0.000	0.000	0.000
m2 (Pr>z)	0.037	0.037	0.039	0.034	0.019	0.014
m3 (Pr>z)	0.691	0.770	0.161	0.165	0.984	0.945
Sargan	0.091	0.025	0.079	0.001	0.002	0.000
Hansen	0.102	0.111	0.004	0.001	0.017	0.021
Number of Instruments	94	64	94	64	94	64
Instrument Set	lags 3+	lags 3 and 4	lags 3+	lags 3 and 4	lags 3+	lags 3 and 4
N	3513	3513	3484	3484	3233	3233

Notes: Year dummies and a constant term included in all models. Controls treated as *exogenous*. Robust standard errors in parentheses, clustered at the plant level and adjusted for Windmeijer's correction. See notes to Table 2.3.

Figure 2.1: Censoring the Level of Foreign Ownership

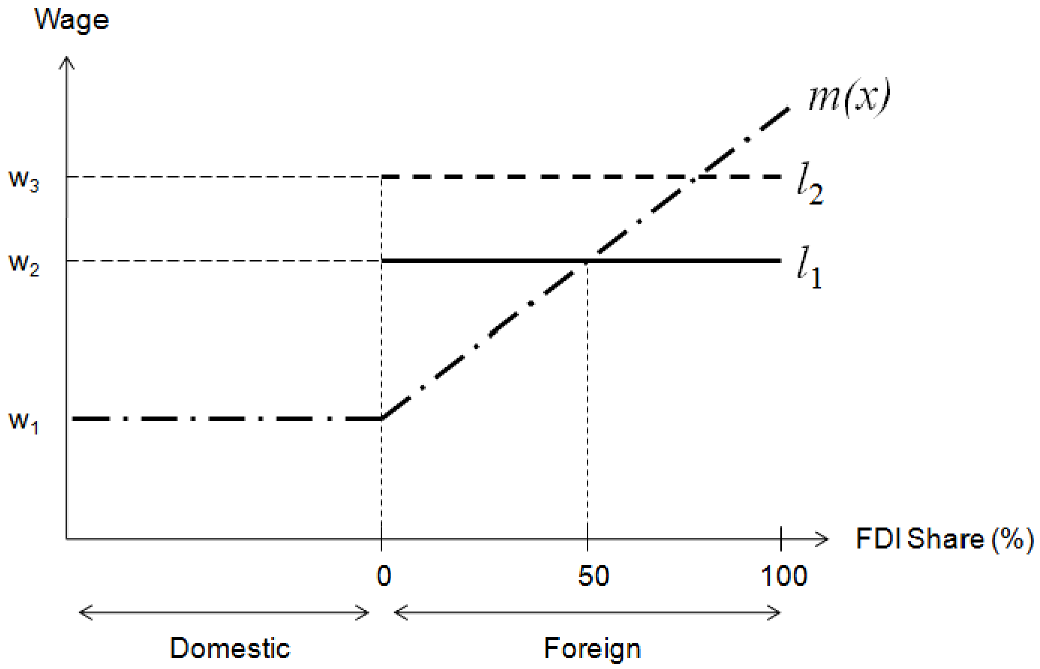
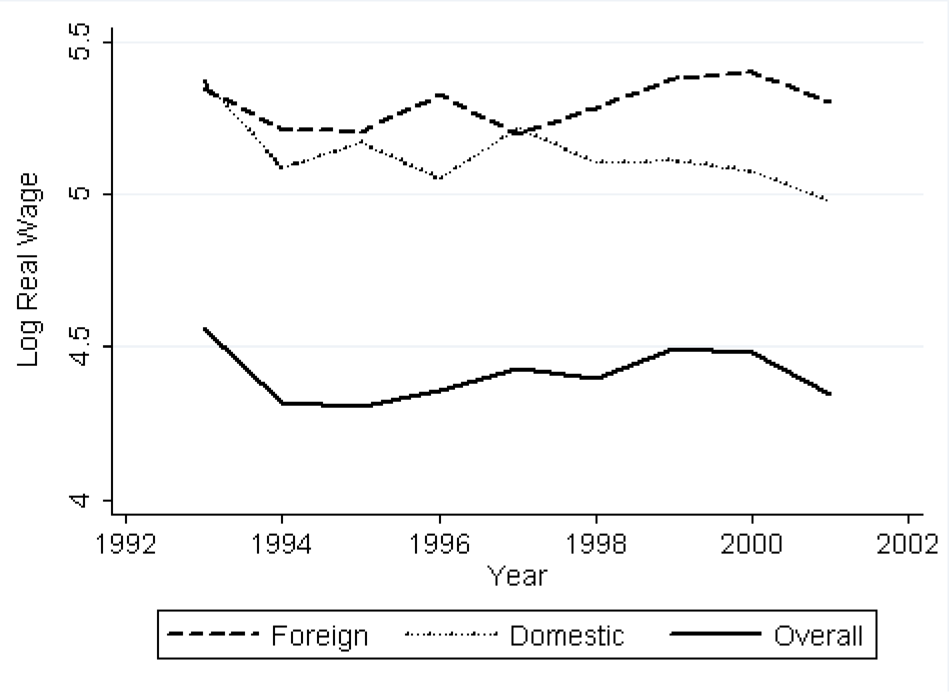


Figure 2.2: Distribution of Foreign Ownership Shares at the Plant Level, 1993-2001

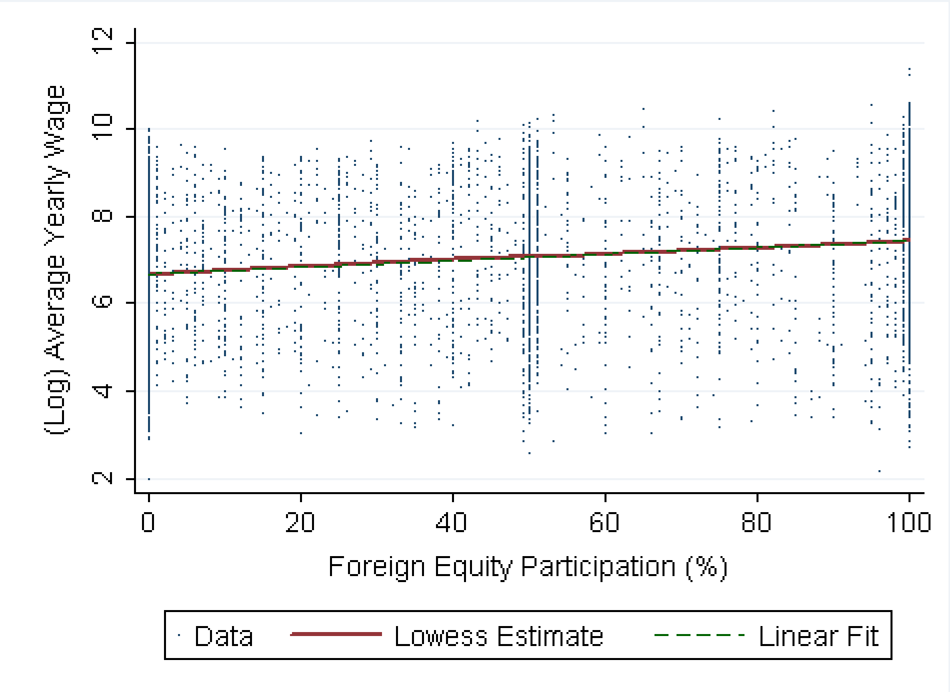
Figure 2.3: Comparison of Wages Across Plants that Experienced a Takeover



Notes: "Foreign" and "Domestic" refer to plants that were subject to a foreign takeover at one point in the sample period and depict wages at these plants when they were under foreign and domestic control, respectively. "Overall" depicts the pattern from the pooled sample of all plants.

Figure 2.4: Nonparametric Estimates of the Relationship between Average Yearly Wage and Share of Foreign Ownership: Pooled OLS Regression

(a) All Workers



(b) Production Workers

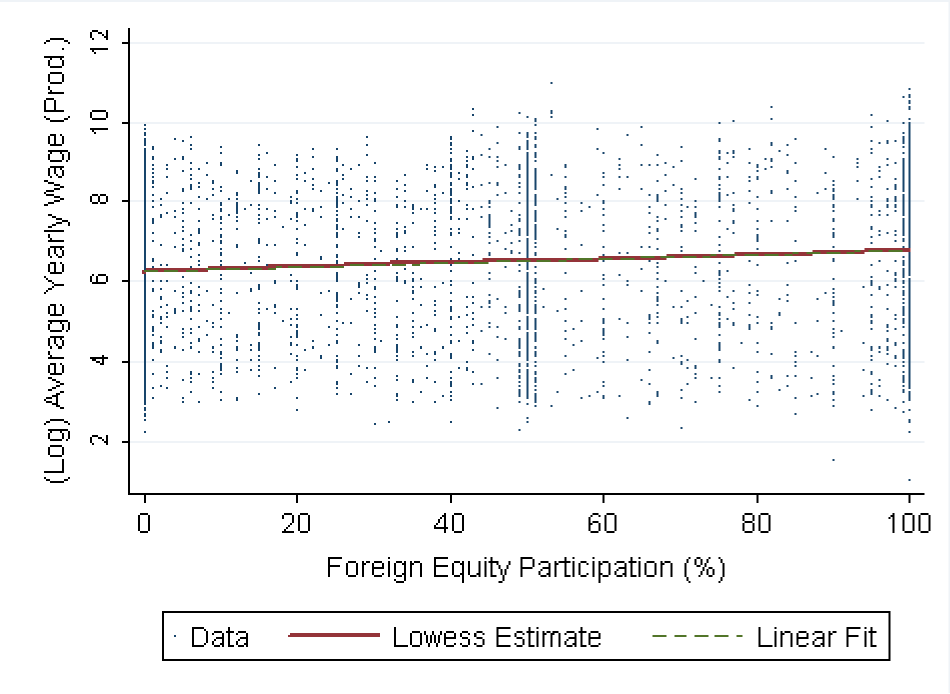


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Figure 2.4 (continued): Nonparametric Estimates of the Relationship between Average Yearly Wage and Share of Foreign Ownership: Pooled OLS Regression

(c) Non-production Workers

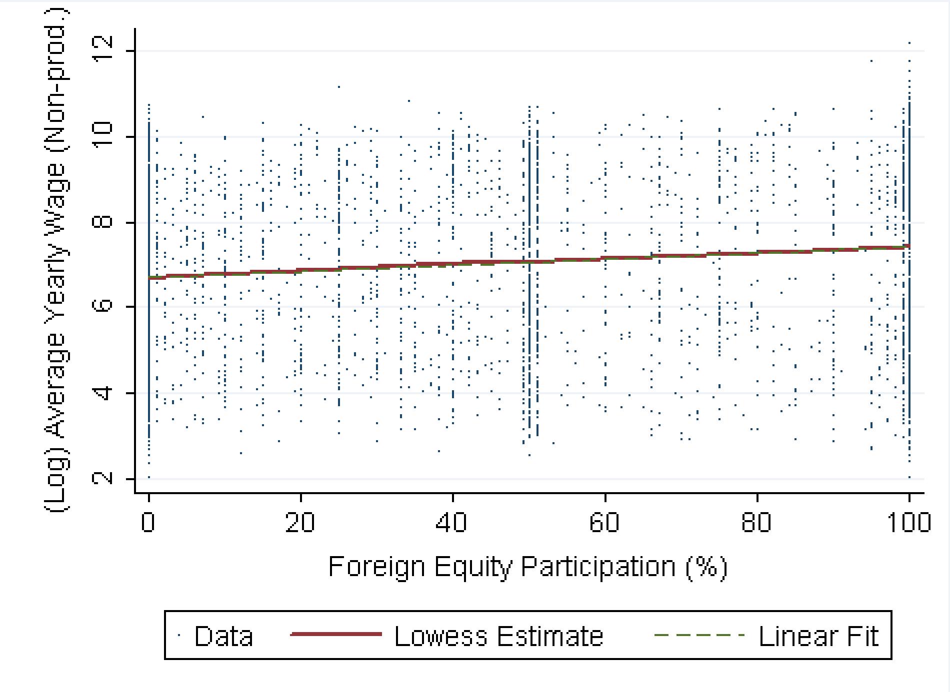
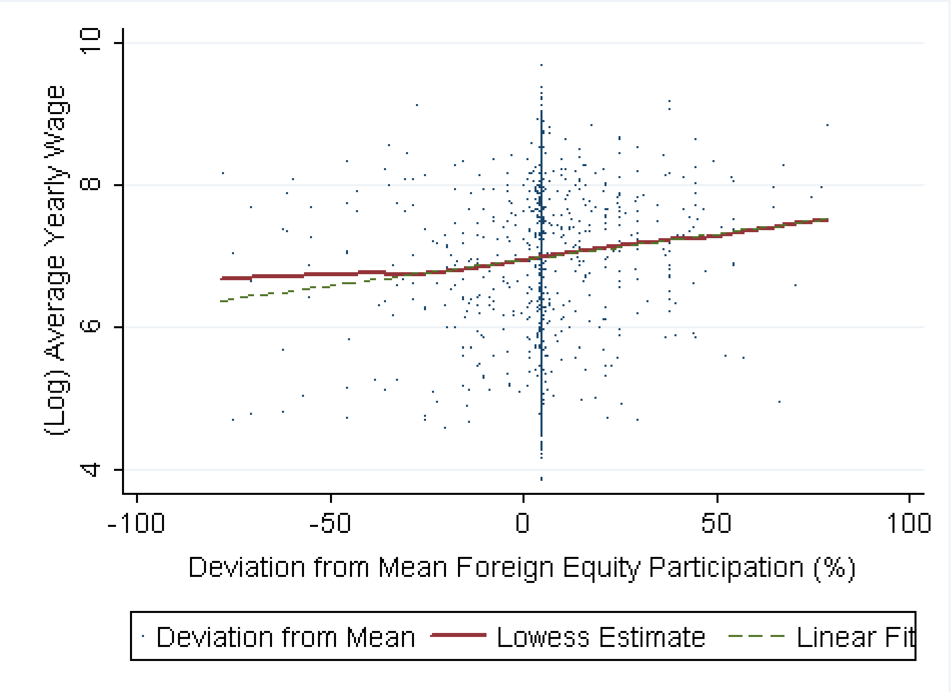


Figure 2.5: Nonparametric Estimates of the Relationship between Average Yearly Wage and Share of Foreign Ownership: Fixed Effects Regression

(a) All Workers



(b) Production Workers

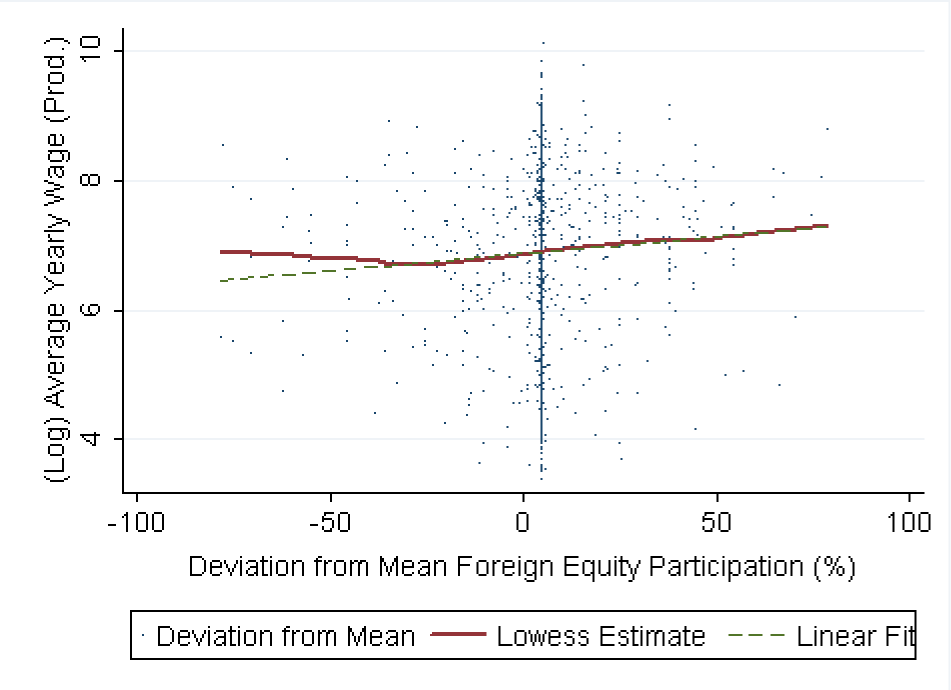


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Figure 2.5 (continued): Nonparametric Estimates of the Relationship between Average Yearly Wage and Share of Foreign Ownership: Fixed Effects Regression

(c) Non-production Workers

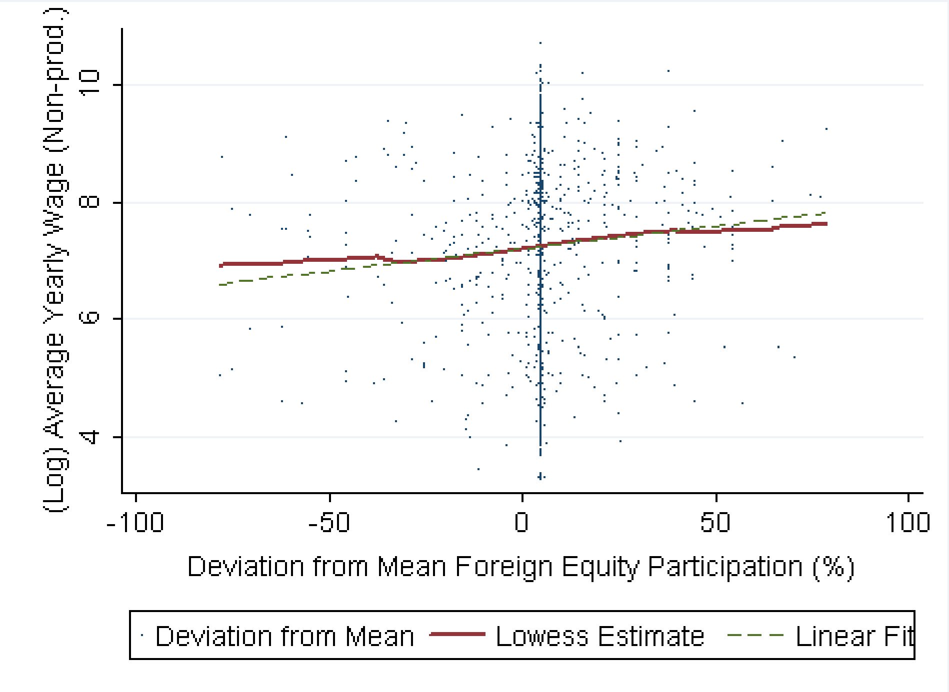
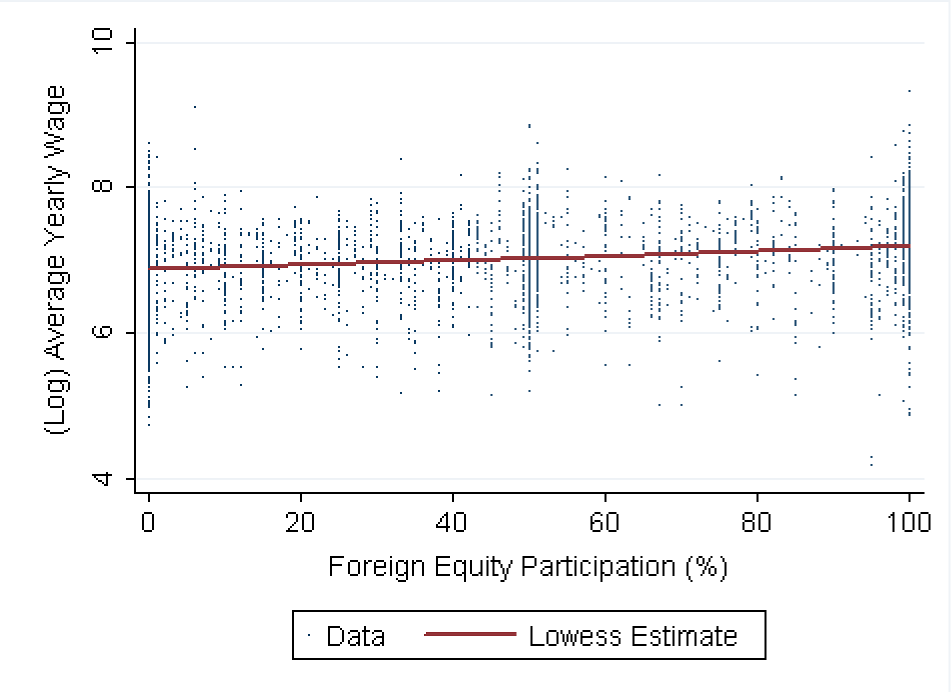


Figure 2.6: Semiparametric Estimates of the Relationship between Average Yearly Wage and Share of Foreign Ownership: Fixed Effects Regression

(a) All Workers



(b) Production Workers

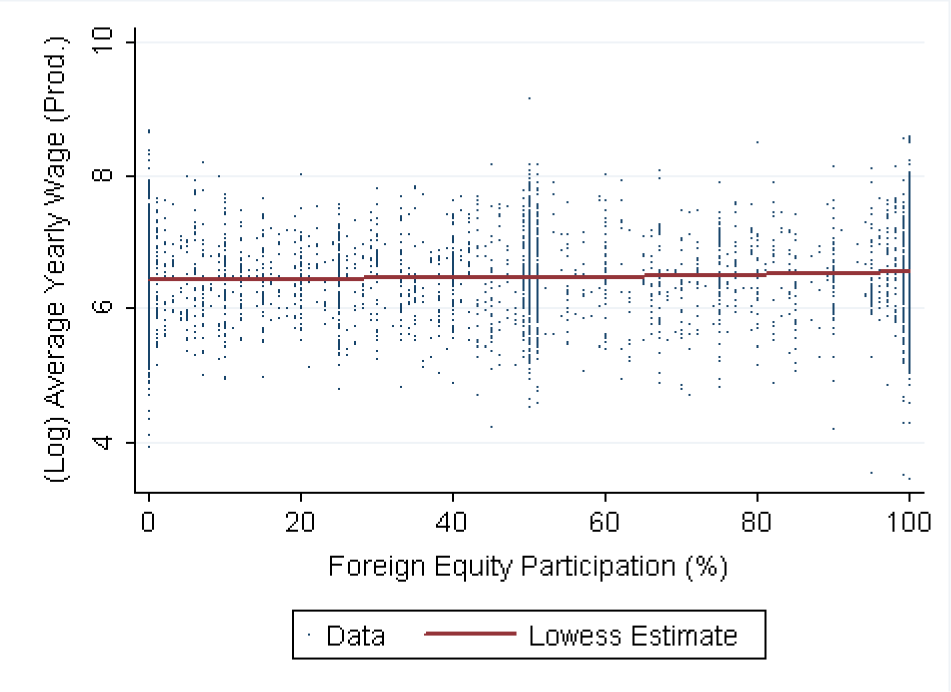


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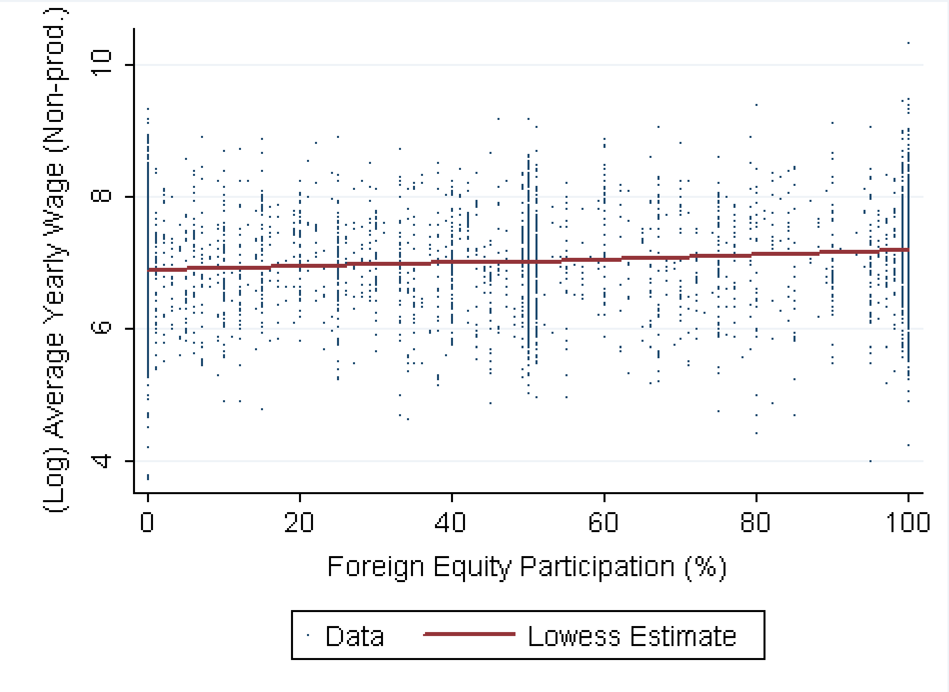
Figure 2.6 (continued): Semiparametric Estimates of the Relationship between Average Yearly Wage and Share of Foreign Ownership: Fixed Effects Regression

(c) Non-production Workers



2.7 Appendix

Table 2.7: Summary Statistics of the Variables Used in the Analysis by Type of Ownership

		Foreign	*Domestic*
Foreign Equity Participation (%)	*N*	3140	91434
	Mean	60.12	0
	Std. Dev.	32.39	0
Average Plant Wage (Turkish Liras)	*N*	3140	91434
	Mean	3712.06	1038.28
	Std. Dev.	5534.14	1651.31
Average Wage for Production Workers (Turkish Liras)	*N*	3120	91225
	Mean	2783.73	972.94
	Std. Dev.	4562.69	1550.13
Average Wage for Non-Production Workers (Turkish Liras)	*N*	3003	79656
	Mean	5816.05	1487.05
	Std. Dev.	9876.44	2807.87
(Log) Plant Size	*N*	3140	91434
	Mean	5.01	3.68
	Std. Dev.	1.27	1.08
Skill Intensity (%)	*N*	3126	91201
	Mean	30.78	19.86
	Std. Dev.	21.41	17.12
Ratio of Production Workers	*N*	3140	91434
	Mean	0.78	1.54
	Std. Dev.	1.58	5.91
(Log) Value Added per Worker	*N*	3102	90049
	Mean	8.69	7.24
	Std. Dev.	1.76	1.75
(Log) Input	*N*	3140	91414
	Mean	13.97	11.62
	Std. Dev.	2.34	2.33

Notes: A foreign plant is defined as a manufacturing plant which has any positive ratio of foreign equity in the plant's ownership. In the sample, the minimum share of foreign ownership was 1% and the maximum share was 100%.

Table 2.8: Foreign Presence in the Turkish Manufacturing Sector

Year	*Number of Foreign Plants*	*Number of Domestic Plants*	*Total Number of Plants*	*Foreign Presence (%)*	*Average Share of Foreign Ownership at Foreign Plants (%)*
1993	301	10,266	10,567	2.85	58.78
1994	312	9,815	10,127	3.08	58.95
1995	325	9,904	10,229	3.18	59.96
1996	326	10,264	10,590	3.08	58.48
1997	362	11,003	11,365	3.19	57.04
1998	416	11,905	12,321	3.38	59.25
1999	406	10,856	11,262	3.61	60.08
2000	414	10,700	11,114	3.73	62.01
2001	439	10,872	11,311	3.88	64.33

Notes: A foreign plant is defined as a manufacturing plant which has any positive ratio of foreign equity in the plant's ownership. In the sample, the minimum share of foreign ownership was 1% and the maximum share was 100%. *Foreign Presence* is the ratio of *Number of Foreign Plants* to *Total Number of Plants*.

Table 2.9: OLS Results: Wages and Multinational Status Defined at Various Thresholds
Dependent Variable: Log Average Yearly Wage

	All Workers				Production Workers				Non-production Workers			
FDI Threshold	(1) 0%	(2) 15%	(3) 30%	(4) 50%	(5) 0%	(6) 15%	(7) 30%	(8) 50%	(9) 0%	(10) 15%	(11) 30%	(12) 50%
FDI Dummy	.4839 (.0212)***	.5064 (.0228)***	.5246 (.0242)***	.5677 (.0293)***	.1708 (.0164)***	.1839 (.0176)***	.1946 (.0188)***	.2167 (.0235)***	.3728 (.0217)***	.4046 (.0233)***	.4133 (.0251)***	.4513 (.0311)***
Log Plant Size	.1959 (.0038)***	.1975 .(0038)***	.1989 (.0038)***	.2016 (.0038)***	.0623 (.0042)***	.0627 (.0042)***	.0631 (.0042)***	.0641 (.0042)***	.0952 (.0059)***	.0962 (.0059)***	.0974 (.0058)***	.0996 (.0058)***
Skill Intensity	.0040 (.0001)***	.0040 (.0001)***	.0040 (.0001)***	.0041 (.0001)***	.0067 (.0001)***	.0067 (.0001)***	.0067 (.0001)***	.0067 (.0002)***	.0037 (.0002)***	.0037 (.0002)***	.0037 (.0002)***	.0037 (.0002)***
Ratio of Production Workers	.0007 (.0003)**	.0008 (.0003)**	.0008 (.0003)**	.0008 (.0003)**	.0083 (.0023)***	.0083 (.0024)***	.0083 (.0024)***	.0083 (.0024)***	.0116 (.0037)***	.0116 (.0036)***	.0116 (.0037)***	.0116 (.0037)***
Log Value Added per Worker	.2011 (.0037)***	.2016 (.0037)***	.2022 (.0037)***	.2047 (.0037)***	.0674 (.0028)***	.0674 (.0028)***	.0675 (.0028)***	.0684 (.0028)***	.0758 (.0035)***	.0758 (.0035)***	.0765 (.0035)***	.0785 (.0035)***
Log Electricity	.0091 (.0013)***	.0092 (.0013)***	.0093 (.0013)***	.0093 (.0013)***	.1090 (.0026)***	.1091 (.0026)***	.1091 (.0026)***	.1091 (.0026)***	.1362 (.0041)***	.1362 (.0041)***	.1363 (.0041)***	.1363 (.0041)***
Sector/Year/ Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.9151	0.9150	0.9149	0.9144	0.8955	0.8955	0.8956	0.8955	0.8415	0.8416	0.8415	0.8412
N	91555	91555	91555	91555	91392	91392	91392	91392	80975	80975	80975	80975

Notes: All standard errors are corrected for heteroskedasticity (cluster at plant level). Coefficients are given in the first line; standard errors in parentheses; *, **, *** indicate significance at the 10%, 5% and 1% level, respectively. All regressions include a constant term.

Table 2.10: FE Results: Wages and Multinational Status Defined at Various Thresholds
Dependent Variable: Log Average Yearly Wage

	All Workers				Production Workers				Non-production Workers			
FDI	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Threshold	0%	15%	30%	50%	0%	15%	30%	50%	0%	15%	30%	50%
FDI Dummy	.1121	.1144	.1165	.1354	.0441	.0468	.0376	.0611	.1802	.2142	.2001	.2505
	(.0214)***	(.0224)***	(.0241)***	(.0307)***	(.0270)	(.0280)*	(.0288)	(.0398)	(.0409)***	(.0427)***	(.0461)***	(.0595)***
Log Plant Size	.0136	.0136	.0138	.0143	-.0247	-.0247	-.0246	-.0244	.0139	.0137	.0143	.0151
	(.0056)**	(.0056)**	(.0056)***	(.0056)***	(.0067)***	(.0067)***	(.0067)***	(.0067)***	(.0099)	(.0099)	(.0099)	(.0099)
Skill Intensity	.0003	.0003	.0003	.0003	.0051	.0051	.0051	.0051	.0017	.0017	.0017	.0017
	(.00008)***	(.00008)***	(.00008)***	(.00008)***	(.0002)***	(.0002)***	(.0002)***	(.0002)***	(.0002)***	(.0002)***	(.0002)***	(.0002)***
Ratio of Production Workers	-.0006	-.0006	-.0006	-.0006	.0070	.0070	.0070	.0070	.0102	.0102	.0102	.0102
	(.0005)	(.0005)	(.0005)	(.0005)	(.0020)***	(.0020)***	(.0020)***	(.0021)***	(.0031)***	(.0035)***	(.0035)***	(.0035)***
Log Value Added per Worker	.0897	.0897	.0897	.0897	.0364	.0364	.0364	.0364	.0242	.0242	.0242	.0241
	(.0025)***	(.0025)***	(.0025)***	(.0025)***	(.0029)***	(.0029)***	(.0029)***	(.0029)***	(.0040)***	(.0040)***	(.0040)***	(.0040)***
Log Electricity	.0044	.0044	.0044	.0043	.1223	.1222	.1222	.1223	.1524	.1524	.1524	.1524
	(.0010)***	(.0010)***	(.0010)***	(.0010)***	(.0026)***	(.0026)***	(.0026)***	(.0026)***	(.0041)***	(.0041)***	(.0041)***	(.0041)***
Time and Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Overall R^2	0.8683	0.8681	0.8680	.8677	0.8846	0.8846	0.8845	0.8846	0.8288	0.8289	0.8287	0.8285
N	91,555	91,555	92,887	92,887	91,392	91,392	91,392	91,392	80,975	80,975	80,975	80,975

Notes: All standard errors are corrected for heteroskedasticity (cluster at plant level). Coefficients are given in the first line; standard errors in parentheses; *, **, *** indicate significance at the 10%, 5% and 1% level, respectively. All regressions include a constant term.

Table 2.11: Results from Difference-Based Semiparametric Regression
Dependent Variable: (Log) Average Yearly Wage

	All Workers (1)	Production Workers (2)	Non-Production Workers (3)
Log Plant Size	.0555 (.0249)**	.0519 (.0318)	.0073 (.0386)
Skill Intensity	.0044 (.0005)***	.0109 (.0007)***	.0052 (.0008)***
Ratio of Production Workers	.0059 (.0053)	.0807 (.0067)***	.1045 (.0082)***
Log Value Added per Worker	.3095 (.0124)***	.1514 (.0158)***	.1605 (.0197)***
Log Input	.0959 (.0108)***	.0659 (.0138)***	.0950 (.0172)***
Year Dummies	Yes	Yes	Yes
V-stat (p-value)	21.064 (0.000)	5.850 (0.000)	9.402 (0.000)
R^2	0.8941	0.8722	0.8431
N	4237	4217	4042

Notes: *, **, *** indicate significance at the 10%, 5% and 1% level, respectively. V-stat is a significance test of the nonparametric component in the regression, foreign equity participation, and is asymptotically $N(0, 1)$. See Yatchew (1997). Both the test statistic and corresponding p-value are reported.

Table 2.12: Two-Step System GMM Results: Hourly Wages and Foreign Ownership (Endogenous Controls)

Dependent Variable: Log Average Hourly Wage for Production Workers

	(1)	(2)	(3)	(4)
Log Wage $_{t-1}$	.1246	.0971	.2665	.2516
	(.0195)***	(.0193)***	(.0363)***	(.0410)***
Foreign Equity Participation	-.0007	.0001	.0014	.0005
(%)	(.0015)	(.0018)	(.0014)	(.0018)
Log Plant Size	.0051	.0497	-.0233	.0325
	(.0740)	(.0940)	(.0843)	(.0969)
Skill Intensity	.0096	.0120	.0080	.0093
	(.0026)***	(.0029)***	(.0030)***	(.0039)**
Ratio of Production Workers	.3814	.4183	.4528	.5150
	(.1676)**	(.2027)**	(.1757)***	(.1986)***
Log Value Added per Worker	.2025	.1813	.0287	.0133
	(.0800)**	(.0896)**	(.0772)	(.1242)
Log Input	.0995	.0909	.1749	.1634
	(.0644)	(.0805)	(.0665)***	(.0836)*
m1 (Pr>z)	0.000	0.000	0.000	0.000
m2 (Pr>z)	0.573	0.353	0.957	0.742
m3 (Pr>z)	0.194	0.216	0.107	0.089
Sargan	0.000	0.000	0.000	0.000
Hansen	0.000	0.000	0.001	0.000
Number of Instruments	253	148	197	127
Instrument Set	lags 2+	lags 2 and 3	lags 3+	lags 3 and 4
N	3474	3474	3474	3474

Notes: Year dummies and a constant term included in all models. Controls treated as *endogenous*. Robust standard errors in parentheses, clustered at the plant level and adjusted for Windmeijer's correction. See notes to Table 2.3.

Table 2.13: Two-Step System GMM Results: Hourly Wages and Foreign Ownership (Exogenous Controls)

Dependent Variable: Log Average Hourly Wage for Production Workers

	(1)	(2)	(3)	(4)
Log Wage $_{t-1}$	.1026	.0738	.5489	.5610
	(.0228)***	(.0221)***	(.0474)***	(.0490)***
Foreign Equity Participation	.0028	.0038	.0006	.0005
(%)	(.0020)	(.0022)*	(.0021)	(.0025)
Log Plant Size	-.1763	-.1841	-.0238	-.0271
	(.0466)***	(.0472)***	(.0373)	(.0369)
Skill Intensity	.0080	.0080	.0081	.0078
	(.0022)***	(.0022)***	(.0022)***	(.0023)***
Ratio of Production Workers	.4380	.4601	.4290	.4337
	(.1305)***	(.1461)***	(.1069)***	(.1041)***
Log Value Added per Worker	.1434	.1362	.0998	.0870
	(.0373)***	(.0377)***	(.0361)***	(.0372)**
Log Input	.1150	.1189	.0722	.0818
	(.0321)***	(.0317)***	(.0304)**	(.0307)***
m1 (Pr>z)	0.000	0.000	0.000	0.000
m2 (Pr>z)	0.251	0.128	0.142	0.141
m3 (Pr>z)	0.127	0.127	0.071	0.065
Sargan	0.000	0.000	0.000	0.000
Hansen	0.000	0.000	0.000	0.000
Number of Instruments	83	53	67	47
Instrument Set	lags 2+	lags 2 and 3	lags 3+	lags 3 and 4
N	3474	3474	3474	3474

Notes: Year dummies and a constant term included in all models. Controls treated as *exogenous*. Robust standard errors in parentheses, clustered at the plant level and adjusted for Windmeijer's correction. See notes to Table 2.3.

CHAPTER III

Emerging Market Business Cycles and Home Bias in Capital

3.1 Introduction

Business cycles in emerging markets are markedly different from business cycles in developed economies. In particular, the business cycle displays much greater volatility along several dimensions in emerging markets, which has been at odds with the standard models. Earlier studies highlighted the role of real interest rates and shocks to trend growth to explain the larger volatility of output and net exports in this set of economies, as well as their strongly countercyclical current account balances (see Neumeyer and Perri (2005) for real interest rates, and Aguiar and Gopinath (2007) for trend growth). In this paper, we document further empirical regularities that characterize the business cycle in emerging markets, which again deviate from earlier findings for small open economies of the West. Motivated by our empirical findings and the fact that intermediates trade constitutes bulk of world trade, we develop an international real business cycle model that incorporates traded investment goods and home bias in capital. Differing levels of home bias in capital goes a long way in explaining the business cycles observed in both developed and emerging economies.

Using quarterly data from the last two decades, we identify some new empirical regularities that describe the behavior of the real exchange rate, exports, and imports in developed and emerging economies. Several consistent findings present themselves as challenges to current models of international real business cycles. First, exports are highly procyclical in developed economies, whereas they are acyclical in emerging economies. Second, while the correlation between exports and real exchange rate is positive in developed economies, it is negative in emerging economies. Third, the real exchange rate is much more procyclical in emerging economies. Fourth, imports are strongly procyclical in both sets of countries, but more so in emerging economies. Fifth, trade balance (defined as the ratio of net exports to output) is consistently and highly negatively correlated with the real exchange rate, and more so in emerging economies.

We also confirm findings by earlier studies and extend some of these findings to the emerging markets. For instance, trade balance is highly counter-cyclical in emerging economies, which was documented in earlier literature (see, for instance, Aguiar and Gopinath (2007)), and only mildly counter-cyclical in developed economies. This pattern seems to be driven by the fact that while both sets of countries increase their imports in the face of high output, it is only in developed countries where exports also rise. The fact that exports do not respond, at least in the short term, to output shocks in emerging economies makes these economies especially dependent on capital flows to fund their burgeoning trade deficits. In addition, we extend the findings of Engel and Wang (2011) about the volatility of exports and imports in OECD economies to the emerging markets. While the behavior of net exports is well known, the behavior of exports and imports have rarely been studied separately in the literature. We find that exports and imports are much more volatile than output in emerging markets, which mirror the findings of Engel and Wang (2011).

Our model can account for these additional findings on volatility, while explaining the major discrepancies between developed and emerging markets we highlight in our empirical work.

We develop a two-country model with tradable intermediate and final goods and economic shocks are transmitted internationally through terms of trade adjustment. While we build on the standard framework of Backus et al. (1994), our analysis shows that excluding the investment sector in an otherwise standard framework fails to capture the volatility in the trade variables and has difficulty matching correlations of the major variables. Including the investment good sector goes a long way in matching the OECD data on several fronts and resolves these anomalies when we calibrate the investment good sector to have only moderate home bias in capital. This is surprising, since it is well known that OECD countries typically display high home bias in capital and that they are the primary producers and exporters of capital (see, for instance, Eaton and Kortum (2001) and Engel and Wang (2011)). When we calibrate the model to have large home bias in capital, the simulation results match very closely the empirical regularities that we identify for the emerging markets business cycles. In particular, a larger home bias leads to more volatility of the components of trade and net exports, and it can replicate the correlations across a wide range of business cycle variables in emerging markets. Hence, our model can explain the behavior of trade and business cycles in both OECD and emerging markets with minimal changes to calibration.

We extend the analysis of international business cycles in the literature along two additional dimensions. First, we study the behavior of exports and imports separately. While the countercyclicality of net exports is a fairly well established phenomenon in both emerging and developed economies, studying the elements of the trade balance separately enables us to explain why it is much more countercyclical in the former set of economies. Engel and Wang (2011) conduct a thorough analysis of the business cycle properties of exports and imports, however their study is restricted to OECD economies. Second, we explicitly study the real exchange rate and how it is driven by intermediate and final goods trade. Existing models of international business cycles tend to be silent on the real exchange rate and they focus on the behavior of the terms of trade, which serves as the transmission channel for productivity shocks across borders (see, for example, Backus et al. (1994), Mendoza (1995), and Heathcote and Perri (2002)).

Our study is related to a large literature on international business cycles. Perhaps the closest counterparts are Boileau (1999), who study an IRBC model with an equipment sector, and Engel and Wang (2011), who study the importance of durable goods in international business cycles. Both of these papers focus on OECD economies. While we also investigate trade movements and the business cycle in OECD economies, our empirical work highlights some previously unknown regularities that characterize the emerging markets. In that sense, the current study joins the group of papers that include Neumeyer and Perri (2005), who focus on shocks to interest rates, and Aguiar and Gopinath (2007), who draw attention to shocks to trend growth as a channel to explain the markedly different behavior of emerging economy business cycles. Our work differs from existing studies on emerging markets with its focus on the real exchange rate and the behavior of exports and imports separately.

The rest of the paper is structured as follows. Section 2 details our empirical findings on trade and the business cycle in developed and emerging markets. We develop our model in Section 3, and report simulation results in Section 4. Section

5 concludes. All theoretical results and the derivation of the model are relegated to the Appendix.

3.2 Empirical Findings

Below are some empirical regularities that relate the dynamics of real exchange rate to movements in output and trade balance. We conduct an exercise that is similar to the ones in Backus et al. (1994) and Neumeyer and Perri (2005). We analyze empirical regularities in a subset of developed and emerging economies. The sample of developed economies consists of the following small open economies: Australia, Canada, New Zealand, and Sweden. The emerging economies consist of: Argentina, Korea, Mexico, and Turkey. In all of the tables and figures we report, we use data from the OECD's Quarterly National Accounts, IMF's International Financial Statistics, and the Bank for International Settlements. All variables are logged (except for Net Exports) and Hodrick-Prescott filtered with a smoothing parameter of 1600.

Table 3.1 shows the correlations of key business cycle variables with the real exchange rate. We highlight some of our findings:

- The real exchange rate (RER) is much more procyclical in emerging economies compared to developed economies (correlation coefficients are 0.63 and 0.31, respectively).

- Trade balance (NX/GDP) is negatively correlated with the real exchange rate in both sets of economies; however, the correlation is much more negative in emerging economies. Similarly, while consumption and investment are positively correlated with the real exchange rate in all economies, the degree of correlation is much higher for both variables in emerging economies. In particular, the correlation between RER and consumption (investment) is at an average of 0.68 (0.59) in emerging economies, while this figure is only 0.44 (0.43) in developed economies.

- The correlations between RER and exports and imports individually show great variation among economies in both subsets. While RER and imports comove positively in both sets of countries (perhaps a little stronger in emerging economies), RER and exports seem to comove negatively (with the exception of Korea) in emerging economies but slightly positively in developed economies.

- Table 3.2 shows the correlations of key business cycle variables with GDP. As in Neumeyer and Perri (2005), consumption and investment are highly and positively correlated with GDP in both sets of countries. The correlations are much stronger in emerging economies, typically over 0.9. Trade balance is, on average, negatively correlated with GDP in both emerging and developed economies, although this correlation is much more (significantly) negative in the emerging world. The correlation between trade balance and GDP seems to be weak in developed economies. Another fact that Table 3.2 reveals is that while imports are highly and positively correlated with GDP in both countries, exports correlate much more positively with GDP in developed economies compared to emerging economies. The correlation between exports and GDP is only around 9% for emerging economies, while it is around 84% for imports, which implies that the high negative correlation between trade balance and GDP is primarily driven by imports.

Figures 3.1-3.22 show the comovement and cross-correlations of the business cycle variables in developed and emerging markets. The first two figures demonstrate the movements of the real exchange rate index (RER) and output (GDP). Note that a higher RER corresponds to a stronger domestic currency. We highlight some of our findings:

- Figure 3.2 reveals the strong comovement of GDP and RER in emerging economies, while Figure 3.1 shows no such pattern in developed economies. This comovement seems to weaken slightly in Argentina and Turkey during times of financial crises, around 2001 for both countries and in 1994 for Turkey. The average correlation coefficient between GDP and RER in emerging economies is 0.63 as opposed to 0.31 in developed economies.
- Figures 5 and 6: With the exception of Argentina in emerging economies (due primarily to default in 2001?), Imports and RER strongly comove with each other. In developed economies, this comovement is similarly strong. The average correlation coefficient in the emerging economies is 0.49 compared to 0.46 in developed economies, although the average is brought down for emerging economies due to Argentina's negative value.
- Figures 7 and 8 indicate a negative comovement between trade balance and real exchange rates. The negative comovement seems to be stronger in emerging economies. The average correlation coefficient is -0.76 in emerging economies compared to -0.49 in developed economies.

We also look at the cross-correlations for leads and lags up to a year. The plots for cross-correlations with the real exchange rates and GDP start with Figure 3.9. Some observations:

- Figures 9 and 10 depict the cross-correlations between GDP and Real Exchange Rates. Figure 3.10 shows that real exchange rates are pro-cyclical in emerging economies, with correlation coefficients ranging from 0.53 in Argentina to 0.74 in

Korea, with an average correlation coefficient of 0.62. In developed economies, real exchange rates are only mildly procyclical and show a lot of variation. While the correlation coefficient is 0.04 in Canada, it is 0.60 in New Zealand, pointing to huge variation (average correlation in developed economies is 0.31). In Korea and Mexico real exchange rates lead the cycle by one to two quarters, while in Argentina, it lags the cycle by a quarter. In Turkey, the two series seem to be moving concurrently with the cycle. The pattern for emerging economies suggests a roughly inverse-V shape.

- Figures 3.11 and 3.12 show that there is a V-shape with the cross-correlations between real exchange rates and trade balance (NX/GDP). This V-shape is much more pronounced in emerging economies.

- Figure 3.15 displays a hump shape for the cross-correlations between imports and the real exchange rate, with Sweden displaying a different pattern. The figure suggests that RER might be leading imports by a quarter. In figure 3.16, Argentina is a significant outlier. With the other three countries, however, there is a nice inverse-V shape.

- Figure 3.17 shows that, with the exception of Australia, exports and GDP are positively correlated and depict a hump shape. There is no clear pattern between exports and GDP in emerging economies (see Figure 3.18).

- Figures 3.19 and 3.20 show that GDP and imports are positively correlated in both sets of economies. While the cross-correlation patterns depict more of an inverse U in developed economies, they depict an inverse V in emerging economies. The average correlation coefficient between GDP and imports is 0.69 in developed economies and 0.84 in emerging economies.

- Figure 3.21 shows that trade balance (NX/GDP) and GDP seem to be mildly counter-cyclical developed economies. However, Figure 3.22 shows that they are highly negatively correlated in emerging economies and they depict a V shape. This is perhaps the most striking difference between developed and emerging economies.

3.3 The Model

The model builds on the stochastic growth framework of Backus et al. (1994) with complete markets. There are two symmetric countries, Home and Foreign, each of which is populated by the same measure of identical and infinitely lived households. Each country has two production sectors with their own technology and specializes in the production of a consumption good and a final investment good. Labor and capital are internationally immobile, while consumption and investment goods can be freely traded. The final investment good cannot be traded, however, and is simply used to augment the country-specific capital stock. All firms are perfectly competitive with flexible prices. In the notation that follows, we classify the Home country as country 1 and the Foreign country as country 2.

Preferences

Households supply labor and rent capital to final consumption good producing firms. The representative household in each country i maximizes the expected value of lifetime utility given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_{it,} 1 - n_{it})$$

where $U(c, 1-n) = [c^{\mu}(1-n)^{1-\mu}]^{\gamma}/\gamma$, and c_{it} and n_{it} are consumption and hours worked in country i at time t. Leisure, $l_{it} = 1 - n_{it}$, follows from our normalization of the period endowment of time to 1.

Technology

There are two production sectors in each country. The representative firm in each country specializes in the production of a final good, which can be used either as a consumption good, labelled a, or as an intermediate investment good, labelled b. Consumption and investment goods are produced using capital, k, and labor, n, with identical linear homogeneous production functions:

$$a_{1t}^H + a_{1t}^F + b_{1t}^H + b_{1t}^F = y_{1t} = z_{1t} k_{1t}^{\theta} n_{1t}^{1-\theta} \tag{3.1}$$

$$a_{2t}^H + a_{2t}^F + b_{2t}^H + b_{2t}^F = y_{2t} = z_{2t} k_{2t}^{\theta} n_{2t}^{1-\theta} \tag{3.2}$$

where the superscripts on the goods denote the country (Home or Foreign) in which they are consumed or used as an input for the final investment good production. For instance, a_{1t}^F is the country 1 consumption good consumed in the Foreign country, and b_{2t}^H is the country 2 investment good used in the Home country. Equations (3.1) and (3.2) embody both the market clearing conditions for each country's final good and their technologies. In (3.1) and (3.2), $(z_{1t},\, z_{2t})$ is a vector of stochastic shocks to productivity, which are the source of fluctuations in the model economy. The two underlying shocks to the economy are governed by the bivariate autoregressions:

$$\mathbf{z}_{t+1} = \mathbf{A}\mathbf{z}_t + \varepsilon_{t+1}^{\mathbf{z}}$$

where $\mathbf{A}$ is a 2×2 matrix, $\mathbf{z} = (z_1, z_2)$ and $\varepsilon^{\mathbf{z}}$ is a 2×1 vector of random variables distributed normally and indepently over time with variance-covariance matrix $\mathbf{V_z}$.

The final investment good is a constant elasticity of substitution (CES) composite of Home- and Foreign-investment goods:

$$\begin{aligned} x_{1t} &= \left[\alpha_1 (b_{1t}^H)^{(\eta_1-1)/\eta_1} + (1-\alpha_1)(b_{2t}^H)^{(\eta_1-1)/\eta_1}\right]^{\eta_1/(\eta_1-1)} \\ x_{2t} &= \left[(1-\alpha_2)(b_{1t}^F)^{(\eta_2-1)/\eta_2} + \alpha_2 (b_{2t}^F)^{(\eta_2-1)/\eta_2}\right]^{\eta_2/(\eta_2-1)} \end{aligned}$$

where η_i is the elasticity of substitution between home and foreign investment goods in country i, and α_i determines the extent of home bias in the composition of domestically produced final investment goods in country i. We choose this form of aggregation for the final investment good sector for its flexibility over the choice of the home bias parameter, α, and the elasticity of substitution between the two intermediate goods, η. In addition, it implies that an efficient production frontier will require the bulk of cross-border trade to constitute of investment goods as we see in the data (citation?). We abstract from capital adjustment costs in our benchmark model, so the final investment good is used to augment the capital stock in the standard way:

$$\begin{aligned} k_{1,t+1} &= (1-\delta)k_{1t} + x_{1t} \\ k_{2,t+1} &= (1-\delta)k_{2t} + x_{2t} \end{aligned}$$

Absorption

Consumption of final goods is a CES composite of Home- and Foreign-final goods:

$$\begin{aligned} c_{1t} &= \left[\omega_1 (a_{1t}^H)^{-\rho_1} + (1-\omega_1)(a_{2t}^H)^{-\rho_1}\right]^{-1/\rho_1} \\ c_{2t} &= \left[(1-\omega_2)(a_{1t}^F)^{-\rho_2} + \omega_2 (a_{2t}^F)^{-\rho_2}\right]^{-1/\rho_2} \end{aligned}$$

where $\rho_i \geq -1$, and $\sigma_i = 1/(1+\rho_i)$ is the elasticity of substitution between domestic and foreign goods in country i. The parameter $\omega_i > 0.5$ indicates the extent of home bias in consumption in country i.

Prices and the Trade Account

Let q_{1t} be the price of the consumption good produced at Home and q_{2t} be the price of the consumption good produced at Foreign. Since final consumption is a composite of Home and Foreign goods, the consumer price index in each country that corresponds to the preferences above is:

$$\begin{aligned} P_{1t}^{C} &= \left[\omega_1^{\sigma_1} q_{1t}^{1-\sigma_1} + (1-\omega_1)^{\sigma_1} q_{2t}^{1-\sigma_1}\right]^{1/(1-\sigma_1)} \\ P_{2t}^{C} &= \left[(1-\omega_2)^{\sigma_2} q_{1t}^{1-\sigma_2} + \omega_2^{\sigma_2} q_{2t}^{1-\sigma_2}\right]^{1/(1-\sigma_2)} \end{aligned}$$

Given that final output can be used either as a consumption or an investment good, equations (3.1) and (3.2) imply that the investment goods prices are identical to those of the final consumption goods (this follows simply from the operation of perfectly competitive firms with identical marginal cost for both uses of the final good). That is, the price of b_1 is q_{1t} and the price of b_{2t} is q_{2t}. Given the CES technology in the final investment good sector, the investment price indices are given by:

$$\begin{aligned} P_{1t}^{I} &= \left[\alpha_1^{\eta_1} q_{1t}^{1-\eta_1} + (1-\alpha_1)^{\eta_1} q_{2t}^{1-\eta_1}\right]^{1/(1-\eta_1)} \\ P_{2t}^{I} &= \left[(1-\alpha_2)^{\eta_2} q_{1t}^{1-\eta_2} + \alpha_2^{\eta_2} q_{2t}^{1-\eta_2}\right]^{1/(1-\eta_2)} \end{aligned}$$

Terms of trade for country i is defined as the price of imports divided by the price of exports, which is given by $p_{it} = q_{jt}/q_{it}$, since country i's consumption and investment goods (i.e. the tradables it produces) command the same price. The overall price index in country i is defined by:

$$P_{it} = \left(P_{it}^{C}\right)^{\pi_{iC}} \left(P_{it}^{I}\right)^{\pi_{iI}}$$

where π_{iC} is the steady state expenditure share of final consumption and π_{iI} is the steady state expenditure share of final investment in country i. While this definition of the overall price index is not based on utility, it is closer to how it is measured in national accounts. We define the real exchange rate for country i to be the ratio of country j's overall price index to that of country i: $E_{it} = P_{jt}/P_{it}$. This ensures that a higher value for E_{it} implies the appreciation of country i's currency.

As we plan to estimate the behavior of exports and imports separately in our calibration, it is worth mentioning how we measure the components of trade. In the model, we measure exports, imports, and net exports (trade balance) the same way we do in the data, i.e. in terms of domestic country prices. For instance, country 1's exports are given by $a_{1t}^F + b_{1t}^F$, its imports by $(q_{2t}/q_{1t})(a_{2t}^H + b_{2t}^H)$, and its net exports by $\left(a_{1t}^F + b_{1t}^F - (q_{2t}/q_{1t})(a_{2t}^H + b_{2t}^H)\right)/y_{1t}$.

Solution Concept

The equilibrium of our two-country model is characterized by exploiting the equivalence between the competitive equilibria and the Pareto optima. We calculate a symmetric steady state equilibrium by solving numerically a second-order approximation to a social planner's problem that weights equally the utility of the consumers in the two countries. Let λ_1 and λ_2 be the social weights on country 1 and 2, respectively. Combining some of the equilibrium conditions above, the social planner maximizes the joint utility of consumers in the two countries subject to domestic and international market clearing conditions:

$$
\begin{array}{ll}
max & \sum_{t=0}^{\infty}\beta^t\left[\lambda_1\frac{\left(\left[\omega_1(a_{1t}^H)^{-\rho_1}+(1-\omega_1)(a_{2t}^H)^{-\rho_1}\right]^{-\mu/\rho_1}(1-n_{1t})^{1-\mu}\right)^{\gamma}}{\gamma}\right. \\
 & \left.+\lambda_2\frac{\left(\left[(1-\omega_2)(a_{1t}^F)^{-\rho_2}+\omega_2(a_{2t}^F)^{-\rho_2}\right]^{-\mu/\rho_2}(1-n_{2t})^{1-\mu}\right)^{\gamma}}{\gamma}\right] \\
s.t. & a_{1t}^H+a_{1t}^F+b_{1t}^H+b_{1t}^F=z_{1t}k_{1t}^{\theta}n_{1t}^{1-\theta} \\
 & a_{2t}^H+a_{2t}^F+b_{2t}^H+b_{2t}^F=z_{2t}k_{2t}^{\theta}n_{2t}^{1-\theta}
\end{array}
$$

$$k_{1,t+1}-(1-\delta)k_{1t}=\left[\alpha_1(b_{1t}^H)^{(\eta_1-1)/\eta_1}+(1-\alpha_1)(b_{2t}^H)^{(\eta_1-1)/\eta_1}\right]^{\eta_1/(\eta_1-1)}$$

$$k_{2,t+1}-(1-\delta)k_{2t}=\left[(1-\alpha_2)(b_{1t}^F)^{(\eta_2-1)/\eta_2}+\alpha_2(b_{2t}^F)^{(\eta_2-1)/\eta_2}\right]^{\eta_2/(\eta_2-1)}$$

Goods prices that would obtain in the competitive equilibrium are calculated from the marginal value of each good derived from the resource constraints above. As such, we define the Lagrange multipliers on the constraints to be q_{1t}, q_{2t}, r_{1t}, and r_{2t}, respectively. Note that r_{it} represents the price of country i's final investment good, thus we have $r_{it}=P_{it}^I$.

The first order conditions to the above program and the market clearing conditions characterize the solution to the social planner's problem. In computing a second-order approximation around a steady state, we first log-linearize the equilibrium conditions and then use Dynare to carry out a further approximation given the linearized system. This means that we don't have to solve for the steady state values of all endogenous variables but for a number of ratios describing them. The solution to the model's steady state and the linearized system can be found in Appendix A.

3.4 Simulation Results

3.4.1 Calibration

We follow Backus et al. (1994) and the convention in the literature to pick the parameters of the model. The most important parameters in the calibration are the home share values of consumption and investment (ω_i and α_i, respectively), and the elasticity of substitution for final goods consumption and capital goods (σ_i and η_i, respectively). It is well known that substitutability between home and foreign country goods plays a crucial role in the model dynamics, and there is considerable uncertainty over what value trade elasticity should take.[1] We therefore report simulation results for three different values of each elasticity (hence, a total of 9 simulations). We calibrate home bias in capital goods, α, by the share of home investment spending in total investment spending, which is given at the steady state by (for country 1): $q_1 b_1^H/(q_1 b_1^H + q_2 b_2^H) = 1/(1 + ((1-\alpha_1)/\alpha_1)^{\eta_1})$.[2]

We assume a symmetric steady state where both countries in the model have the same technologies both in their consumption and investment good sectors. This means that in the final investment good sector we have $\alpha_1 = \alpha_2$ and $\eta_1 = \eta_2$, and for the consumption aggregator we have $\omega_1 = \omega_2$ and $\sigma_1 = \sigma_2$. This implies identical home bias across the two countries in consumption and in investment as well as identical elasticity of substitution between domestic and foreign goods in both aggregates.

The values used for the calibration of Case 1 are given in Table 3.4. The productivity process that provides the underlying shocks to the economy are taken directly from Backus et al. (1994), which imply persistent disturbances to productivity with some moderate spillover across countries. Note that this specification of technology shocks is estimated to mimic the business cycle in the developed world. Hence, it will

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[1] Hooper et al. (2000) report estimates that range from 0.1 to 2 for the G-7 countries, while Heathcote and Perri (2002) estimate an elasticity of 0.9.

[2] It is worth noting that there are different ways that researches calibrate home bias in the literature. In this paper, we build home bias in capital exogenously by picking the share of home investment spending in total investment spending. An alternative way to calibrate home bias would be via iceberg trade costs, which would endogenously lead to a bigger share of home consumption and investment. While this would be a closer picture of reality, it would introduce more wrinkles into the trade elasticities and home bias in consumption and investment.

naturally underestimate volatilities for the emerging market business cycles, while we expect it to closely match those for the developed markets.

3.4.2 Simulation 1 - Importance of the Investment Goods Sector

We initially assume no home bias in capital goods, and therefore set $\alpha_1 = \alpha_2 = 0.5$. Regardless of the elasticity of substitution for investment goods, this implies that the share of home investment spending in total investment spending is one half. All results are HP filtered, etc.

In interpreting the results of the simulation, we focus on the case where $\sigma = 1.5$ and $\eta = 1.5$ (the literature typically assumes $\sigma = 1.5$; there is no certain evidence on the value of η - Bems (2008) suggests it is similar in rich and poor countries and close to 1, which implies a Cobb-Douglas technology). The model with no home bias in capital goods can match the basic features of the business cycle for an average OECD economy. The model replicates the within-country correlations between the major macroeconomic variables with the correct sign and similar magnitude, except for that between output and terms of trade (in the data, terms of trade are acyclical, while the model produces strongly procyclical terms of trade - this is a very typical failing of IRBC models with traded goods only). In particular, the model generates the joint behavior of exports, imports, output, and the real exchange rate with good success. In terms of volatility, the model can generate the observed pattern of more volatile export and import behavior compared to output, while it fails to capture the high volatility of the real exchange rate and terms of trade. Overall, the model with no home bias in capital seems to fit the OECD data well.

What does the impulse response analysis tell us? Figure 3.23 shows the behavior of the model variables in response to a one percent shock to home country's technology. In the face of a positive shock in the home country (country 1), the price of home consumption and investment goods decreases (relative to foreign). The home terms of trade jump immediately as a result. This leads to substitution from country 2 consumption goods to country 1 consumption goods in both home and foreign. The price of the final investment good decreases by the same amount in both home and foreign, owing to the symmetric setup in the investment sector. Both home and foreign investment goods used at home (country 1) increase, driving imports up and sustaining large imports at home, while they drop on impact at foreign (country 2) only to recover with a lag. The persistence of the shock and the spillover create a wealth effect for country 2, which increases the consumption of both country goods at foreign. This works to increase exports at home, leading to the familiar countercyclical behavior of net exports. Because the overall price level is lower at home than foreign, the real exchange rate of home increases.

A rather puzzling finding from the impulse responses is the kinked response of the investment goods (b_1^H, b_1^F, b_2^H, b_2^F). The one period kink arises from the fact that it takes one period for invested goods to turn into usable capital. With no adjustment costs present in the model, the behavior is not smooth at all, although it will turn out in the next section that the investment goods follow a smooth path when there is large home bias in capital (more on this below). We know that the kinked behavior is not due to the presence of spillovers, since when we turn off the spillover channel we still get the same impulse responses. The kink probably reflects the fact that investment is very lumpy when there are no adjustment costs.

Why does introducing an investment good sector increase the volatility of prices? In a standard IRBC model, the prices of consumption goods would not be very responsive to technology shocks since such models typically work with risk-averse consumer preferences that are designed for consumption smoothing. When the only traded good in a model is the final consumption good, then the volatility of terms of trade would also be small. In contrast, the prices of investment goods would respond more to technology shocks as they readily reflect the changes to marginal productivities and they would be more responsive the smaller costs to adjusting capital are. In our model, because the final output of a country can be traded freely and used both for consumption and as an investment good, the two goods command the same price. Hence, when cross-border trade is mostly composed of trade in investment goods due to a technology shock, terms of trade become more volatile as prices respond to changes in marginal returns of capital.

What role does the elasticity of substitution play? In the data, we typically observe higher volatility in international prices compared to output, which standard business cycle models cannot reproduce. Our model shares this shortcoming with earlier models, while being able to account for more volatile quantities. The model can generate higher volatility in the terms of trade compared to output when the elasticity of substitution for investment goods is sufficiently low. The intuition comes from the fact that a smaller elasticity of substitution is associated with a smaller impact of technology shocks on traded quantities, hence the bulk of the adjustment takes place through the terms of trade.

3.4.3 Simulation 2 - Importance of Home Bias in Capital

The previous section studied the importance of introducing an investment goods sector to a canonical international RBC model. In this section, we start studying how differences in home bias in the investment goods sector affects the system. We maintain the assumption of a symmetric steady state. In OECD economies, there is strong bias in capital towards home investment goods (approx. 70%, Engel and Wang (2011). The same scenario is very likely to hold in the emerging economies as well, however we do not have empirical evidence yet). Since the share of home investment spending in total investment spending is given by $q_1 b_1^H/(q_1 b_1^H + q_2 b_2^H) = 1/(1+((1-\alpha_1)/\alpha_1)^{\eta_1})$ at the steady state for country 1, we solve for α_1 equating the left hand side to 70% given η_1. Assuming an intermediate value of $\eta_1 = 1.5$, we get $\alpha_1 \simeq 0.64$. Note that home bias increases with the elasticity of substitution, but for the simulations we will fix $\alpha_1 = 0.65$, and let elasticity of substitution vary as before. The other values used for the calibration of Simulation 2 are the same as before.

In interpreting the results of the simulation, we focus on the case where $\sigma = 1.5$ and $\eta = 1.5$. The model with large home bias in the investment sector does a very good job in matching the within-country correlations of macroeconomic variables in emerging economies. In particular, we can replicate the acyclicality of exports and the negative correlation between exports and the real exchange rate in emerging economies, which are the two most distinctive patterns observed in this group compared to OECD countries. Moreover, the asymmetry in the investment sector helps to account for greater procylicality of imports (and thus the greater counter-cyclicality of net exports) in emerging economies as well as matching the behavior of the real exchange rate with success. The model also matches the volatilities of exports and imports in emerging economies well, although it shares with other IRBC models in grossly underestimating the volatility of the terms of trade and real exchange rate.

What does the impulse response analysis tell us? Figure 3.24 shows the behavior of the model variables in response to a one percent shock to home country's technology. In the face of a positive shock in the home country (country 1), the price of home consumption and investment goods decreases (relative to foreign). The home terms of trade jump immediately as a result, although this jump is not as pronounced as in Simulation 1. This leads to substitution from country 2 consumption goods towards country 1 consumption goods in both home and foreign. The price of the final investment good decreases in both countries, but by more at home due to the large home bias. This leads to substitution towards home investment goods in both countries, and both country 1 and country 2 investment goods increase at home, while they drop on impact at foreign. Home bias in the investment sector amplifies the wealth effect for home, and thus demand for country 2's consumption good jumps (compare to Simulation 1), which leads to even greater imports. The same mechanism implies a weak wealth effect at foreign, which sees less demand for country 1's consumption good and a bigger decline in country 1's investment good. This essentially rules out any opportunity for home to export its goods until demand picks up again at foreign, hence leading to acyclical exports at home. This also creates a strongly counter-cyclical trade balance. As before, the real exchange rate increases as prices at home are lower in general compared to foreign.

Notice that the impulse responses for certain variables show differences from Simulation 1. Specifically, we see a humped shape pattern in the terms of trade for country 1, whereby the home bias in capital implies a more persistent relative price effect for country 1. This serves to smooth out the response of the investment goods (b_1^H, b_1^F, b_2^H, b_2^F), as more home investment goods are produced for a longer time taking advantage of the persistence of the technology shock. Looking at other variables such as net exports, we see that they too display a much smoother path in this case compared to Simulation 1. Thus, home bias in capital renders the relative price of the home investment goods more favorable for a longer period of time when a shock hits the economy, which makes the production of home investment goods more persistent.

3.5 Conclusion

Business cycles in emerging markets display a number of empirical discrepancies compared to developed economies. Exports are acyclical, they correlate negatively with the real exchange rate, and the real exchange rate is much more procyclical in emerging markets. In addition, imports are more procyclical, leading to the well-known strong countercyclicality of net exports in emerging markets. Standard dynamic general equilibrium models are unable to replicate these disparate regularities of the business cycle in emerging and developed economies. We develop a two-country model that embodies trade in investment goods and accounts for business cycle characteristics in both sets of economies. Our premise is that the two sets of economies have different levels of home bias in their final investment goods sector, which implies that terms of trade adjustments to technology shocks differ significantly in the two sets of economies. Our findings suggest that varying levels of home bias in capital are an important determinant of business cycle properties. In future research, we plan to work on extending the model developed here to account for varying levels of home bias in capital in different countries. We also plan to take into account how differences in country size in an otherwise standard symmetric model affect the model dynamics.

Table 3.1: Comovements in Trade and Business Cycle: Correlations with GDP

	Exports	Imports	NX/GDP	Consumption	Investment
Developed Economies:					
Australia	-0.0824	0.6079	-0.5326	0.6524	0.7386
Canada	0.8938	0.7187	0.0096	0.7963	0.6699
New Zealand	0.3159	0.6275	-0.4567	0.7794	0.8817
Sweden	0.8050	0.8250	0.0517	0.7492	0.8699
Average	0.4831	0.6947	-0.2320	0.7443	0.7900
Emerging Economies:					
Argentina	-0.3006	0.6858	-0.7453	0.9422	0.9201
Korea	0.3063	0.9112	-0.8304	0.9174	0.9105
Mexico	-0.1326	0.9080	-0.8343	0.9113	0.9539
Turkey	0.4949	0.8729	-0.6785	0.9067	0.8613
Average	0.0920	0.8445	-0.7721	0.9194	0.9115
Emerging Economies (Crisis Years Excluded):					
Argentina	-0.3488	0.7640	-0.7569	0.9543	0.9283
Korea	0.4478	0.8594	-0.6892	0.8112	0.8229
Mexico	0.1586	0.9047	-0.7034	0.8636	0.9199
Turkey	0.5320	0.7984	-0.4593	0.8833	0.8300
Average	0.1974	0.8316	-0.6522	0.8781	0.8753

Notes: Data are from OECD, IFS, and BIS. All variables are logged (except for Net Exports) and HP filtered with a smoothing parameter of 1600.

Table 3.2: Comovements in Trade and Business Cycle: Correlations with Real Exchange Rate

	GDP	Exports	Imports	NX/GDP	Consumption	Investment
Developed Economies:						
Australia	0.2617	0.1022	0.4922	-0.3671	0.3183	0.3156
Canada	0.0475	0.1750	0.5439	-0.7142	0.2509	0.4282
New Zealand	0.6003	0.1166	0.5674	-0.5178	0.7508	0.5995
Sweden	0.3364	0.0209	0.2419	-0.3965	0.4566	0.4094
Average	0.3115	0.1037	0.4614	-0.4989	0.4442	0.4382
Emerging Economies:						
Argentina	0.5365	-0.9026	-0.1290	-0.8119	0.7055	0.4250
Korea	0.7399	0.2552	0.7773	-0.7244	0.7219	0.6449
Mexico	0.6733	-0.4078	0.7091	-0.8395	0.7377	0.7517
Turkey	0.5540	-0.0593	0.6217	-0.6894	0.5648	0.5743
Average	0.6259	-0.2786	0.4948	-0.7663	0.6825	0.5990
Emerging Economies (Crisis Years Excluded):						
Argentina	0.6837	-0.8361	0.2397	-0.8430	0.8111	0.7012
Korea	0.6536	0.3969	0.6527	-0.5037	0.5708	0.4950
Mexico	0.5562	-0.3155	0.5422	-0.8062	0.6902	0.6200
Turkey	0.3863	-0.1611	0.4786	-0.5699	0.4588	0.4158
Average	0.5700	-0.2290	0.4783	-0.6807	0.6327	0.5580

Notes: Data are from OECD, IFS, and BIS. All variables are logged (except for Net Exports) and HP filtered with a smoothing parameter of 1600.

Table 3.3: Calibration Values

Parameter	Value	Description
β	0.99	Discount factor
μ	0.34	Consumption share
γ	-1	Risk aversion
θ	0.36	Capital share
δ	0.025	Depreciation rate
$\omega_1 = \omega_2$	0.76	Home bias in consumption
$\alpha_1 = \alpha_2$	0.50; 0.65	Home bias in investment
$\sigma_1 = \sigma_2$	0.5; 1.5; 2.5	Elasticity of substitution between consumption goods
$\eta_1 = \eta_2$	0.5; 1.5; 2.5	Elasticity of substitution between investment goods
Productivity Process		Taken from Backus et al (1994)

Table 3.4: Results for Simulation 1, No Home Bias in Capital

		Correlations								
		(nx,y)	(nx,p)	(y,p)	(nx,rer)	(y,rer)	(exp,y)	(imp,y)	(exp,rer)	(imp,rer)
Data (OECD)		-0.29	-0.46	0.03	-0.50	0.31	0.48	0.69	0.10	0.46
Data (Emerging)		-0.77	-	-	-0.77	0.63	0.09	0.84	-0.28	0.49
Elasticity of Subst. for Final Goods	Elasticity of Subst. for Capital Goods									
$\sigma = 0.5$	$\eta = 0.5$	0.18	0.48	0.38	0.48	0.38	0.52	0.28	0.62	-0.20
	$\eta = 1.5$	0.19	0.42	0.47	0.42	0.47	0.76	0.65	0.61	0.09
	$\eta = 2.5$	-0.06	-0.11	0.53	-0.11	0.53	0.99	0.99	0.47	0.49
$\sigma = 1.5$	$\eta = 0.5$	0.43	0.80	0.54	0.80	0.54	0.99	0.96	0.52	0.29
	$\eta = 1.5$	-0.13	-0.23	0.59	-0.23	0.59	0.48	0.65	0.04	0.39
	$\eta = 2.5$	-0.13	-0.22	0.63	-0.22	0.63	0.20	0.44	-0.09	0.31
$\sigma = 2.5$	$\eta = 0.5$	0.38	0.70	0.54	0.70	0.54	0.97	0.87	0.52	0.11
	$\eta = 1.5$	-0.12	-0.21	0.59	-0.21	0.59	0.42	0.60	-0.04	0.33
	$\eta = 2.5$	-0.13	-0.21	0.63	-0.21	0.63	0.15	0.39	-0.11	0.28

Notes: This table reports the results of Simulation 1, where $\alpha_1 = \alpha_2 = 0.5$. Entries are theoretical moments. Statistics are based on logged (except for Net Exports) and HP filtered data. nx: Net Exports; p: Terms of Trade; y: Output; rer: Real Exchange Rate; exp: Exports; imp: Imports.

Table 3.5: Results for Simulation 1, No Home Bias in Capital

		Standard Deviation (percent)					
		nx	y	p	rer	$\text{exp}^{\dagger}$	$\text{imp}^{\dagger}$
Data (OECD)*		1.06	1.53	2.92	5.00	*2.65*	*3.08*
Data (Emerging)		2.48	3.20	-	9.85	7.27	9.65
Elasticity of Subst. for Final Goods	Elasticity of Subst. for Capital Goods						
$\sigma = 0.5$	$\eta = 0.5$	2.44	1.14	1.71	0.36	3.76	3.04
	$\eta = 1.5$	1.09	1.20	1.46	0.30	2.15	1.72
	$\eta = 2.5$	0.12	1.25	1.29	0.27	1.34	1.35
$\sigma = 1.5$	$\eta = 0.5$	0.14	1.26	1.37	0.71	1.77	1.59
	$\eta = 1.5$	1.08	1.31	1.22	0.64	2.66	2.88
	$\eta = 2.5$	2.13	1.36	1.11	0.58	4.60	4.82
$\sigma = 2.5$	$\eta = 0.5$	0.24	1.26	1.42	0.94	2.29	1.96
	$\eta = 1.5$	1.04	1.32	1.25	0.83	3.57	3.79
	$\eta = 2.5$	2.13	1.37	1.13	0.75	6.55	6.77

Notes: This table reports the results of Simulation 1, where $\alpha_1 = \alpha_2 = 0.5$. Entries are theoretical moments. Statistics are based on logged (except for Net Exports) and HP filtered data. nx: Net Exports; p: Terms of Trade; y: Output; rer: Real Exchange Rate; exp: Exports; imp: Imports.

$\star$ The figures for nx, y, and p are from Backus et al. (1994), rer is our own calculation, exp and imp are from Engel and Wang (2011).

† The figures for (real) exports and imports are from Engel and Wang (2011), and expressed relative to GDP. In Engel and Wang (2011), the mean (median) standard deviation of GDP is 1.51 (1.36).

Table 3.6: Results for Simulation 2, Home Bias in Capital

		Correlations								
		(nx,y)	(nx,p)	(y,p)	(nx,rer)	(y,rer)	(exp,y)	(imp,y)	(exp,rer)	(imp,rer)
Data (OECD)		-0.29	-0.46	0.03	-0.50	0.31	0.48	0.69	0.10	0.46
Data (Emerging)		-0.77	-	-	-0.77	0.63	0.09	0.84	-0.28	0.49
Elasticity of Subst. for Final Goods	Elasticity of Subst. for Capital Goods									
$\sigma = 0.5$	$\eta = 0.5$	-0.44	-0.86	0.46	-0.86	0.46	0.61	0.81	-0.19	0.84
	$\eta = 1.5$	-0.59	-0.72	0.53	-0.72	0.53	0.28	0.94	-0.26	0.72
	$\eta = 2.5$	-0.63	-0.66	0.52	-0.66	0.52	0.39	0.99	-0.13	0.61
$\sigma = 1.5$	$\eta = 0.5$	-0.44	-0.56	0.58	-0.56	0.58	0.12	0.80	-0.31	0.63
	$\eta = 1.5$	-0.57	-0.44	0.55	-0.44	0.55	0.02	0.91	-0.23	0.49
	$\eta = 2.5$	-0.58	-0.28	0.49	-0.28	0.49	0.16	0.96	-0.06	0.34
$\sigma = 2.5$	$\eta = 0.5$	-0.45	-0.56	0.59	-0.56	0.59	0.03	0.78	-0.38	0.61
	$\eta = 1.5$	-0.57	-0.43	0.55	-0.43	0.55	-0.09	0.88	-0.29	0.46
	$\eta = 2.5$	-0.58	-0.26	0.49	-0.26	0.49	0.01	0.92	-0.12	0.29

Notes: This table reports the results of Simulation 2, where $\alpha_1 = \alpha_2 = 0.65$. Entries are theoretical moments. Statistics are based on logged (except for Net Exports) and HP filtered data. nx: Net Exports; p: Terms of Trade; y: Output; rer: Real Exchange Rate; exp: Exports; imp: Imports.

Table 3.7: Results for Simulation 2, Home Bias in Capital

		Standard Deviation (percent)					
		nx	y	p	rer	exp†	imp†
Data (OECD)⋆		1.06	1.53	2.92	5.00	*2.65*	*3.08*
Data (Emerging)		2.48	3.20	-	9.85	7.27	9.65
Elasticity of Subst. for Final Goods	Elasticity of Subst. for Capital Goods						
$\sigma = 0.5$	$\eta = 0.5$	1.01	1.20	1.81	0.45	1.34	2.44
	$\eta = 1.5$	0.78	1.34	0.98	0.31	1.31	1.83
	$\eta = 2.5$	0.43	1.39	0.65	0.24	1.03	1.28
$\sigma = 1.5$	$\eta = 0.5$	1.17	1.32	1.28	0.72	2.76	3.39
	$\eta = 1.5$	0.72	1.41	0.70	0.44	2.22	2.47
	$\eta = 2.5$	0.37	1.44	0.47	0.32	1.59	1.68
$\sigma = 2.5$	$\eta = 0.5$	1.15	1.33	1.32	0.93	3.99	4.66
	$\eta = 1.5$	0.69	1.41	0.71	0.55	3.40	3.67
	$\eta = 2.5$	0.35	1.44	0.47	0.39	2.52	2.62

Notes: This table reports the results of Simulation 2, where $\alpha_1 = \alpha_2 = 0.65$. Entries are theoretical moments. Statistics are based on logged (except for Net Exports) and HP filtered data. nx: Net Exports; p: Terms of Trade; y: Output; rer: Real Exchange Rate; exp: Exports; imp: Imports.

⋆ The figures for nx, y, and p are from BKK, rer is my own calculation, exp and imp are from Engel and Wang (2011).

† The figures for (real) exports and imports are from Engel and Wang (2011), and expressed relative to GDP. In Engel and Wang (2011), the mean (median) standard deviation of GDP is 1.51 (1.36).

Figure 3.1: Output and Real Exchange Rates in Developed Economies

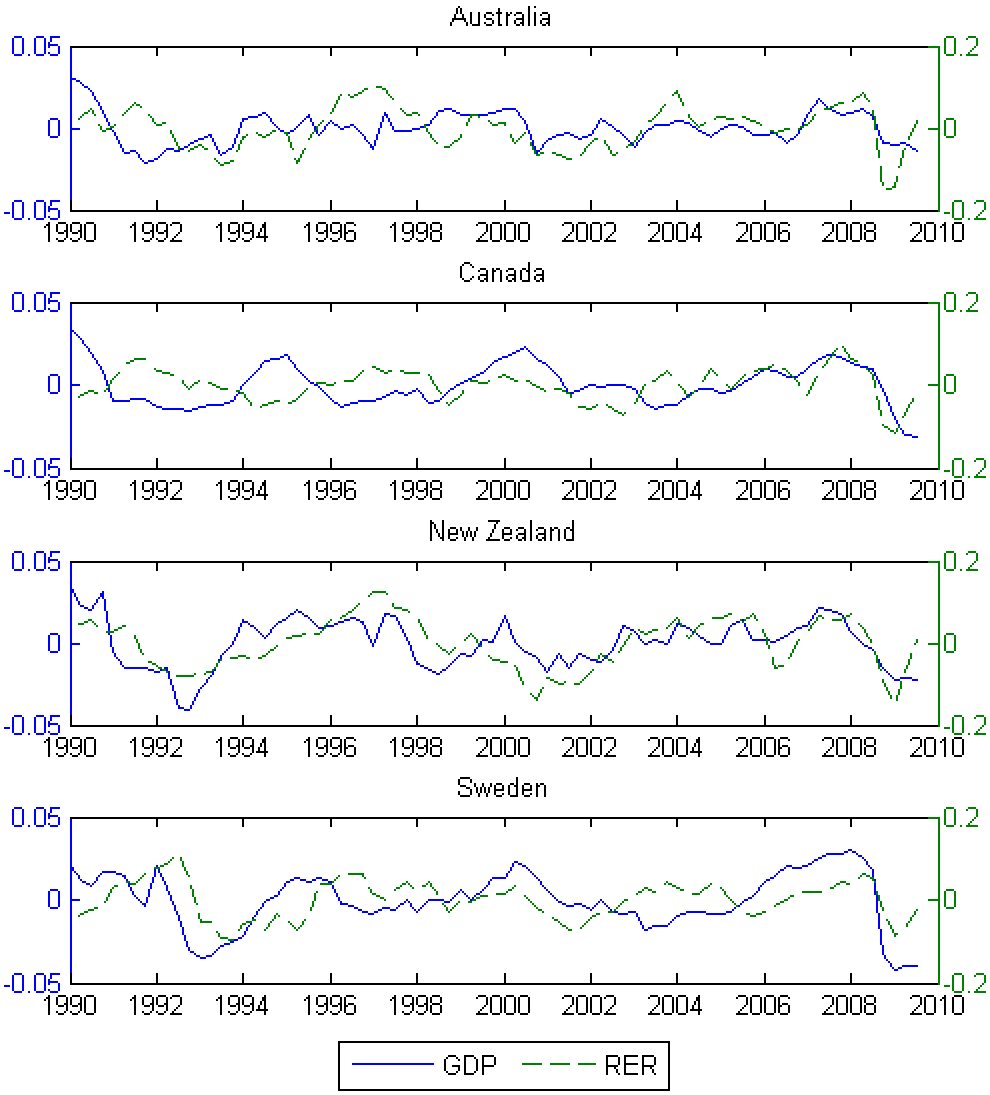


Figure 3.2: Output and Real Exchange Rates in Emerging Economies

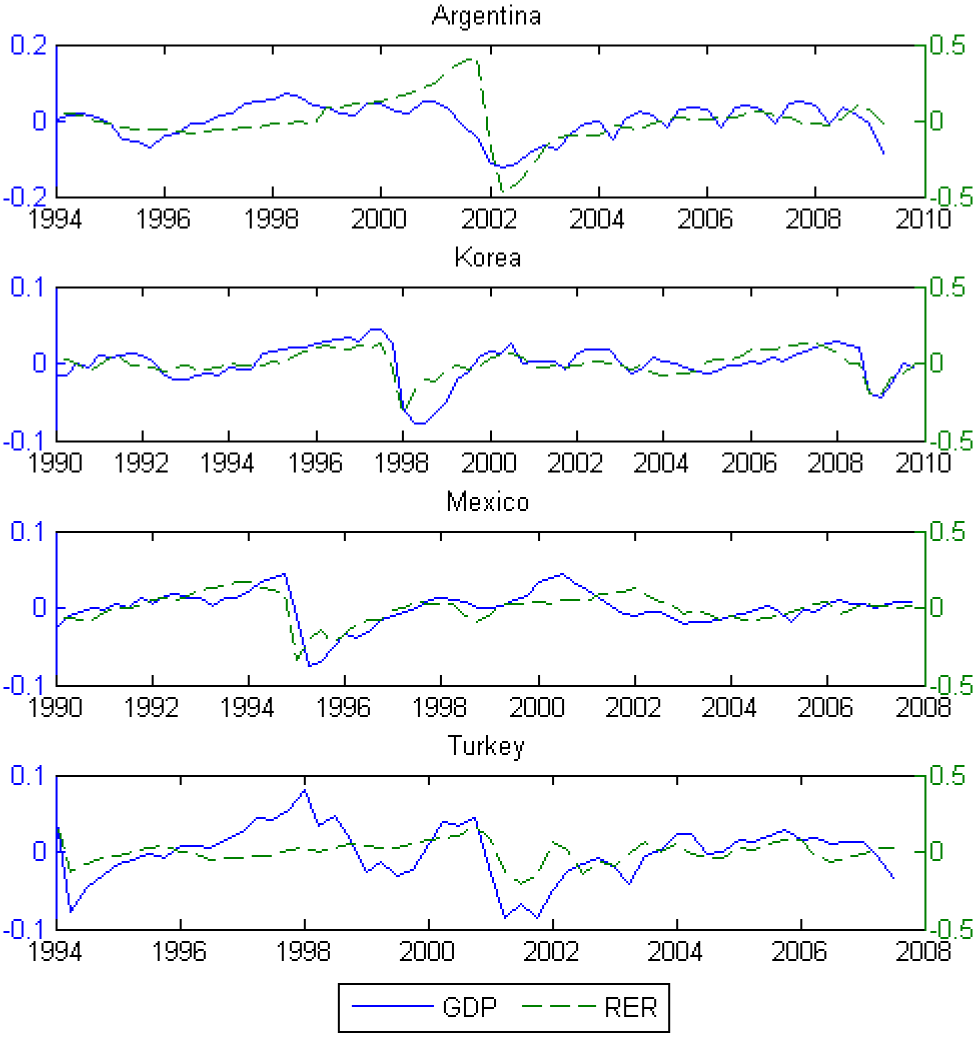


Figure 3.3: Exports and Real Exchange Rates in Developed Economies

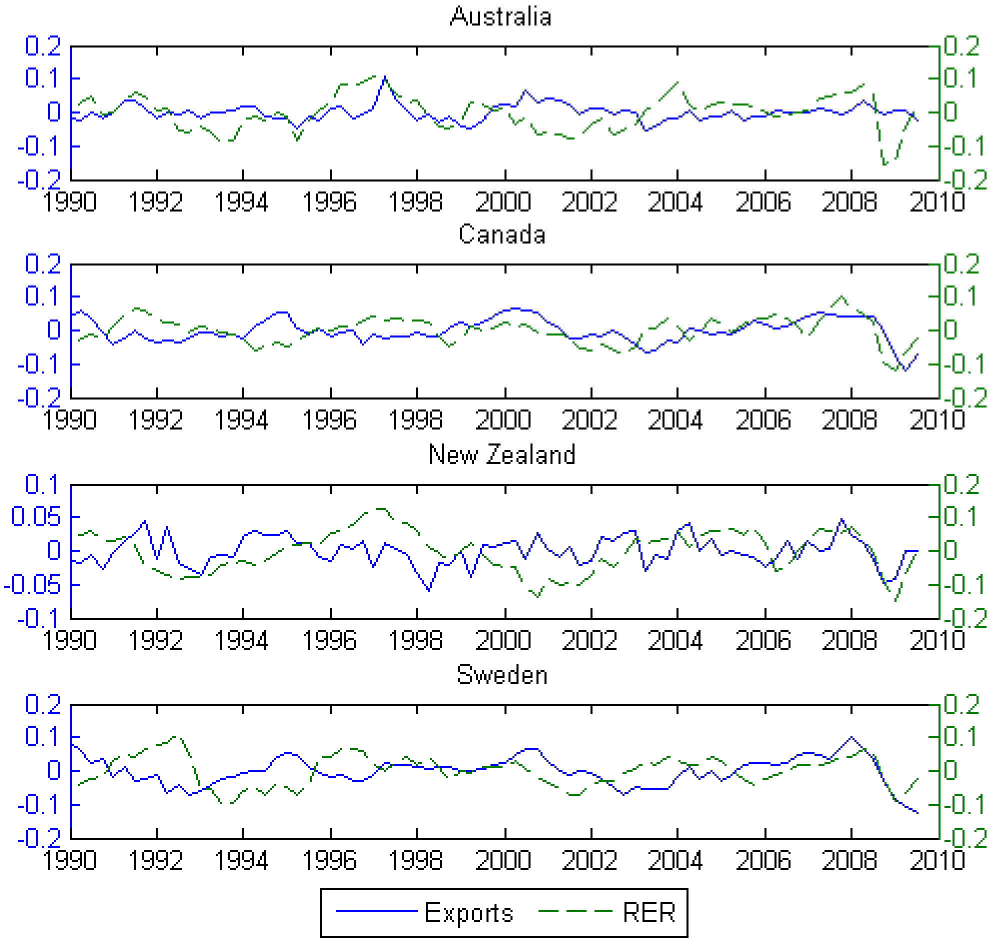


Figure 3.4: Exports and Real Exchange Rates in Emerging Economies

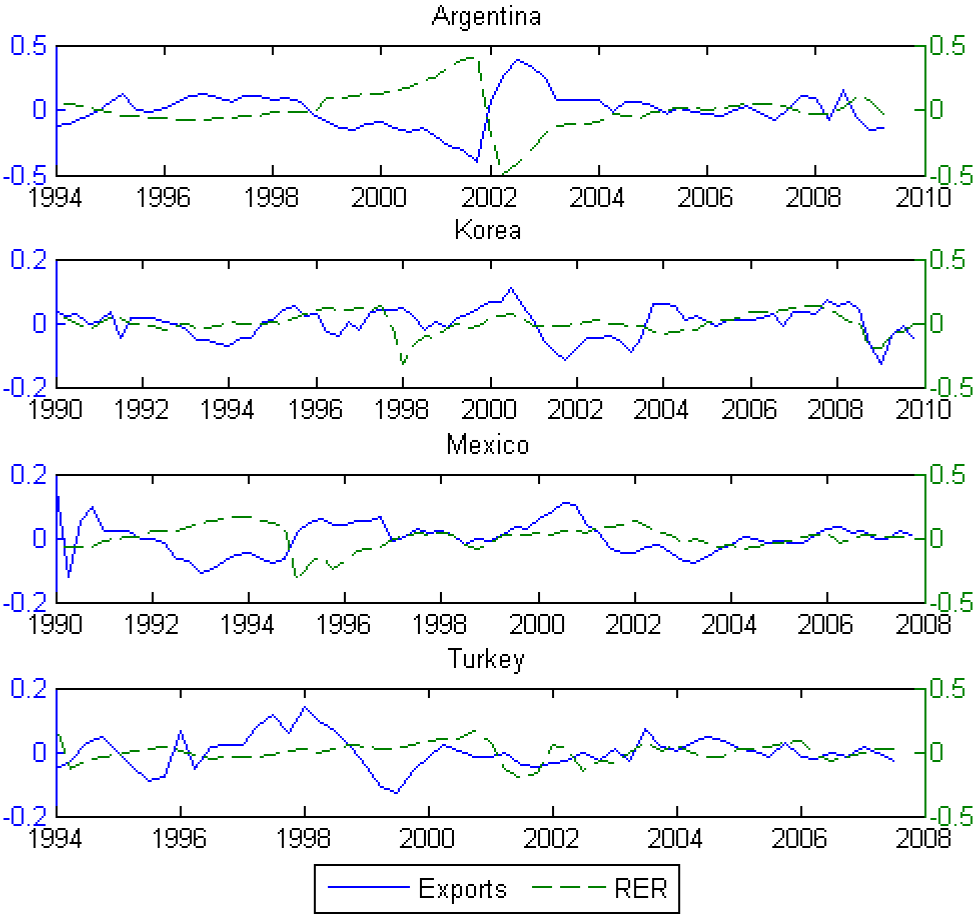


Figure 3.5: Imports and Real Exchange Rates in Developed Economies

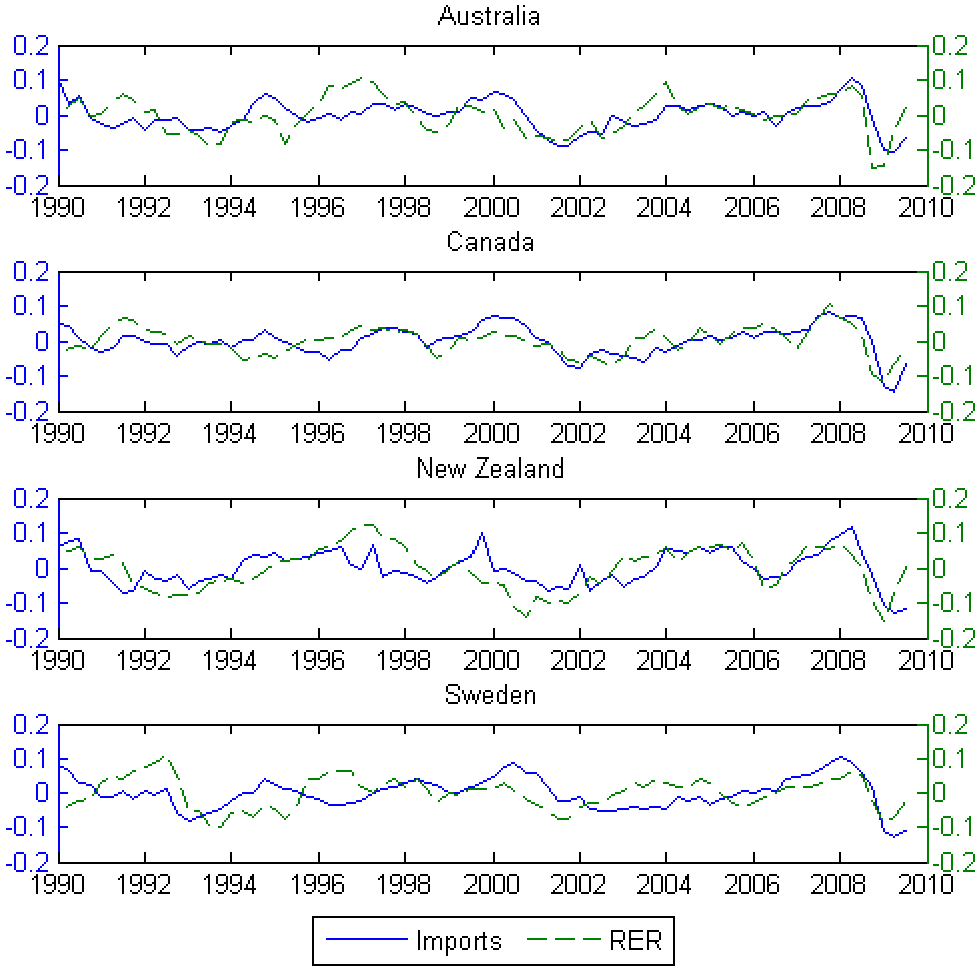


Figure 3.6: Imports and Real Exchange Rates in Emerging Economies

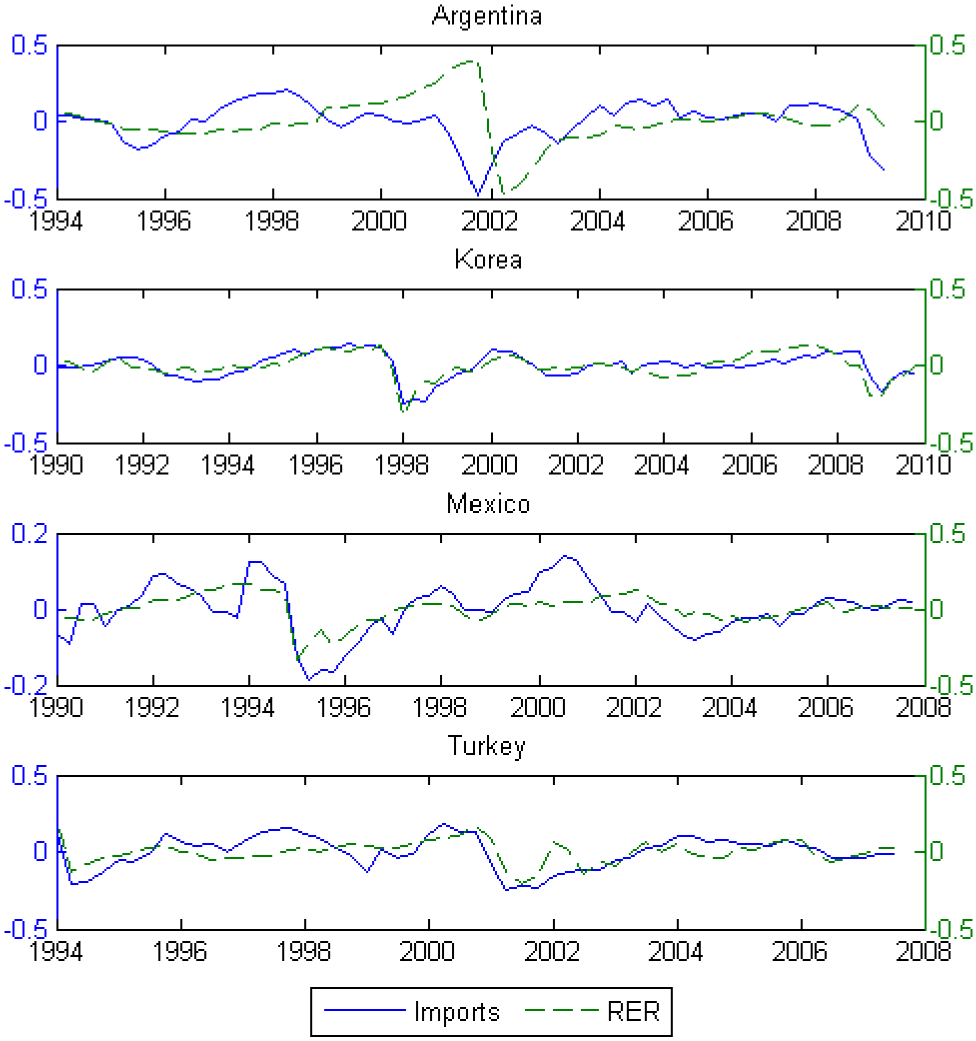


Figure 3.7: Net Exports and Real Exchange Rates in Developed Economies

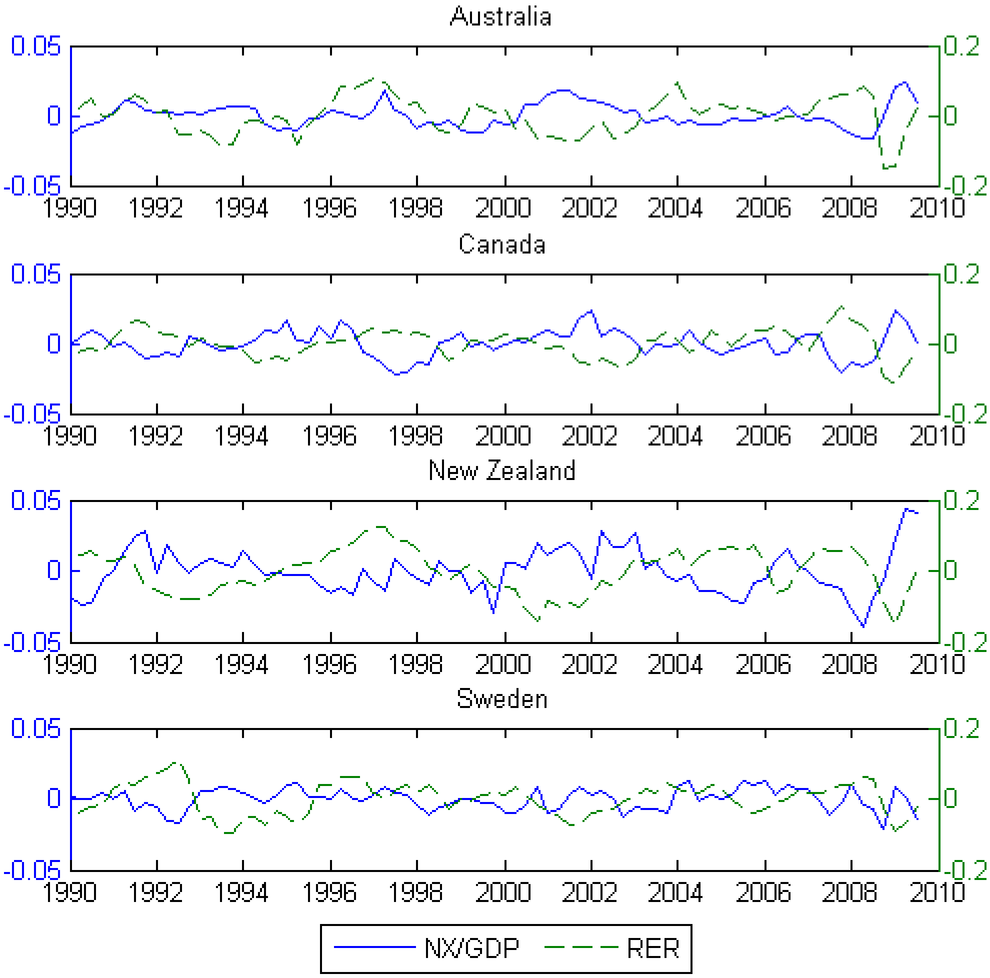


Figure 3.8: Net Exports and Real Exchange Rates in Emerging Economies

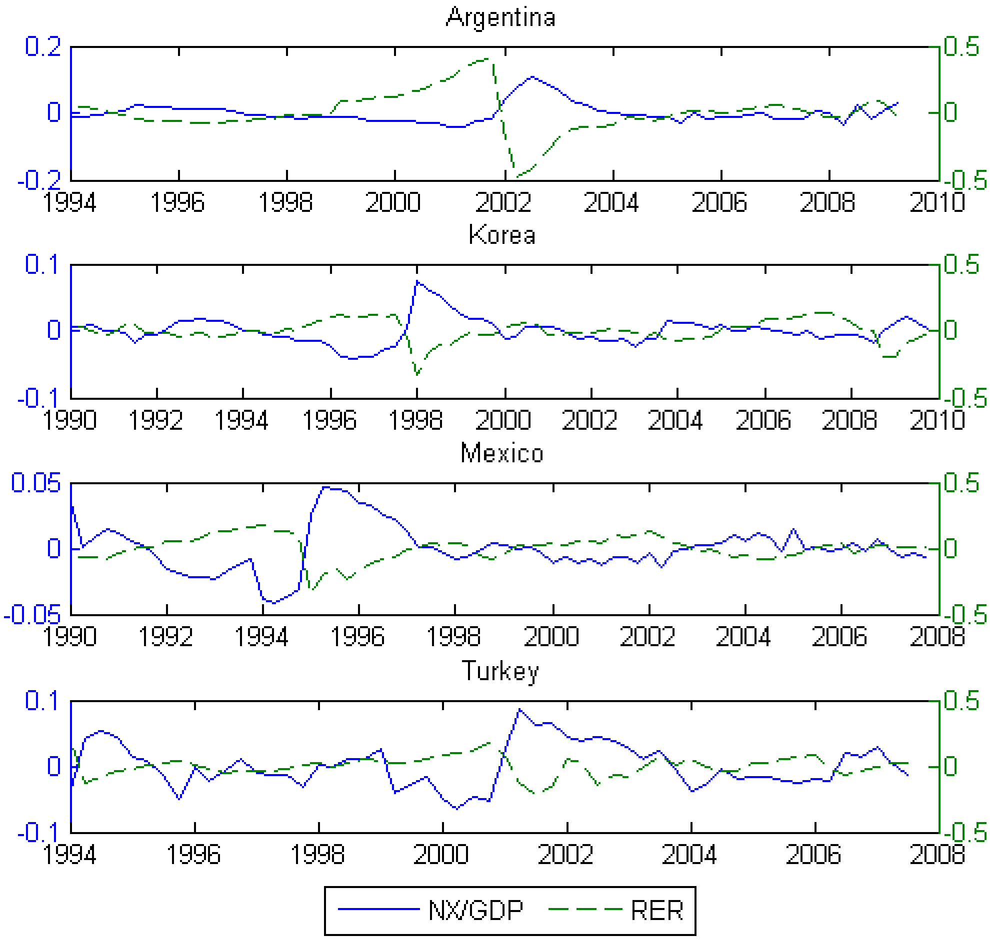


Figure 3.9: Cross-Correlations between GDP and Real Exchange Rates in Developed Economies

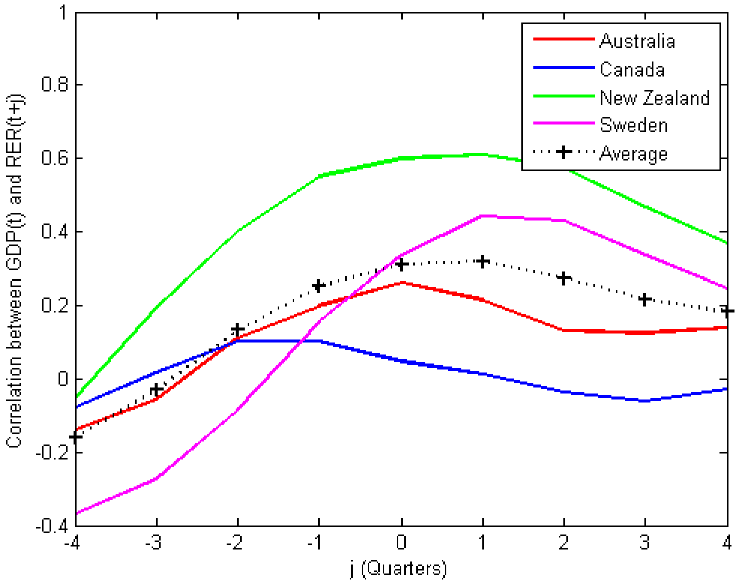


Figure 3.10: Cross-Correlations between GDP and Real Exchange Rates in Emerging Economies

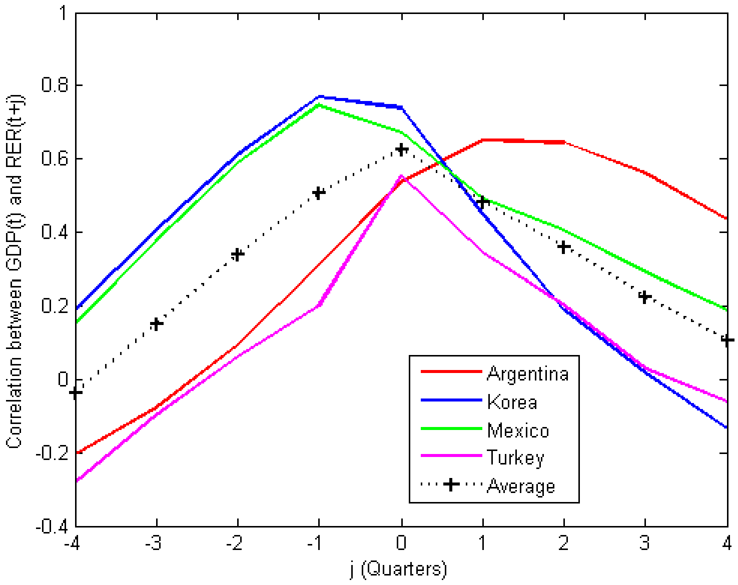


Figure 3.11: Cross-Correlations between NX/GDP and Real Exchange Rates in Developed Economies

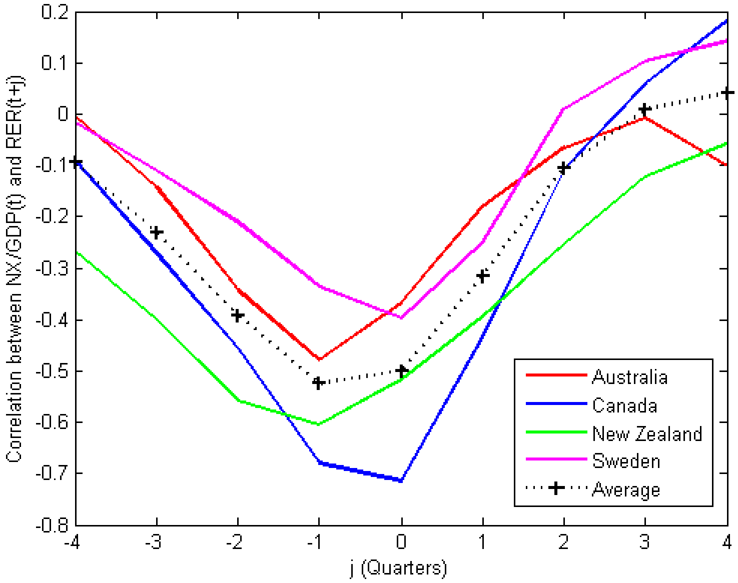


Figure 3.12: Cross-Correlations between NX/GDP and Real Exchange Rates in Emerging Economies

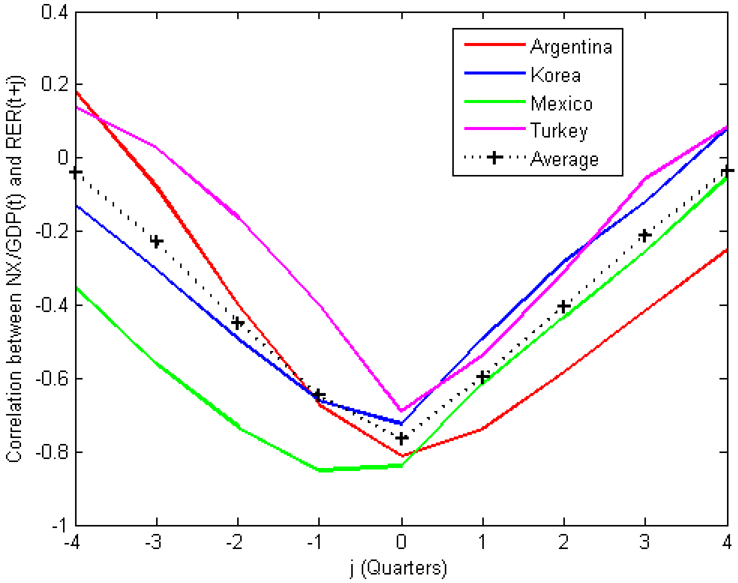


Figure 3.13: Cross-Correlations between Exports and Real Exchange Rates in Developed Economies

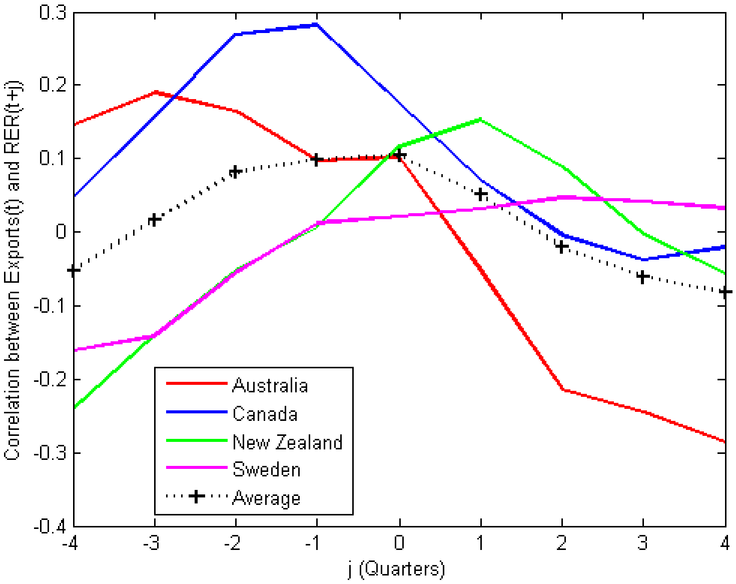


Figure 3.14: Cross-Correlations between Exports and Real Exchange Rates in Emerging Economies

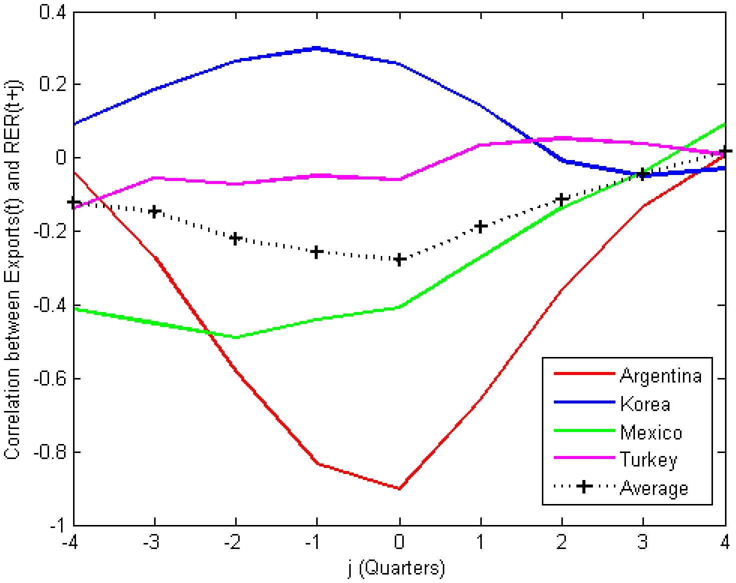


Figure 3.15: Cross-Correlations between Imports and Real Exchange Rates in Developed Economies

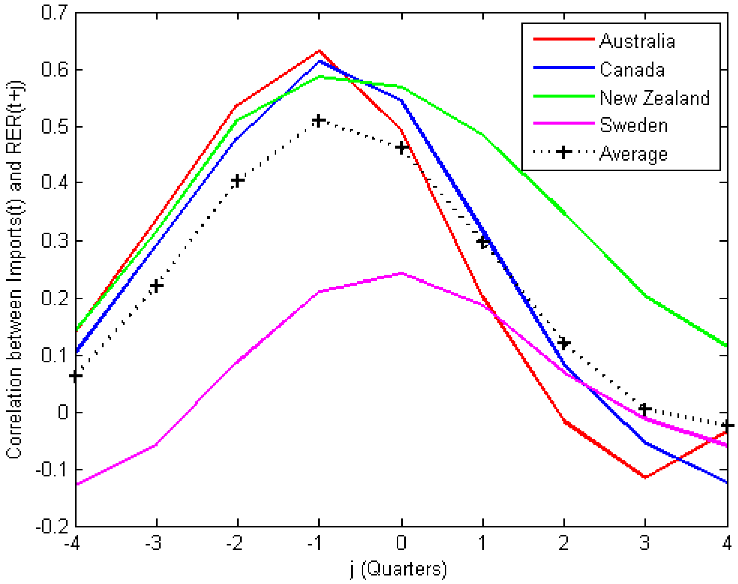


Figure 3.16: Cross-Correlations between Imports and Real Exchange Rates in Emerging Economies

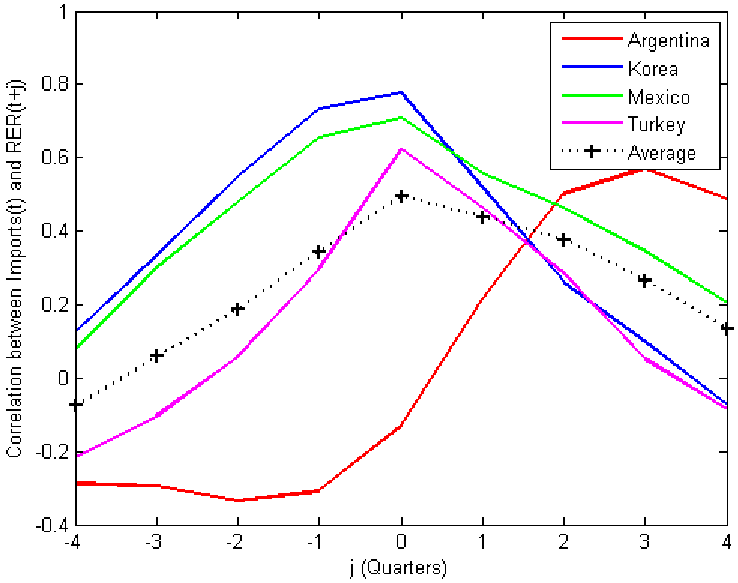


Figure 3.17: Cross-Correlations between Exports and GDP in Developed Economies

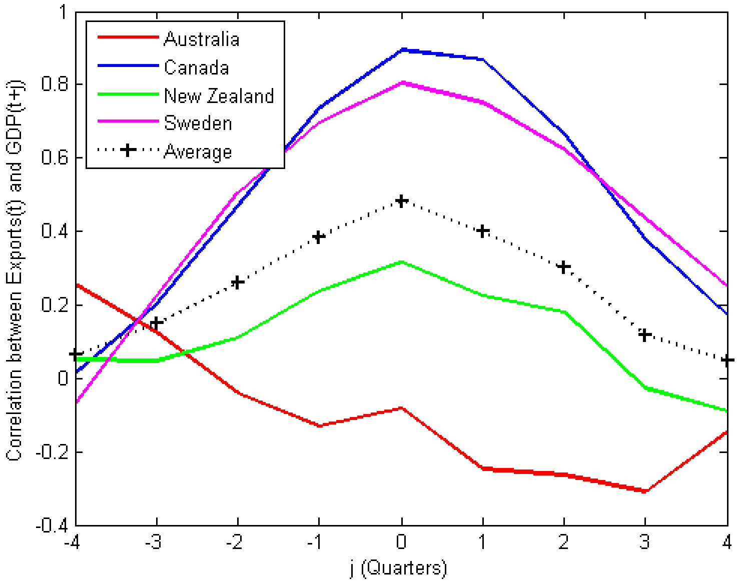


Figure 3.18: Cross-Correlations between Exports and GDP in Emerging Economies

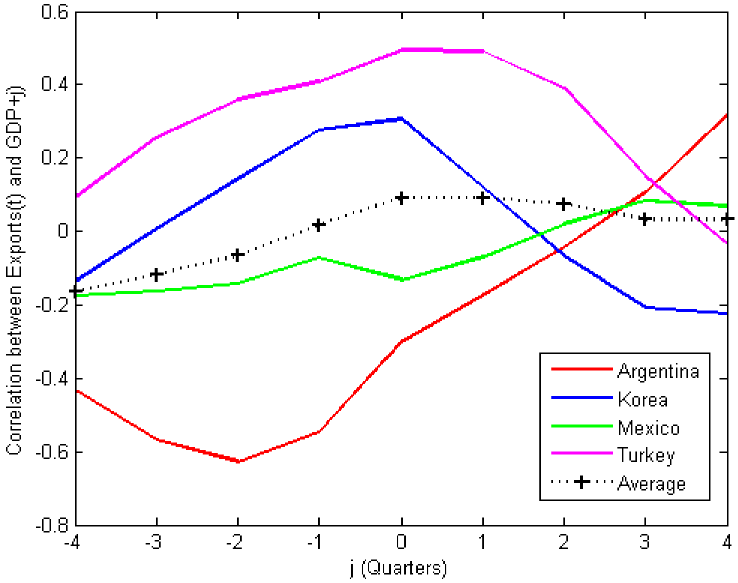


Figure 3.19: Cross-Correlations between Imports and GDP in Developed Economies

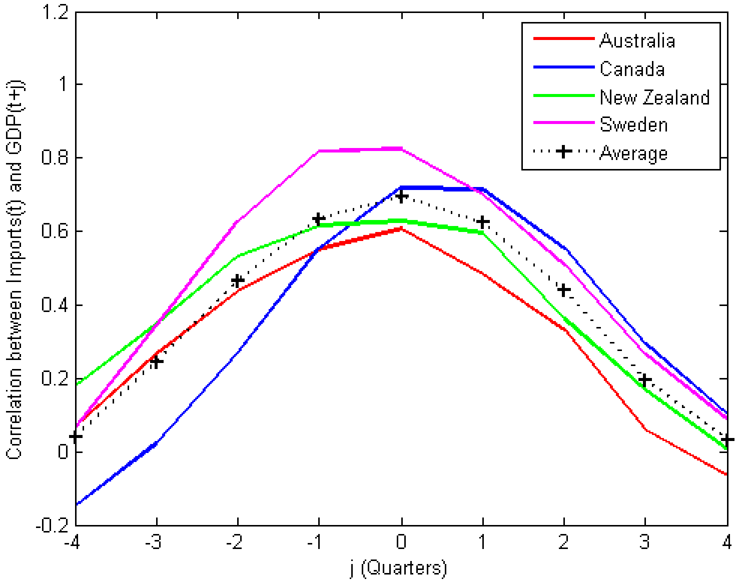


Figure 3.20: Cross-Correlations between Imports and GDP in Emerging Economies

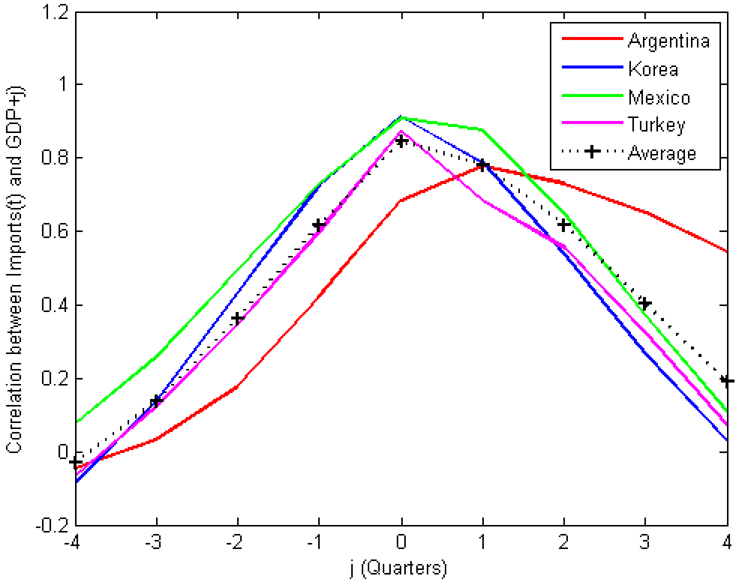


Figure 3.21: Cross-Correlations between Net Exports and GDP in Developed Economies

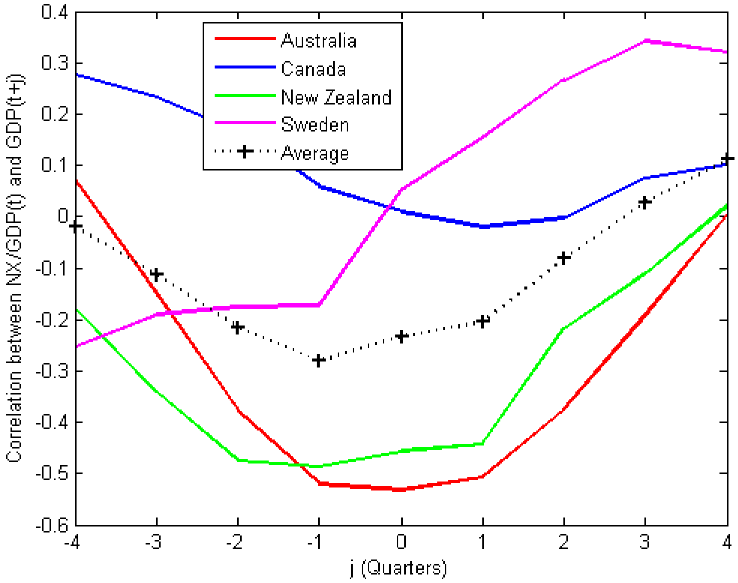


Figure 3.22: Cross-Correlations between Net Exports and GDP in Emerging Economies

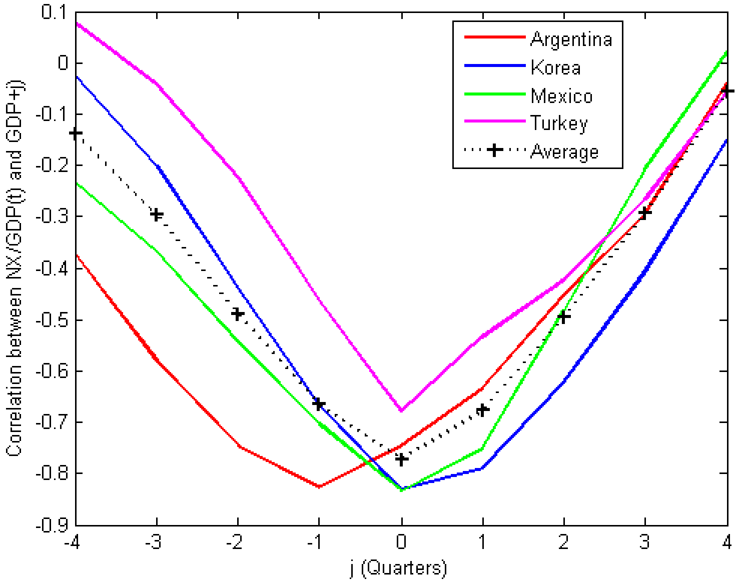


Figure 3.23: Impulse Responses for Simulation 1, No Home Bias in Capital

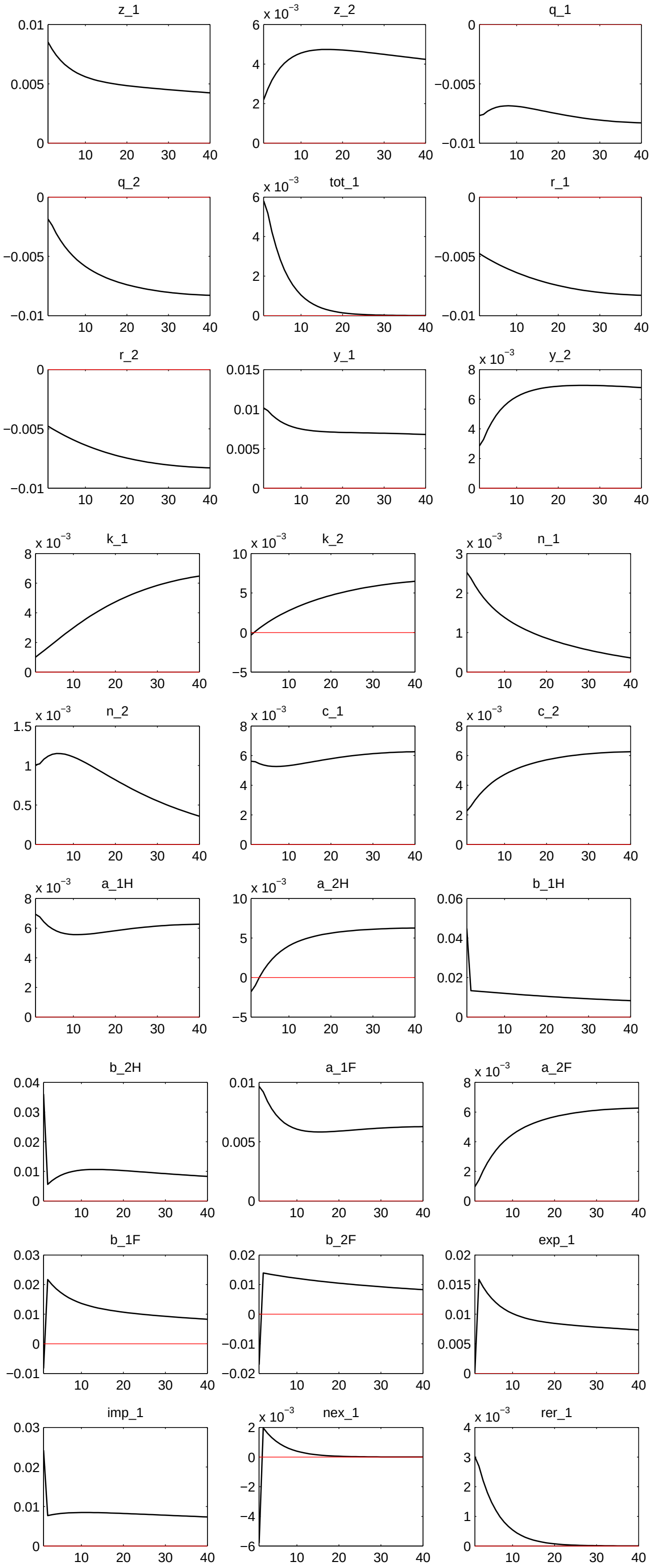
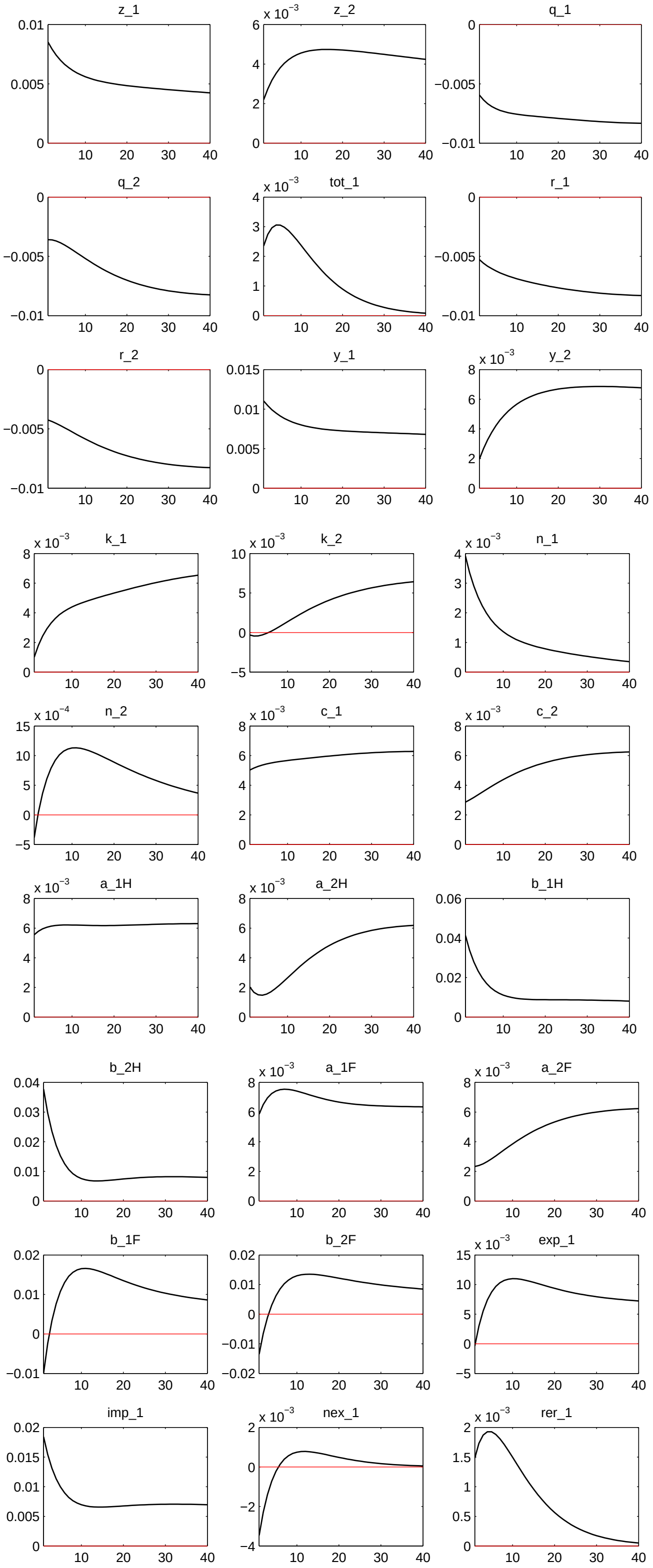


Figure 3.24: Impulse Responses for Simulation 2, Home Bias in Capital



3.6 Appendix A

This appendix contains some intermediate results and the solution of the model as described in the body of the text. See the text for details on the setup of the model. Let λ_1 and λ_2 be the social weights on country 1 and 2, respectively. The social planner solves the following problem:

$$max \qquad \sum_{t=0}^{\infty} \beta^t \left[\lambda_1 \frac{\left(\left[\omega_1 (a_{1t}^H)^{-\rho_1} + (1-\omega_1)(a_{2t}^H)^{-\rho_1}\right]^{-\mu/\rho_1} (1-n_{1t})^{1-\mu} \right)^{\gamma}}{\gamma} \right.$$

$$\left. + \lambda_2 \frac{\left(\left[(1-\omega_2)(a_{1t}^F)^{-\rho_2} + \omega_2 (a_{2t}^F)^{-\rho_2}\right]^{-\mu/\rho_2} (1-n_{2t})^{1-\mu} \right)^{\gamma}}{\gamma} \right]$$

$$s.t. \qquad a_{1t}^H + a_{1t}^F + b_{1t}^H + b_{1t}^F = z_{1t} k_{1t}^{\theta} n_{1t}^{1-\theta}$$

$$a_{2t}^H + a_{2t}^F + b_{2t}^H + b_{2t}^F = z_{2t} k_{2t}^{\theta} n_{2t}^{1-\theta}$$

$$k_{1,t+1} - (1-\delta) k_{1t} = \left[\alpha_1 (b_{1t}^H)^{(\eta_1-1)/\eta_1} + (1-\alpha_1)(b_{2t}^H)^{(\eta_1-1)/\eta_1}\right]^{\eta_1/(\eta_1-1)}$$

$$k_{2,t+1} - (1-\delta) k_{2t} = \left[(1-\alpha_2) (b_{1t}^F)^{(\eta_2-1)/\eta_2} + \alpha_2 (b_{2t}^F)^{(\eta_2-1)/\eta_2}\right]^{\eta_2/(\eta_2-1)}$$

Define the Lagrange multipliers on the constraints to be q_{1t}, q_{2t}, r_{1t}, and r_{2t}, respectively. Note that q_{it} represents the price of country i's consumption and investment goods, while r_{it} represents the price of its final investment good. Thus, we have $r_{it} = P_{it}^I$. For notational ease, let $\phi_1 = (\eta_1 - 1)/\eta_1$ and $\phi_2 = (\eta_2 - 1)/\eta_2$. The current value Lagrangian associated with the above program is:

$$
\begin{aligned}
\mathcal{L} &= \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\lambda_1}{\gamma} \left[\omega_1 (a_{1t}^H)^{-\rho_1} + (1-\omega_1)(a_{2t}^H)^{-\rho_1} \right]^{-\mu\gamma/\rho_1} (1-n_{1t})^{(1-\mu)\gamma} \right. \\
&+ \frac{\lambda_2}{\gamma} \left[(1-\omega_2)(a_{1t}^F)^{-\rho_2} + \omega_2 (a_{2t}^F)^{-\rho_2} \right]^{-\mu\gamma/\rho_2} (1-n_{2t})^{(1-\mu)\gamma} \\
&+ q_{1t} \left[z_{1t} k_{1t}^{\theta} n_{1t}^{1-\theta} - a_{1t}^H - a_{1t}^F - b_{1t}^H - b_{1t}^F \right] \\
&+ q_{2t} \left[z_{2t} k_{2t}^{\theta} n_{2t}^{1-\theta} - a_{2t}^H - a_{2t}^F - b_{2t}^H - b_{2t}^F \right] \\
&+ r_{1t} \left[\left(\alpha_1 (b_{1t}^H)^{\phi_1} + (1-\alpha_1)(b_{2t}^H)^{\phi_1} \right)^{1/\phi_1} - k_{1,t+1} + (1-\delta) k_{1t} \right] \\
&+ \left. r_{2t} \left[\left((1-\alpha_2)(b_{1t}^F)^{\phi_2} + \alpha_2 (b_{2t}^F)^{\phi_2} \right)^{1/\phi_2} - k_{2,t+1} + (1-\delta) k_{2t} \right] \right\}
\end{aligned}
$$

The first order conditions associated with the Lagrangian are given by:

$$\partial a_{1t}^H : \lambda_1 (1-n_{1t})^{(1-\mu)\gamma} \mu \left[\omega_1 (a_{1t}^H)^{-\rho_1} + (1-\omega_1)(a_{2t}^H)^{-\rho_1} \right]^{-\frac{\mu\gamma}{\rho_1}-1} \omega_1 (a_{1t}^H)^{-\rho_1-1} = q_{1t}$$

$$\partial a_{2t}^H : \lambda_1 (1-n_{1t})^{(1-\mu)\gamma} \mu \left[\omega_1 (a_{1t}^H)^{-\rho_1} + (1-\omega_1)(a_{2t}^H)^{-\rho_1} \right]^{-\frac{\mu\gamma}{\rho_1}-1} (1-\omega_1)(a_{2t}^H)^{-\rho_1-1} = q_{2t}$$

$$\partial a_{1t}^F : \lambda_2 (1-n_{2t})^{(1-\mu)\gamma} \mu \left[(1-\omega_2)(a_{1t}^F)^{-\rho_2} + \omega_2 (a_{2t}^F)^{-\rho_2} \right]^{-\frac{\mu\gamma}{\rho_2}-1} (1-\omega_2)(a_{1t}^F)^{-\rho_2-1} = q_{1t}$$

$$\partial a_{2t}^F : \lambda_2 (1-n_{2t})^{(1-\mu)\gamma} \mu \left[(1-\omega_2)(a_{1t}^F)^{-\rho_2} + \omega_2 (a_{2t}^F)^{-\rho_2} \right]^{-\frac{\mu\gamma}{\rho_2}-1} \omega_2 (a_{2t}^F)^{-\rho_2-1} = q_{2t}$$

$$\partial b_{1t}^H : r_{1t} \left[\alpha_1 (b_{1t}^H)^{\phi_1} + (1-\alpha_1)(b_{2t}^H)^{\phi_1} \right]^{\frac{1}{\phi_1}-1} \alpha_1 (b_{1t}^H)^{\phi_1-1} = q_{1t}$$

$$\partial b_{2t}^H : r_{1t} \left[\alpha_1 (b_{1t}^H)^{\phi_1} + (1-\alpha_1)(b_{2t}^H)^{\phi_1} \right]^{\frac{1}{\phi_1}-1} (1-\alpha_1)(b_{2t}^H)^{\phi_1-1} = q_{2t}$$

$$\partial b_{1t}^F : r_{2t} \left[(1-\alpha_2)(b_{1t}^F)^{\phi_2} + \alpha_2 (b_{2t}^F)^{\phi_2} \right]^{\frac{1}{\phi_2}-1} (1-\alpha_2)(b_{1t}^F)^{\phi_2-1} = q_{1t}$$

$$\partial b_{2t}^F : r_{2t} \left[(1-\alpha_2)(b_{1t}^F)^{\phi_2} + \alpha_2 (b_{2t}^F)^{\phi_2} \right]^{\frac{1}{\phi_2}-1} \alpha_2 (b_{2t}^F)^{\phi_2-1} = q_{2t}$$

$$\partial n_{1t} : \lambda_1 \left[\omega_1 (a_{1t}^H)^{-\rho_1} + (1-\omega_1)(a_{2t}^H)^{-\rho_1} \right]^{-\frac{\mu\gamma}{\rho_1}} (1-\mu)(1-n_{1t})^{(1-\mu)\gamma-1} = (1-\theta) q_{1t} z_{1t} k_{1t}^{\theta} n_{1t}^{-\theta}$$

$$\partial n_{2t} : \lambda_2 \left[(1-\omega_2)(a_{1t}^F)^{-\rho_2} + \omega_2 (a_{2t}^F)^{-\rho_2} \right]^{-\frac{\mu\gamma}{\rho_2}} (1-\mu)(1-n_{2t})^{(1-\mu)\gamma-1} = (1-\theta) q_{2t} z_{2t} k_{2t}^{\theta} n_{2t}^{-\theta}$$

$$\partial k_{1,t+1} : r_{1t} = \beta E_t \left[(1-\delta) r_{1,t+1} + \theta q_{1,t+1} z_{1,t+1} k_{1,t+1}^{\theta-1} n_{1,t+1}^{1-\theta} \right]$$

$$\partial k_{2,t+1} : r_{2t} = \beta E_t \left[(1-\delta) r_{2,t+1} + \theta q_{2,t+1} z_{2,t+1} k_{2,t+1}^{\theta-1} n_{2,t+1}^{1-\theta} \right]$$

Domestic and international market clearing conditions are given by:

$$
\begin{aligned}
a_{1t}^{H} + a_{1t}^{F} + b_{1t}^{H} + b_{1t}^{F} &= z_{1t} k_{1t}^{\theta} n_{1t}^{1-\theta} \\
a_{2t}^{H} + a_{2t}^{F} + b_{2t}^{H} + b_{2t}^{F} &= z_{2t} k_{2t}^{\theta} n_{2t}^{1-\theta} \\
k_{1,t+1} - (1-\delta) k_{1t} &= \left[\alpha_1 (b_{1t}^{H})^{\phi_1} + (1-\alpha_1)(b_{2t}^{H})^{\phi_1}\right]^{1/\phi_1} \\
k_{2,t+1} - (1-\delta) k_{2t} &= \left[(1-\alpha_2)(b_{1t}^{F})^{\phi_2} + \alpha_2 (b_{2t}^{F})^{\phi_2}\right]^{1/\phi_2}
\end{aligned}
$$

The first order conditions and the market clearing conditions above characterize the solution to the social planner's problem. Before log-linearizing the above system of equations, I list the steady-state conditions, which will help us in solving for some identities helpful for the calibration. I drop the bars and time subscripts from the endogenous variables to simplify the notation. At the steady state:

$$
\begin{aligned}
&\lambda_1 (1-n_1)^{(1-\mu)\gamma} \mu \left[\omega_1 (a_1^{H})^{-\rho_1} + (1-\omega_1)(a_2^{H})^{-\rho_1}\right]^{-\frac{\mu\gamma}{\rho_1}-1} \omega_1 (a_1^{H})^{-\rho_1-1} = q_1 \\
&\lambda_1 (1-n_1)^{(1-\mu)\gamma} \mu \left[\omega_1 (a_1^{H})^{-\rho_1} + (1-\omega_1)(a_2^{H})^{-\rho_1}\right]^{-\frac{\mu\gamma}{\rho_1}-1} (1-\omega_1)(a_2^{H})^{-\rho_1-1} = q_2 \\
&\lambda_2 (1-n_2)^{(1-\mu)\gamma} \mu \left[(1-\omega_2)(a_1^{F})^{-\rho_2} + \omega_2 (a_2^{F})^{-\rho_2}\right]^{-\frac{\mu\gamma}{\rho_2}-1} (1-\omega_2)(a_1^{F})^{-\rho_2-1} = q_1 \\
&\lambda_2 (1-n_2)^{(1-\mu)\gamma} \mu \left[(1-\omega_2)(a_1^{F})^{-\rho_2} + \omega_2 (a_2^{F})^{-\rho_2}\right]^{-\frac{\mu\gamma}{\rho_2}-1} \omega_2 (a_2^{F})^{-\rho_2-1} = q_2
\end{aligned}
$$

$$
\begin{aligned}
&r_1 \left[\alpha_1 (b_1^{H})^{\phi_1} + (1-\alpha_1)(b_2^{H})^{\phi_1}\right]^{\frac{1}{\phi_1}-1} \alpha_1 (b_1^{H})^{\phi_1-1} = q_1 \\
&r_1 \left[\alpha_1 (b_1^{H})^{\phi_1} + (1-\alpha_1)(b_2^{H})^{\phi_1}\right]^{\frac{1}{\phi_1}-1} (1-\alpha_1)(b_2^{H})^{\phi_1-1} = q_2 \\
&r_2 \left[(1-\alpha_2)(b_1^{F})^{\phi_2} + \alpha_2 (b_2^{F})^{\phi_2}\right]^{\frac{1}{\phi_2}-1} (1-\alpha_2)(b_1^{F})^{\phi_2-1} = q_1 \\
&r_2 \left[(1-\alpha_2)(b_1^{F})^{\phi_2} + \alpha_2 (b_2^{F})^{\phi_2}\right]^{\frac{1}{\phi_2}-1} \alpha_2 (b_2^{F})^{\phi_2-1} = q_2
\end{aligned}
$$

$$\lambda_1 \left[\omega_1(a_1^H)^{-\rho_1} + (1-\omega_1)(a_2^H)^{-\rho_1}\right]^{-\frac{\mu\gamma}{\rho_1}} (1-\mu)(1-n_1)^{(1-\mu)\gamma-1} = (1-\theta)q_1 z_1 k_1^{\theta} n_1^{-\theta}$$

$$\lambda_2 \left[(1-\omega_2)(a_1^F)^{-\rho_2} + \omega_2(a_2^F)^{-\rho_2}\right]^{-\frac{\mu\gamma}{\rho_2}} (1-\mu)(1-n_2)^{(1-\mu)\gamma-1} = (1-\theta)q_2 z_2 k_2^{\theta} n_2^{-\theta}$$

$$r_1(\frac{1}{\beta} - 1 + \delta) = \theta q_1 z_1 k_1^{\theta-1} n_1^{1-\theta}$$

$$r_2(\frac{1}{\beta} - 1 + \delta) = \theta q_2 z_2 k_2^{\theta-1} n_2^{1-\theta}$$

Steady state values for the market clearing conditions are:

$$\begin{aligned}
a_1^H + a_1^F + b_1^H + b_1^F &= z_1 k_1^{\theta} n_1^{1-\theta} \\
a_2^H + a_2^F + b_2^H + b_2^F &= z_2 k_2^{\theta} n_2^{1-\theta} \\
\delta k_1 &= \left[\alpha_1(b_1^H)^{\phi_1} + (1-\alpha_1)(b_2^H)^{\phi_1}\right]^{1/\phi_1} \\
\delta k_2 &= \left[(1-\alpha_2)(b_1^F)^{\phi_2} + \alpha_2(b_2^F)^{\phi_2}\right]^{1/\phi_2}
\end{aligned}$$

We compute the equilibrium numerically by a second-order approximation around the steady state. We log-linearize the equilibrium conditions by hand (first order), and Dynare carries out a further approximation given the linearized system (second order). This way, we don't have to solve for the steady state values of all endogenous variables but for a number of ratios describing them. For notational ease, define leisure to be $l_{it} = 1 - n_{it}$. The log-linearized system looks as follows (in terms of notation, I drop the time subscripts and omit bars for steady state values, and tildes mean log deviations):

$$\begin{aligned}
\left(1+\frac{\omega_1}{1-\omega_1}\left(\frac{a_2^H}{a_1^H}\right)^{\rho_1}\right)\left((1-\mu)\gamma\tilde{l}_{1t}-\tilde{q}_{1t}\right) &= \left(1+\rho_1+(1-\mu\gamma)\frac{\omega_1}{1-\omega_1}\left(\frac{a_2^H}{a_1^H}\right)^{\rho_1}\right)\tilde{a}_{1t}^H \\
&\quad -(\mu\gamma+\rho_1)\tilde{a}_{2t}^H \\
\left(1+\frac{1-\omega_1}{\omega_1}\left(\frac{a_1^H}{a_2^H}\right)^{\rho_1}\right)\left((1-\mu)\gamma\tilde{l}_{1t}-\tilde{q}_{2t}\right) &= \left(1+\rho_1+(1-\mu\gamma)\frac{1-\omega_1}{\omega_1}\left(\frac{a_1^H}{a_2^H}\right)^{\rho_1}\right)\tilde{a}_{2t}^H \\
&\quad -(\mu\gamma+\rho_1)\tilde{a}_{1t}^H \\
\left(1+\frac{1-\omega_2}{\omega_2}\left(\frac{a_2^F}{a_1^F}\right)^{\rho_2}\right)\left((1-\mu)\gamma\tilde{l}_{2t}-\tilde{q}_{1t}\right) &= \left(1+\rho_2+(1-\mu\gamma)\frac{1-\omega_2}{\omega_2}\left(\frac{a_2^F}{a_1^F}\right)^{\rho_2}\right)\tilde{a}_{1t}^F \\
&\quad -(\mu\gamma+\rho_2)\tilde{a}_{2t}^F \\
\left(1+\frac{\omega_2}{1-\omega_2}\left(\frac{a_1^F}{a_2^F}\right)^{\rho_2}\right)\left((1-\mu)\gamma\tilde{l}_{2t}-\tilde{q}_{2t}\right) &= \left(1+\rho_2+(1-\mu\gamma)\frac{\omega_2}{1-\omega_2}\left(\frac{a_1^F}{a_2^F}\right)^{\rho_2}\right)\tilde{a}_{2t}^F \\
&\quad -(\mu\gamma+\rho_2)\tilde{a}_{1t}^F
\end{aligned}$$

$$\begin{aligned}
\tilde{r}_{1t}-\tilde{q}_{1t} &= \frac{\phi_1-1}{1+\frac{\alpha_1}{1-\alpha_1}\left(\frac{b_1^H}{b_2^H}\right)^{\phi_1}}(\tilde{b}_{2t}^H-\tilde{b}_{1t}^H) \\
\tilde{r}_{1t}-\tilde{q}_{2t} &= \frac{\phi_1-1}{1+\frac{1-\alpha_1}{\alpha_1}\left(\frac{b_2^H}{b_1^H}\right)^{\phi_1}}(\tilde{b}_{1t}^H-\tilde{b}_{2t}^H) \\
\tilde{r}_{2t}-\tilde{q}_{1t} &= \frac{\phi_2-1}{1+\frac{1-\alpha_2}{\alpha_2}\left(\frac{b_1^F}{b_2^F}\right)^{\phi_2}}(\tilde{b}_{2t}^F-\tilde{b}_{1t}^F) \\
\tilde{r}_{2t}-\tilde{q}_{2t} &= \frac{\phi_2-1}{1+\frac{\alpha_2}{1-\alpha_2}\left(\frac{b_2^F}{b_1^F}\right)^{\phi_2}}(\tilde{b}_{1t}^F-\tilde{b}_{2t}^F)
\end{aligned}$$

$$\begin{aligned}
&\frac{\mu\gamma}{1+\frac{1-\omega_1}{\omega_1}\left(\frac{a_1^H}{a_2^H}\right)^{\rho_1}}\tilde{a}_{1t}^H+\frac{\mu\gamma}{1+\frac{\omega_1}{1-\omega_1}\left(\frac{a_2^H}{a_1^H}\right)^{\rho_1}}\tilde{a}_{2t}^H=\tilde{q}_{1t}+\tilde{z}_{1t}+\theta\tilde{k}_{1t}-\theta\tilde{n}_{1t}-((1-\mu)\gamma-1)\tilde{l}_{1t}\\
&\frac{\mu\gamma}{1+\frac{\omega_2}{1-\omega_2}\left(\frac{a_1^F}{a_2^F}\right)^{\rho_2}}\tilde{a}_{1t}^F+\frac{\mu\gamma}{1+\frac{1-\omega_2}{\omega_2}\left(\frac{a_2^F}{a_1^F}\right)^{\rho_2}}\tilde{a}_{2t}^F=\tilde{q}_{2t}+\tilde{z}_{2t}+\theta\tilde{k}_{2t}-\theta\tilde{n}_{2t}-((1-\mu)\gamma-1)\tilde{l}_{2t}\\
&\frac{1}{\beta}\tilde{r}_{1t}=(1-\delta)\tilde{r}_{1,t+1}+(\frac{1}{\beta}-1+\delta)(\tilde{q}_{1,t+1}+\tilde{z}_{1,t+1}+(\theta-1)\tilde{k}_{1,t+1}+(1-\theta)\tilde{n}_{1,t+1})\\
&\frac{1}{\beta}\tilde{r}_{2t}=(1-\delta)\tilde{r}_{2,t+1}+(\frac{1}{\beta}-1+\delta)(\tilde{q}_{2,t+1}+\tilde{z}_{2,t+1}+(\theta-1)\tilde{k}_{2,t+1}+(1-\theta)\tilde{n}_{2,t+1})\\
&\frac{l_1}{n_1}\tilde{l}_{1t}=-\tilde{n}_{1t}\\
&\frac{l_2}{n_2}\tilde{l}_{2t}=-\tilde{n}_{2t}
\end{aligned}$$

Log-linearizing the market clearing conditions:

$$\begin{aligned}
&\frac{a_1^H}{y_1}\tilde{a}_{1t}^H+\frac{a_1^F}{y_1}\tilde{a}_{1t}^F+\frac{b_1^H}{y_1}\tilde{b}_{1t}^H+\frac{b_1^F}{y_1}\tilde{b}_{1t}^F=\tilde{z}_{1t}+\theta\tilde{k}_{1t}+(1-\theta)\tilde{n}_{1t}\\
&\frac{a_2^H}{y_2}\tilde{a}_{2t}^H+\frac{a_2^F}{y_2}\tilde{a}_{2t}^F+\frac{b_2^H}{y_2}\tilde{b}_{2t}^H+\frac{b_2^F}{y_2}\tilde{b}_{2t}^F=\tilde{z}_{2t}+\theta\tilde{k}_{2t}+(1-\theta)\tilde{n}_{2t}\\
&\tilde{k}_{1,t+1}-(1-\delta)\tilde{k}_{1t}=\frac{\delta}{1+\frac{1-\alpha_1}{\alpha_1}\left(\frac{b_2^H}{b_1^H}\right)^{\phi_1}}\tilde{b}_{1t}^H+\frac{\delta}{1+\frac{\alpha_1}{1-\alpha_1}\left(\frac{b_1^H}{b_2^H}\right)^{\phi_1}}\tilde{b}_{2t}^H\\
&\tilde{k}_{2,t+1}-(1-\delta)\tilde{k}_{2t}=\frac{\delta}{1+\frac{\alpha_2}{1-\alpha_2}\left(\frac{b_2^F}{b_1^F}\right)^{\phi_2}}\tilde{b}_{1t}^F+\frac{\delta}{1+\frac{1-\alpha_2}{\alpha_2}\left(\frac{b_1^F}{b_2^F}\right)^{\phi_2}}\tilde{b}_{2t}^F
\end{aligned}$$

The technology shocks process follows:

$$\begin{aligned}
\tilde{z}_{1,t+1} &= A_{11}\tilde{z}_{1t}+A_{12}\tilde{z}_{2t}+\varepsilon_{t+1}\\
\tilde{z}_{2,t+1} &= A_{12}\tilde{z}_{1t}+A_{11}\tilde{z}_{2t}+\varepsilon_{t+1}
\end{aligned}$$

We incorporate the behavior of consumption, terms of trade, price indices, and real exchange rate to the linearized model:

$$
\begin{aligned}
\tilde{c}_{1t} &= \frac{1}{1+\frac{1-\omega_1}{\omega_1}\left(\frac{a_1^H}{a_2^H}\right)^{\rho_1}}\tilde{a}_{1t}^H + \frac{1}{1+\frac{\omega_1}{1-\omega_1}\left(\frac{a_2^H}{a_1^H}\right)^{\rho_1}}\tilde{a}_{2t}^H \\
\tilde{c}_{2t} &= \frac{1}{1+\frac{\omega_2}{1-\omega_2}\left(\frac{a_1^F}{a_2^F}\right)^{\rho_2}}\tilde{a}_{1t}^F + \frac{1}{1+\frac{1-\omega_2}{\omega_2}\left(\frac{a_2^F}{a_1^F}\right)^{\rho_2}}\tilde{a}_{2t}^F \\
\tilde{p}_{1t} &= \tilde{q}_{2t} - \tilde{q}_{1t} \\
\tilde{p}_{2t} &= \tilde{q}_{1t} - \tilde{q}_{2t} \\
\tilde{P}_{1t}^C &= \frac{1}{1+\left(\frac{1-\omega_1}{\omega_1}\right)^{\sigma_1}\left(\frac{q_2}{q_1}\right)^{1-\sigma_1}}\tilde{q}_{1t} + \frac{1}{1+\left(\frac{\omega_1}{1-\omega_1}\right)^{\sigma_1}\left(\frac{q_1}{q_2}\right)^{1-\sigma_1}}\tilde{q}_{2t} \\
\tilde{P}_{2t}^C &= \frac{1}{1+\left(\frac{\omega_2}{1-\omega_2}\right)^{\sigma_2}\left(\frac{q_2}{q_1}\right)^{1-\sigma_2}}\tilde{q}_{1t} + \frac{1}{1+\left(\frac{1-\omega_2}{\omega_2}\right)^{\sigma_2}\left(\frac{q_1}{q_2}\right)^{1-\sigma_2}}\tilde{q}_{2t} \\
\tilde{P}_{1t} &= \pi_{1C}\tilde{P}_{1t}^C + \pi_{1I}\tilde{r}_{1t} \\
\tilde{P}_{2t} &= \pi_{2C}\tilde{P}_{2t}^C + \pi_{2I}\tilde{r}_{2t} \\
\tilde{E}_{1t} &= \tilde{P}_{2t} - \tilde{P}_{1t} \\
\tilde{E}_{2t} &= \tilde{P}_{1t} - \tilde{P}_{2t}
\end{aligned}
$$

Finally, total output, exports, imports, and net exports are added to the linearized model following the definitions earlier (note that net exports are not deviations from steady state - we express net exports in terms of the linearized variables):

$$
\begin{aligned}
\tilde{y}_{1t} &= \frac{a_1^H}{y_1}\tilde{a}_{1t}^H + \frac{a_1^F}{y_1}\tilde{a}_{1t}^F + \frac{b_1^H}{y_1}\tilde{b}_{1t}^H + \frac{b_1^F}{y_1}\tilde{b}_{1t}^F \\
\tilde{y}_{2t} &= \frac{a_2^H}{y_2}\tilde{a}_{2t}^H + \frac{a_2^F}{y_2}\tilde{a}_{2t}^F + \frac{b_2^H}{y_2}\tilde{b}_{2t}^H + \frac{b_2^F}{y_2}\tilde{b}_{2t}^F \\
e\tilde{x}p_{1t} &= \frac{1}{1+b_1^F/a_1^F}\tilde{a}_{1t}^F + \frac{1}{1+a_1^F/b_1^F}\tilde{b}_{1t}^F \\
e\tilde{x}p_{2t} &= \frac{1}{1+b_2^H/a_2^H}\tilde{a}_{2t}^H + \frac{1}{1+a_2^H/b_2^H}\tilde{b}_{2t}^H \\
i\tilde{m}p_{1t} &= \tilde{p}_{1t} + \frac{1}{1+b_2^H/a_2^H}\tilde{a}_{2t}^H + \frac{1}{1+a_2^H/b_2^H}\tilde{b}_{2t}^H \\
i\tilde{m}p_{2t} &= \tilde{p}_{2t} + \frac{1}{1+b_1^F/a_1^F}\tilde{a}_{1t}^F + \frac{1}{1+a_1^F/b_1^F}\tilde{b}_{1t}^F \\
nx_{1t} &= \frac{a_1^F}{y_1}e^{\tilde{a}_{1t}^F-\tilde{y}_{1t}} + \frac{b_1^F}{y_1}e^{\tilde{b}_{1t}^F-\tilde{y}_{1t}} - \frac{a_2^H}{y_1}e^{\tilde{p}_{1t}+\tilde{a}_{2t}^H-\tilde{y}_{1t}} - \frac{b_2^H}{y_1}e^{\tilde{p}_{1t}+\tilde{b}_{2t}^H-\tilde{y}_{1t}} \\
nx_{2t} &= \frac{a_2^H}{y_2}e^{\tilde{a}_{2t}^H-\tilde{y}_{2t}} + \frac{b_2^H}{y_2}e^{\tilde{b}_{2t}^H-\tilde{y}_{2t}} - \frac{a_1^F}{y_2}e^{\tilde{p}_{2t}+\tilde{a}_{1t}^F-\tilde{y}_{2t}} - \frac{b_1^F}{y_2}e^{\tilde{p}_{2t}+\tilde{b}_{1t}^F-\tilde{y}_{2t}}
\end{aligned}
$$

So in order to calibrate the model correctly, we need to solve for the following ratios of steady state values (the other ratios appearing above can be inferred):

$$
\frac{a_1^H}{a_2^H},\ \frac{a_1^F}{a_2^F},\ \frac{b_1^H}{b_2^H},\ \frac{b_1^F}{b_2^F},\ \frac{n_i}{l_i},\ \frac{a_i^H}{y_i},\ \frac{a_i^F}{y_i},\ \frac{b_i^H}{y_i},\ \frac{b_i^F}{y_i}
$$

Some immediate results from the steady state conditions:

(3.3)

$$
\frac{q_1}{q_2} = \frac{\omega_1}{1-\omega_1}\left(\frac{a_2^H}{a_1^H}\right)^{\rho_1+1} = \frac{1-\omega_2}{\omega_2}\left(\frac{a_2^F}{a_1^F}\right)^{\rho_2+1} = \frac{\alpha_1}{1-\alpha_1}\left(\frac{b_1^H}{b_2^H}\right)^{\phi_1-1} = \frac{1-\alpha_2}{\alpha_2}\left(\frac{b_1^F}{b_2^F}\right)^{\phi_2-1}
$$

Some intermediate results:

$$\frac{b_1^H}{k_1} = \delta\left(\frac{q_1}{\alpha_1 r_1}\right)^{\frac{1}{\phi_1-1}} = \delta\alpha_1^{\eta_1}\left[\alpha_1^{\eta_1} + (1-\alpha_1)^{\eta_1}\left(\frac{q_2}{q_1}\right)^{1-\eta_1}\right]^{\frac{\eta_1}{1-\eta_1}}$$

$$\frac{b_2^H}{k_1} = \delta\left(\frac{q_2}{(1-\alpha_1) r_1}\right)^{\frac{1}{\phi_1-1}} = \delta(1-\alpha_1)^{\eta_1}\left[(1-\alpha_1)^{\eta_1} + \alpha_1^{\eta_1}\left(\frac{q_1}{q_2}\right)^{1-\eta_1}\right]^{\frac{\eta_1}{1-\eta_1}}$$

$$\alpha_1^{\eta_1} + (1-\alpha_1)^{\eta_1}\left(\frac{q_2}{q_1}\right)^{1-\eta_1} = \left(\frac{\theta}{\frac{1}{\beta}-1+\delta}\right)^{1-\eta_1}(\underbrace{z_1 k_1^{\theta-1} n_1^{1-\theta}}_{y_1/k_1})^{1-\eta_1}$$

$$\alpha_2^{\eta_2} + (1-\alpha_2)^{\eta_2}\left(\frac{q_1}{q_2}\right)^{1-\eta_2} = \left(\frac{\theta}{\frac{1}{\beta}-1+\delta}\right)^{1-\eta_2}(\underbrace{z_2 k_2^{\theta-1} n_2^{1-\theta}}_{y_2/k_2})^{1-\eta_2}$$

$$\frac{\mu}{1-\mu}\omega_1\frac{1-n_1}{n_1}(1-\theta)\frac{y_1}{a_1^H} = \omega_1 + (1-\omega_1)\left(\frac{a_1^H}{a_2^H}\right)^{\rho_1} \tag{3.4}$$

We assume a symmetric steady state where both countries in the model have the same technologies both in their consumption and investment good sectors. This means that in the final investment good sector we have $\alpha_1 = \alpha_2$ and $\eta_1 = \eta_2$, and for the consumption aggregator we have $\omega_1 = \omega_2$ and $\sigma_1 = \sigma_2$. This implies identical home bias across the two countries in consumption and in investment as well as identical elasticities of substitution between domestic and foreign goods in both aggregates.

In a symmetric steady state, $y_1 = y_2$, $q_1 = q_2$, $a_1^H = a_2^F$, $a_2^H = a_1^F$, $b_1^H = b_2^F$, and $b_2^H = b_1^F$. This implies a steady state value of one for the terms of trade and pins down most of the ratios we need for the calibration (see equation (3.3)). Some of the intermediate results above simplify to:

$$
\begin{aligned}
\frac{b_1^H}{k_1} &= \delta\alpha_1^{\eta_1}\left[\alpha_1^{\eta_1}+(1-\alpha_1)^{\eta_1}\right]^{\frac{\eta_1}{1-\eta_1}} \\
\frac{b_2^H}{k_1} &= \delta(1-\alpha_1)^{\eta_1}\left[\alpha_1^{\eta_1}+(1-\alpha_1)^{\eta_1}\right]^{\frac{\eta_1}{1-\eta_1}} \\
\frac{k_1}{y_1} &= \frac{\theta}{\frac{1}{\beta}-1+\delta}\left[\alpha_1^{\eta_1}+(1-\alpha_1)^{\eta_1}\right]^{-\frac{1}{1-\eta_1}} \\
\frac{k_2}{y_2} &= \frac{\theta}{\frac{1}{\beta}-1+\delta}\left[\alpha_2^{\eta_2}+(1-\alpha_2)^{\eta_2}\right]^{-\frac{1}{1-\eta_2}}
\end{aligned}
$$

These results imply:

$$\frac{b_1^H}{y_1}=\frac{b_2^F}{y_2}=\frac{\delta\theta}{\frac{1}{\beta}-1+\delta}\frac{1}{1+\left(\frac{1-\alpha_1}{\alpha_1}\right)^{\eta_1}}$$

$$\frac{b_2^H}{y_2}=\frac{b_1^F}{y_1}=\frac{\delta\theta}{\frac{1}{\beta}-1+\delta}\frac{1}{1+\left(\frac{\alpha_1}{1-\alpha_1}\right)^{\eta_1}}$$

Using the market clearing conditions and the results above, we get:

$$\frac{a_1^H}{y_1}=\frac{a_2^F}{y_2}=\frac{1-\frac{\delta\theta}{1/\beta-1+\delta}}{1+\left(\frac{1-\omega_1}{\omega_1}\right)^{\sigma_1}}$$

$$\frac{a_2^H}{y_2}=\frac{a_1^F}{y_1}=\frac{1-\frac{\delta\theta}{1/\beta-1+\delta}}{1+\left(\frac{\omega_1}{1-\omega_1}\right)^{\sigma_1}}$$

Using the intermediate result (3.4), we get:

$$\frac{l_1}{n_1}=\frac{l_2}{n_2}=\frac{1-\mu}{\mu}\frac{1}{1-\theta}\left(1-\frac{\delta\theta}{\frac{1}{\beta}-1+\delta}\right)$$

Also useful for the calibration, we calculate the steady state expenditure shares of consumption and investment (we calculate by $\pi_1^C = P_1^C c_1/(P_1^C c_1 + r_1 x_1)$, and similarly for π_1^I), which is useful in calculating the overall price index:

$$\pi_1^C=\pi_2^C=1-\frac{\delta\theta}{\frac{1}{\beta}-1+\delta}$$

$$\pi_1^I = \pi_2^I = \frac{\delta\theta}{\frac{1}{\beta} - 1 + \delta}$$

Using the properties of the symmetric steady state, we rewrite the log-linearized system as follows.

First order conditions:

$$\begin{aligned}
\left(1 + \left(\frac{\omega_1}{1-\omega_1}\right)^{\sigma_1}\right)\left((1-\mu)\gamma\tilde{l}_{1t} - \tilde{q}_{1t}\right) &= \left(\frac{1}{\sigma_1} + (1-\mu\gamma)\left(\frac{\omega_1}{1-\omega_1}\right)^{\sigma_1}\right)\tilde{a}_{1t}^H \\
&\quad -(\mu\gamma + \frac{1}{\sigma_1} - 1)\tilde{a}_{2t}^H \\
\left(1 + \left(\frac{1-\omega_1}{\omega_1}\right)^{\sigma_1}\right)\left((1-\mu)\gamma\tilde{l}_{1t} - \tilde{q}_{2t}\right) &= \left(\frac{1}{\sigma_1} + (1-\mu\gamma)\left(\frac{1-\omega_1}{\omega_1}\right)^{\sigma_1}\right)\tilde{a}_{2t}^H \\
&\quad -(\mu\gamma + \frac{1}{\sigma_1} - 1)\tilde{a}_{1t}^H \\
\left(1 + \left(\frac{1-\omega_2}{\omega_2}\right)^{\sigma_2}\right)\left((1-\mu)\gamma\tilde{l}_{2t} - \tilde{q}_{1t}\right) &= \left(\frac{1}{\sigma_2} + (1-\mu\gamma)\left(\frac{1-\omega_2}{\omega_2}\right)^{\sigma_2}\right)\tilde{a}_{1t}^F \\
&\quad -(\mu\gamma + \frac{1}{\sigma_2} - 1)\tilde{a}_{2t}^F \\
\left(1 + \left(\frac{\omega_2}{1-\omega_2}\right)^{\sigma_2}\right)\left((1-\mu)\gamma\tilde{l}_{2t} - \tilde{q}_{2t}\right) &= \left(\frac{1}{\sigma_2} + (1-\mu\gamma)\left(\frac{\omega_2}{1-\omega_2}\right)^{\sigma_2}\right)\tilde{a}_{2t}^F \\
&\quad -(\mu\gamma + \frac{1}{\sigma_2} - 1)\tilde{a}_{1t}^F
\end{aligned}$$

$$\begin{aligned}
\tilde{r}_{1t} + \frac{1/\eta_1}{1 + \left(\frac{\alpha_1}{1-\alpha_1}\right)^{\eta_1}}(\tilde{b}_{2t}^H - \tilde{b}_{1t}^H) &= \tilde{q}_{1t} \\
\tilde{r}_{1t} + \frac{1/\eta_1}{1 + \left(\frac{1-\alpha_1}{\alpha_1}\right)^{\eta_1}}(\tilde{b}_{1t}^H - \tilde{b}_{2t}^H) &= \tilde{q}_{2t} \\
\tilde{r}_{2t} + \frac{1/\eta_2}{1 + \left(\frac{1-\alpha_2}{\alpha_2}\right)^{\eta_2}}(\tilde{b}_{2t}^F - \tilde{b}_{1t}^F) &= \tilde{q}_{1t} \\
\tilde{r}_{2t} + \frac{1/\eta_2}{1 + \left(\frac{\alpha_2}{1-\alpha_2}\right)^{\eta_2}}(\tilde{b}_{1t}^F - \tilde{b}_{2t}^F) &= \tilde{q}_{2t}
\end{aligned}$$

$$
\begin{aligned}
&\frac{\mu\gamma}{1+\left(\frac{1-\omega_1}{\omega_1}\right)^{\sigma_1}}\tilde{a}^H_{1t}+\frac{\mu\gamma}{1+\left(\frac{\omega_1}{1-\omega_1}\right)^{\sigma_1}}\tilde{a}^H_{2t}=\tilde{q}_{1t}+\tilde{z}_{1t}+\theta\tilde{k}_{1t}-\theta\tilde{n}_{1t}-((1-\mu)\gamma-1)\tilde{l}_{1t}\\
&\frac{\mu\gamma}{1+\left(\frac{\omega_2}{1-\omega_2}\right)^{\sigma_2}}\tilde{a}^F_{1t}+\frac{\mu\gamma}{1+\left(\frac{1-\omega_2}{\omega_2}\right)^{\sigma_2}}\tilde{a}^F_{2t}=\tilde{q}_{2t}+\tilde{z}_{2t}+\theta\tilde{k}_{2t}-\theta\tilde{n}_{2t}-((1-\mu)\gamma-1)\tilde{l}_{2t}\\
&\frac{1}{\beta}\tilde{r}_{1t}=(1-\delta)\tilde{r}_{1,t+1}+(\frac{1}{\beta}-1+\delta)(\tilde{q}_{1,t+1}+\tilde{z}_{1,t+1}+(\theta-1)\tilde{k}_{1,t+1}+(1-\theta)\tilde{n}_{1,t+1})\\
&\frac{1}{\beta}\tilde{r}_{2t}=(1-\delta)\tilde{r}_{2,t+1}+(\frac{1}{\beta}-1+\delta)(\tilde{q}_{2,t+1}+\tilde{z}_{2,t+1}+(\theta-1)\tilde{k}_{2,t+1}+(1-\theta)\tilde{n}_{2,t+1})\\
&\frac{l_1}{n_1}\tilde{l}_{1t}=-\tilde{n}_{1t}\\
&\frac{l_2}{n_2}\tilde{l}_{2t}=-\tilde{n}_{2t}
\end{aligned}
$$

Market clearing conditions:

$$
\begin{aligned}
&\frac{a^H_1}{y_1}\tilde{a}^H_{1t}+\frac{a^F_1}{y_1}\tilde{a}^F_{1t}+\frac{b^H_1}{y_1}\tilde{b}^H_{1t}+\frac{b^F_1}{y_1}\tilde{b}^F_{1t}=\tilde{z}_{1t}+\theta\tilde{k}_{1t}+(1-\theta)\tilde{n}_{1t}\\
&\frac{a^H_2}{y_2}\tilde{a}^H_{2t}+\frac{a^F_2}{y_2}\tilde{a}^F_{2t}+\frac{b^H_2}{y_2}\tilde{b}^H_{2t}+\frac{b^F_2}{y_2}\tilde{b}^F_{2t}=\tilde{z}_{2t}+\theta\tilde{k}_{2t}+(1-\theta)\tilde{n}_{2t}\\
&\tilde{k}_{1,t+1}-(1-\delta)\tilde{k}_{1t}=\frac{\delta}{1+\left(\frac{1-\alpha_1}{\alpha_1}\right)^{\eta_1}}\tilde{b}^H_{1t}+\frac{\delta}{1+\left(\frac{\alpha_1}{1-\alpha_1}\right)^{\eta_1}}\tilde{b}^H_{2t}\\
&\tilde{k}_{2,t+1}-(1-\delta)\tilde{k}_{2t}=\frac{\delta}{1+\left(\frac{\alpha_2}{1-\alpha_2}\right)^{\eta_2}}\tilde{b}^F_{1t}+\frac{\delta}{1+\left(\frac{1-\alpha_2}{\alpha_2}\right)^{\eta_2}}\tilde{b}^F_{2t}
\end{aligned}
$$

Simplifying further some of the other equations of the system:

$$
\begin{aligned}
\tilde{c}_{1t}&=\frac{1}{1+\left(\frac{1-\omega_1}{\omega_1}\right)^{\sigma_1}}\tilde{a}^H_{1t}+\frac{1}{1+\left(\frac{\omega_1}{1-\omega_1}\right)^{\sigma_1}}\tilde{a}^H_{2t}\\
\tilde{c}_{2t}&=\frac{1}{1+\left(\frac{\omega_2}{1-\omega_2}\right)^{\sigma_2}}\tilde{a}^F_{1t}+\frac{1}{1+\left(\frac{1-\omega_2}{\omega_2}\right)^{\sigma_2}}\tilde{a}^F_{2t}\\
\tilde{P}^C_{1t}&=\frac{1}{1+\left(\frac{1-\omega_1}{\omega_1}\right)^{\sigma_1}}\tilde{q}_{1t}+\frac{1}{1+\left(\frac{\omega_1}{1-\omega_1}\right)^{\sigma_1}}\tilde{q}_{2t}\\
\tilde{P}^C_{2t}&=\frac{1}{1+\left(\frac{\omega_2}{1-\omega_2}\right)^{\sigma_2}}\tilde{q}_{1t}+\frac{1}{1+\left(\frac{1-\omega_2}{\omega_2}\right)^{\sigma_2}}\tilde{q}_{2t}
\end{aligned}
$$

We code the above system of linearized equations into Dynare for the second-order approximation and to retrieve the simulation results.

3.7 Appendix B

In this appendix, we try to answer the question: How much can existing models explain? As a first step, we simulate an endowment economy version of the model in Backus et al. (1994). Table 3.8 shows the cross-country correlations for three different calibrations of the model, highlighting the role of country size.

With the endowment economy, there are several salient features that lie in stark contrast with what we observe in the data. First, there is perfect correlation between exports and output, which one can prove theoretically. Accordingly, the correlation between exports and output is always greater than the correlation between imports and output. Second, net exports and output are positively correlated. A third anomaly with the endowment economy is that real exchange rates correlate almost perfectly (and positively) with net exports.

Calibrating the model for different country sizes helps us explain some findings from the data; for instance, imports and output are much more correlated for a small economy compared to a big one. Moreover, real exchange rates are more procyclical in a small economy. However, we are still faced with an additional puzzle, which is that imports are negatively correlated with the real exchange rate in the big economy. In addition, the correlation between real exchange rate and net exports seem to be fairly unresponsive to country size. We therefore turn to test whether the addition of capital, as in the BKK model, can help explain the behavior of real exchange rates.

Table 3.8: Endowment Economy

	Correlation						
	(Ex,Y)	(Im,Y)	(NX, Y)	(Rer, Y)	(Rer, Ex)	(Rer, Im)	(Rer, NX)
Similar Countries							
$\omega_1 = 0.8$, $\omega_2 = 0.2$	1	0.89	0.71	0.69	0.69	0.30	0.99
$\omega_1 = 0.6$, $\omega_2 = 0.4$	1	0.89	0.71	0.70	0.70	0.31	0.99
Small Country							
$\omega_1 = 0.8$, $\omega_2 = 0.2$	1	0.99	0.95	0.95	0.9515	0.8941	0.9946
$\omega_1 = 0.6$, $\omega_2 = 0.4$	1	0.99	0.95	0.95	0.9507	0.8948	0.9973
Big Country							
$\omega_1 = 0.8$, $\omega_2 = 0.2$	1	0.5306	0.3101	0.3063	0.3063	-0.6308	0.9962
$\omega_1 = 0.6$, $\omega_2 = 0.4$	1	0.5306	0.3101	0.3084	0.3084	-0.6307	0.9990
BKK (No Capital)			0.66				

Notes: The stochastic endowments are drawn using the same seed for the random number generator; as such, notice that the standard deviation of output is the same in the first two lines. A change in ω's does not affect the correlations between Exports and Output, Inports and Output, and Net Exports and Output. Statistics are averages over 20 states of 400 periods each.

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