Optimal Degree of Foreign Ownership under Uncertainty

Çağatay Bircan*
University of Michigan

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Abstract

This paper studies the integration strategies of multinational firms in a multi-period model under incomplete contracts and uncertainty. I incorporate continuous levels of integration to the study of organizational choice in an existing model of foreign direct investment (Antras and Helpman, 2004) and extend the model to a multi-period framework of learning. The joint productivity of the two partners in an integrated firm is unknown initially to both sides and is revealed only after continued joint production. The model gives rise to a nondegenerate distribution of foreign ownership at the firm level and shows that the optimal level of integration rises with the age of the firm. These patterns are supported by detailed plant-level data on share of foreign ownership. The model predicts that the degree of foreign ownership is an increasing function of joint productivity and intra-firm trade should rise over time as a result of increased control by multinationals. I test the implications of my theory with plant-level data from Turkey and find support for the predictions of the model.

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Correspondence: Department of Economics, University of Michigan, Ann Arbor, MI 48109. Email: cbircan@umich.edu.

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 (by either dissolving their match or reducing their shares) 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. While Honda Turkey imports key mechanical pieces as well as engine and electrical 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

[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.

[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.

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 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.

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 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 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 depicts the distribution of foreign equity participation in the pooled sample of plant-year observations, which points to a 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.

[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 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 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.

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 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 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 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 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

[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 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 3, but makes the jump from age 1 to age 2 less pronounced.

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.

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:

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

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:

$$x_j(i) = \theta \left[\frac{h_j(i)}{\eta_j}\right]^{\eta_j} \left[\frac{m_j(i)}{1-\eta_j}\right]^{1-\eta_j}, \; 0 < \eta_j < 1, \tag{2}$$

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.

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:

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

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

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

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 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:

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

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 $\beta_V = \beta + \delta^{\alpha} - \beta\delta^{\alpha}$

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.

[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.

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 $(0, \theta]$.[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 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

[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.

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 (2), as:

$$R(i) = X^{\mu-\alpha}\theta^{\alpha}\left[\frac{h(i)}{\eta}\right]^{\alpha\eta}\left[\frac{m(i)}{1-\eta}\right]^{\alpha(1-\eta)}, \tag{3}$$

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 (3) for $R(i)$ and taking first order conditions, the Nash equilibrium quantities are:

$$h^*(i) = \eta\left(X^{\mu-\alpha}\theta^{\alpha}\alpha\right)^{\frac{1}{1-\alpha}}\left(\frac{\beta_V}{w_N}\right)^{\frac{1-\alpha(1-\eta)}{1-\alpha}}\left(\frac{1-\beta_V}{w_S}\right)^{\frac{\alpha(1-\eta)}{1-\alpha}} \tag{4}$$

$$m^*(i) = (1-\eta)\left(X^{\mu-\alpha}\theta^{\alpha}\alpha\right)^{\frac{1}{1-\alpha}}\left(\frac{\beta_V}{w_N}\right)^{\frac{\alpha\eta}{1-\alpha}}\left(\frac{1-\beta_V}{w_S}\right)^{\frac{1-\alpha\eta}{1-\alpha}} \tag{5}$$

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 (3).

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

$$\frac{h^*(i)}{m^*(i)} = \frac{\eta}{1-\eta} \frac{\delta^\alpha(1-\beta)+\beta}{1-\delta^\alpha(1-\beta)-\beta} \frac{w_S}{w_N}, \tag{6}$$

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 (4) and (5) along with (3) gives the total per-period value of the firm as measured by total operating profits:

$$\pi(\delta,\, \theta,\, X,\, \eta) = X^{\frac{\mu-\alpha}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \psi(\delta,\, \eta) - w_N \delta^\phi \tag{7}$$

where

$$\psi(\delta,\, \eta) = \alpha^{\frac{\alpha}{1-\alpha}} \left(\frac{\beta_V}{w_N}\right)^{\frac{\alpha\eta}{1-\alpha}} \left(\frac{1-\beta_V}{w_S}\right)^{\frac{\alpha(1-\eta)}{1-\alpha}} (1-\alpha\eta\beta_V - \alpha(1-\eta)(1-\beta_V)) \tag{8}$$

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

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 (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 still unknown). It is equivalent to asking whether the firm's operating profits, (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 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

[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.

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 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 (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 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-

[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.

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(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.

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 the

[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.

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

$$\pi(\theta) = X^{\frac{\mu-\alpha}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \psi(\delta_2, \eta) - w_N \delta_2 \tag{9}$$

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 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:

$$J(\theta) = \begin{cases} \pi(\theta) + \frac{1}{r+\lambda} J(\theta) & for\ \theta \geq \underline{\theta} \\ \frac{1}{r} Q & for\ \theta \leq \underline{\theta} \end{cases} \tag{10}$$

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

$$\frac{r+\lambda}{r+\lambda-1} \pi(\underline{\theta}) = \frac{1}{r} Q \tag{11}$$

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 ex-

[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 (10) implies $J(\theta) = \frac{r+\lambda}{r+\lambda-1} \pi(\theta)$ for $\theta \geq \underline{\theta}$.

pected 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 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]

$$\pi(\tilde{\theta}) = X^{\frac{\mu-\alpha}{1-\alpha}} E\left[\theta^{\frac{\alpha}{1-\alpha}}|y\right] \psi(\delta_1, \eta) - w_N \delta_1 \tag{12}$$

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:

$$V(\tilde{\theta}) = max\left\{\pi(\tilde{\theta}) + \frac{1}{r+\lambda}\int J(\theta')dP(\theta'|\tilde{\gamma}, \tilde{b}), \frac{1}{r}Q\right\} \tag{13}$$

In (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, (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:

$$V(\tilde{\theta}) = \begin{cases} \pi(\tilde{\theta}) + \frac{1}{r+\lambda}\int J(\theta')dP(\theta'|\tilde{\gamma}, \tilde{b}) & for\ \tilde{\theta} \geq \underline{\tilde{\theta}} \\ \frac{1}{r}Q & for\ \tilde{\theta} \leq \underline{\tilde{\theta}} \end{cases} \tag{14}$$

[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.

[23] The following equations are written with some abuse of notation. Notice that equation (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.

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

$$\pi(\tilde{\underline{\theta}}) + \frac{1}{r+\lambda}\int J(\theta')dP(\theta'|\tilde{\gamma}, \tilde{b}) = \frac{1}{r}Q \tag{15}$$

It is possible to show (see Appendix) that $\pi(\underline{\theta}) > \pi(\tilde{\underline{\theta}})$; 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 $\underline{\theta} > \tilde{\underline{\theta}}$, 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 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:

$$Q = \int V(\tilde{\theta})dG(\tilde{\theta}|\hat{\gamma}, \hat{b}) \tag{16}$$

The final good producer's optimal policy is characterized by the equations (10),

[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.

(14), and (16), which give rise to a single Bellman equation in V:

$$V(\tilde{\theta}) = max\left\{\pi(\tilde{\theta}) + \frac{1}{r+\lambda}\int max\left\{\frac{r+\lambda}{r+\lambda-1}\pi(\theta),\, \frac{1}{r}\int V(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\hat{b})\right\}dP(\theta|\tilde{\gamma},\tilde{b}),\right.$$
$$\left.\frac{1}{r}\int V(\tilde{\theta}')dG(\tilde{\theta}'|\hat{\gamma},\hat{b})\right\} \qquad (17)$$

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 (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 $\underline{\tilde{\theta}}$. 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 (6). Notice that (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.

[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.

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

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.

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:

$$m_j(i) = k_{i,j}^a l_{i,j}^b n_{i,j}^c e_{i,j}^d \tag{18}$$

where k represents physical capital, l represents labor, n represents raw material inputs, and e represents energy consumption. Substituting (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:

$$logv_j(i) = \beta_0 + \beta_k logk_j(i) + \beta_l logl_j(i) + log\theta + \varepsilon \tag{19}$$

The parameters of the value-added equation (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 (19) at the ISIC Rev. 2 three digit industry level; coefficient estimates are reported in Table A3.[28]

Table 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

[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 A2, 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.

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.

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 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:

$$y_{it}^{*} = \alpha + \beta_{\theta} ln(\theta)_{it} + \beta_{K/L} ln(K/L)_{gt} + \beta_{S/L} ln(S/L)_{gt} + \mu_t + \varepsilon_{it} \qquad (20)$$

$$y_{it} = \begin{cases} y_{it}^{*} & if\, 0 < y_{it}^{*} \leq 100 \\ 0 & if\, y_{it}^{*} \leq 0 \end{cases} \qquad (21)$$

where i indexes plants, g indexes industries, and t indexes time. In (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 4 reports the estimates of the model in (20). In all columns, I report standardized "beta" coefficients, which makes it easy to analyze and compare the size of the

[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.

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 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 (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:

$$y^*_{it} = \alpha + \beta_\theta ln(\theta)_{it} + \beta_{K/L} ln(K/L)_{it} + \beta_{S/L} ln(S/L)_{it} + \gamma' \mathbf{X}_{it} + \varepsilon_{it}, \qquad (22)$$

where y^*_{it} is defined by (21) and $\mathbf{X}_{it}$ is a vector of firm-level controls.[30] The pooled

[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.

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 5 reports the estimates from the model in (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, 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 (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

[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 5. Controlling for sector effects ensures that this relationship is driven by *within-industry* variation.

[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 (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.

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 (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 (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 (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 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

[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."

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

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 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 ownership positively.

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 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 3 years. I

[36] The reason for choosing 1 percent for the definition is 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.

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:

$$S(a_m) = P(T > a_m) = \Pi_{r=1}^{m} P(T > a_r | T > a_{r-1}) \tag{23}$$

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 (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 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} 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 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.

[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.

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:

$$\lambda(T_i) = exp(-\mathbf{x}_i'\beta)\lambda_0(T_i) \tag{24}$$

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 6 presents the estimates of the model in (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

[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.

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 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 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).

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 intensive margin in 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.

A Appendix

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

A.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):

$$\max_{\beta_V} \pi(\beta_V) = X^{\frac{\mu-\alpha}{1-\alpha}} \theta^{\frac{\alpha}{1-\alpha}} \psi(\beta_V) - w_N \left(\frac{\beta_V - \beta}{1-\beta}\right)^{\frac{\phi}{\alpha}} \tag{25}$$

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:

$$\begin{aligned} \frac{\partial \pi(\beta_V)}{\partial \beta_V} &= \left[\frac{\alpha^\alpha X^{\mu-\alpha}\theta^\alpha}{w_N^{\alpha\eta} w_S^{\alpha(1-\eta)}}\right]^{\frac{1}{1-\alpha}} \left[\frac{\alpha \beta_V^{\frac{\alpha\eta}{1-\alpha}-1}(1-\beta_V)^{\frac{\alpha(1-\eta)}{1-\alpha}-1}}{(1-\alpha)}\right] \\ &\quad \times \left[\beta_V^2(2\eta-1) + \beta_V(2\eta(\alpha-\alpha\eta-1)) + \eta(1-\alpha+\alpha\eta)\right] \\ &\quad - \frac{\phi w_N}{\alpha(1-\beta)} \left(\frac{\beta_V-\beta}{1-\beta}\right)^{\frac{\phi-\alpha}{\alpha}} \\ &= 0 \end{aligned} \tag{26}$$

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 (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 $\beta_V \to 1$.

[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 $\partial\pi(\beta_V)/\partial\beta_V = 0$.

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 A1 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 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]

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

[42] This is relatively easy to see. Let D be a convex set and $f : D \to \mathbb{R}$ be strictly concave. Let B

Since $\phi > \alpha$, the costs of organizational form in (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 (25) is concave in β_V. The second order condition to the final good producer's problem is given by:

$$\begin{aligned}\frac{\partial^2\pi(\beta_V)}{\partial\beta_V^2} \quad = \quad & \frac{\alpha}{(1-\alpha)^2}\left[\frac{X^{\mu-\alpha}\theta^{\alpha}\alpha^{\alpha}}{w_N^{\alpha\eta}w_S^{\alpha(1-\eta)}}\right]^{\frac{1}{1-\alpha}}\left[\beta_V^{\frac{\alpha\eta}{1-\alpha}-2}(1-\beta_V)^{\frac{\alpha(1-\eta)}{1-\alpha}-2}\right] \\ & \times[\beta_V^3(1-2\eta)\alpha+\beta_V^2(1+\alpha\eta-\alpha)(4\alpha\eta-1) \\ & +\beta_V(1+\alpha\eta-\alpha)(2-3\alpha-2\alpha\eta)\eta+(1+\alpha\eta-\alpha)(\alpha+\alpha\eta-1)\eta] \\ & -\frac{\phi w_N(\phi-\alpha)}{\alpha^2(1-\beta)^2}\left(\frac{\beta_V-\beta}{1-\beta}\right)^{\frac{\phi-\alpha}{\alpha}-1}\end{aligned} \tag{27}$$

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 A2, 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 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.)

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:

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

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

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

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 (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.

A.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 (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 (27). I show in the proof of Proposition 1 that (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.

A.3 Proof of $\pi(\underline{\theta}) > \pi(\underline{\tilde{\theta}})$

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 now show formally why this holds.

Using (10) and (11) in equation (15), and adding and subtracting like terms where necessary, we get:

[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}) + \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}) + \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}) + \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.

A.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 (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 (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 (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:

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

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

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

Hence, T is a contraction operator with modulus $1/r$ which gives us that the functional equation in (17) has a unique fixed point in the space of bounded and continuous functions.

A.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:

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

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

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

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

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

A.6 Proof of Proposition 4

In the text.

A.7 Proof of Proposition 5

In the text.

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Table 1: Presence of Multinationals in Turkish Manufacturing

(a) Multinational Presence by Year

	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

(b) Multinational Presence by Sector

		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

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 2: Summary Statistics on Firm-Level Variables

(a) Intra-Sector Heterogeneity

	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

(b) Correlations Across Firm-Level Variables

	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

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 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 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 (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 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***	1.809***	1.370***	0.158***	1.809***	1.384***	1.180***
	(0.123)	(0.135)	(0.129)	(0.044)	(0.219)	(0.218)	(0.235)
ln Capital Intensity		1.023***	0.937***	0.511***		1.038***	0.922***
		(0.092)	(0.097)	(0.046)		(0.099)	(0.107)
ln Skill Intensity		1.085***	1.146***	0.457***		1.144***	1.165***
		(0.130)	(0.132)	(0.058)		(0.141)	(0.144)
ln Plant Size			1.469***	0.973***			1.601***
			(0.119)	(0.060)			(0.142)
ln Electric Use			-0.126	0.027			-0.085
			(0.113)	(0.043)			(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***	0.532***	0.519***
					(0.004)	(0.004)	(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 (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 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 (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: Distribution of Foreign Ownership in the Pooled Sample

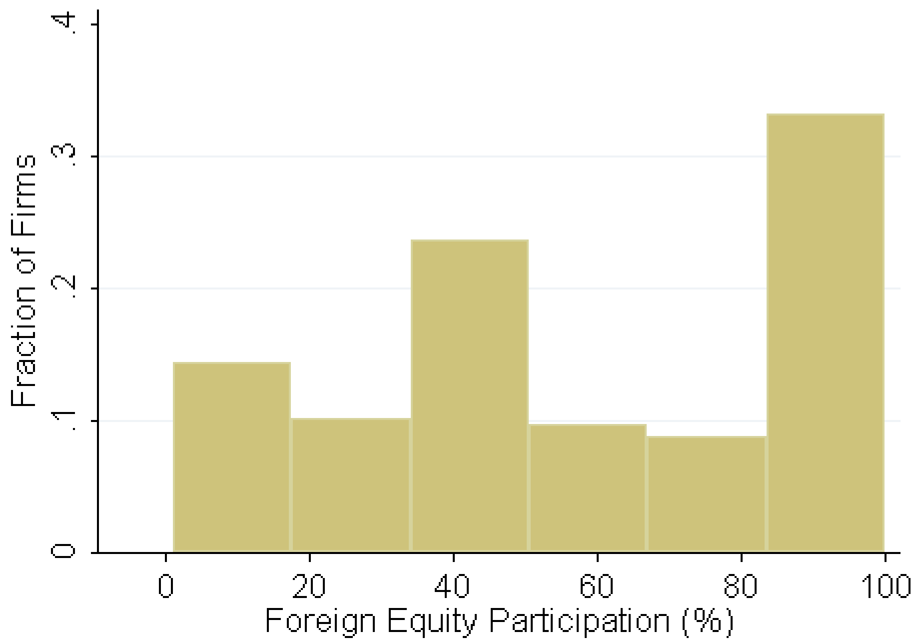
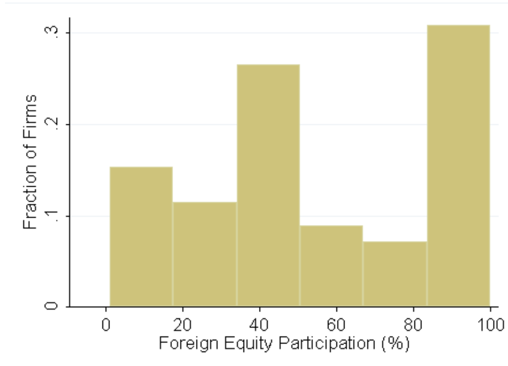
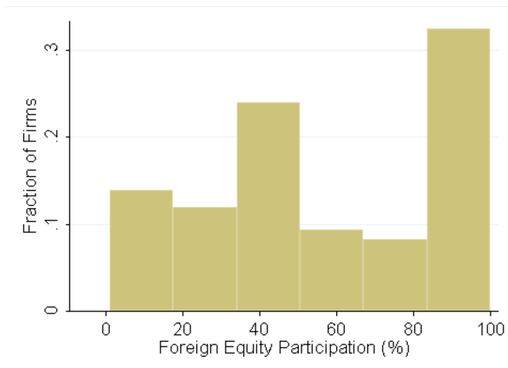


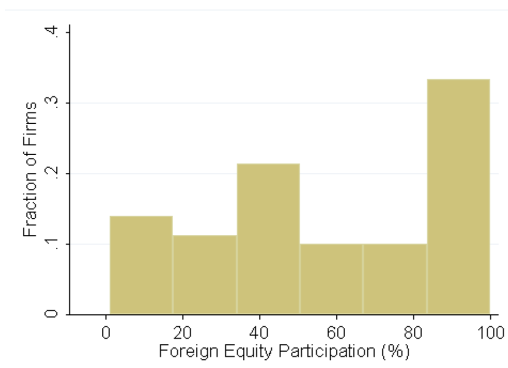
Figure 2: Distribution of Foreign Ownership by Age



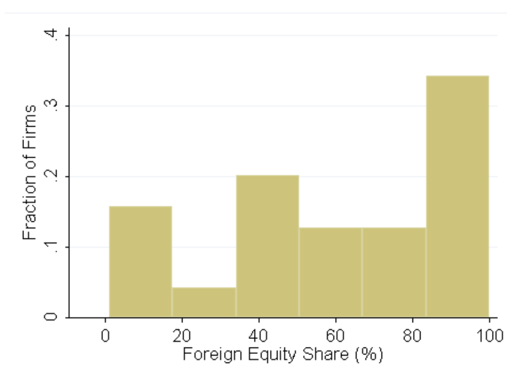
Age 1:



Age 3:



Age 5:



Age 7:

Figure 3: Average Degree of Foreign Ownership by Age

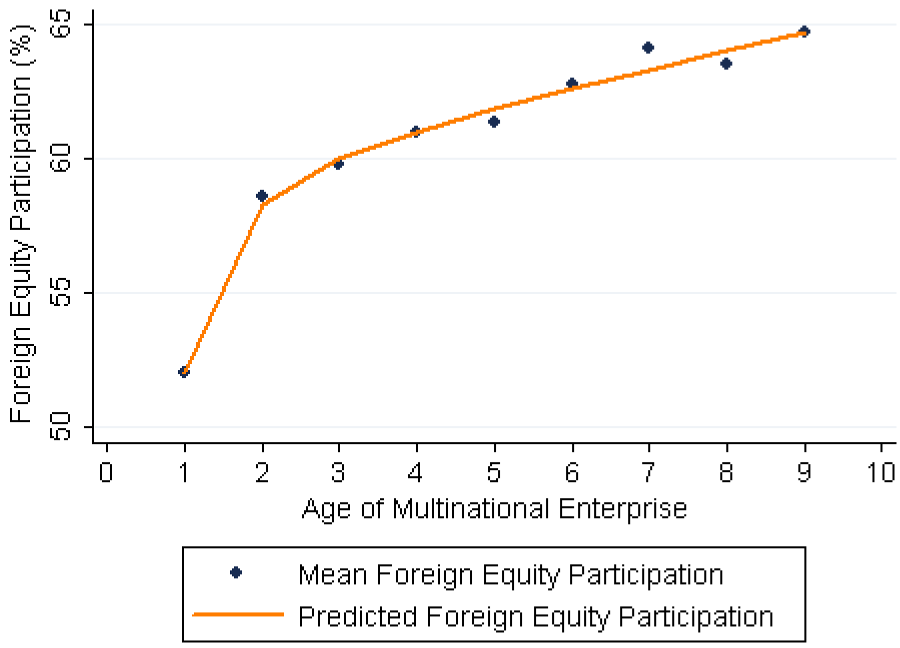
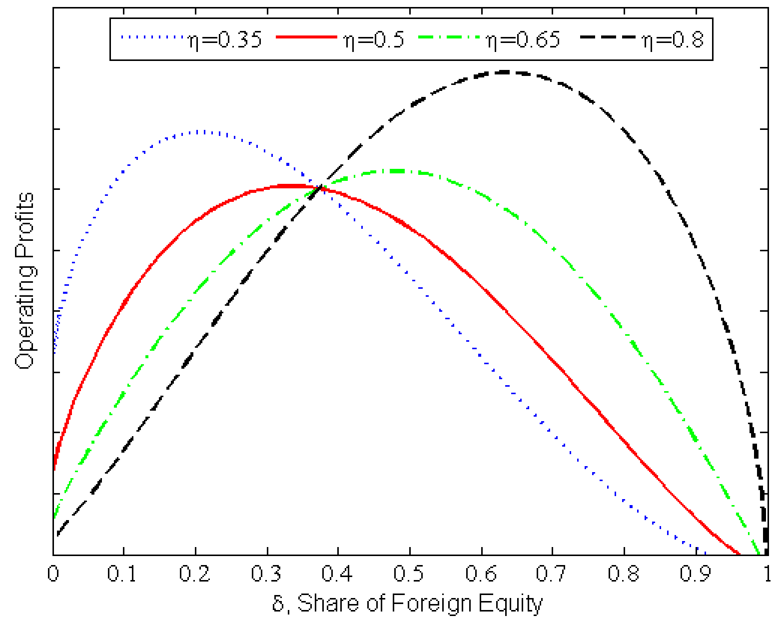
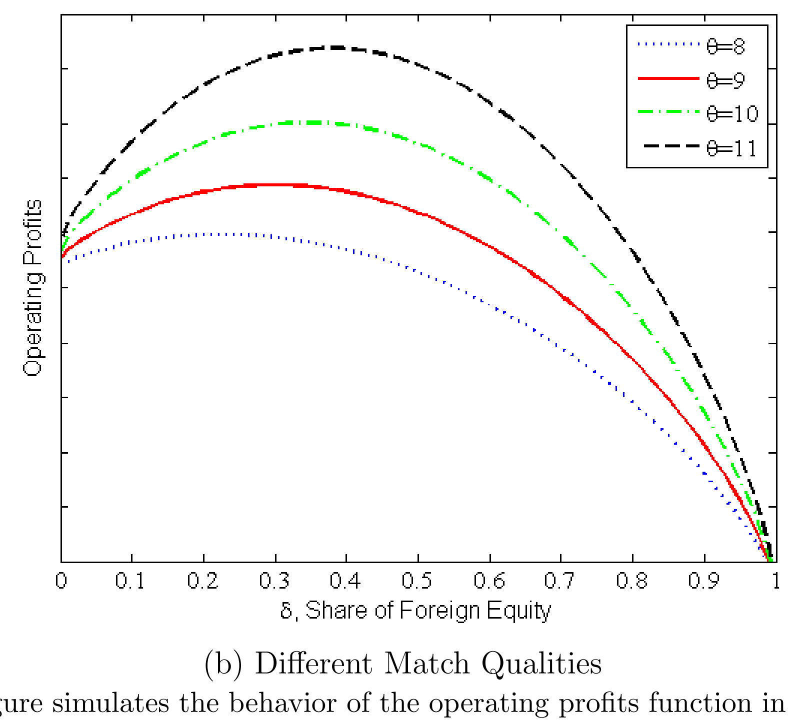


Figure 4: Operating Profits and the Level of Integration



(a) Different Headquarter Intensities

Notes: This figure simulates the behavior of the operating profits function in (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 (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 5: Optimal Policy in Period 2

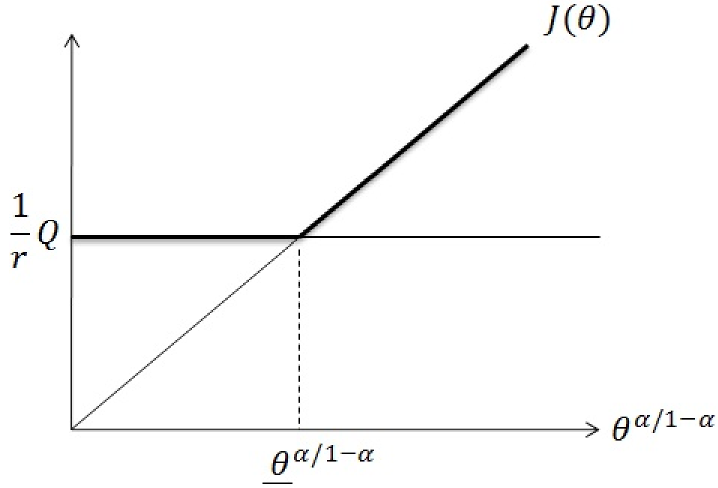
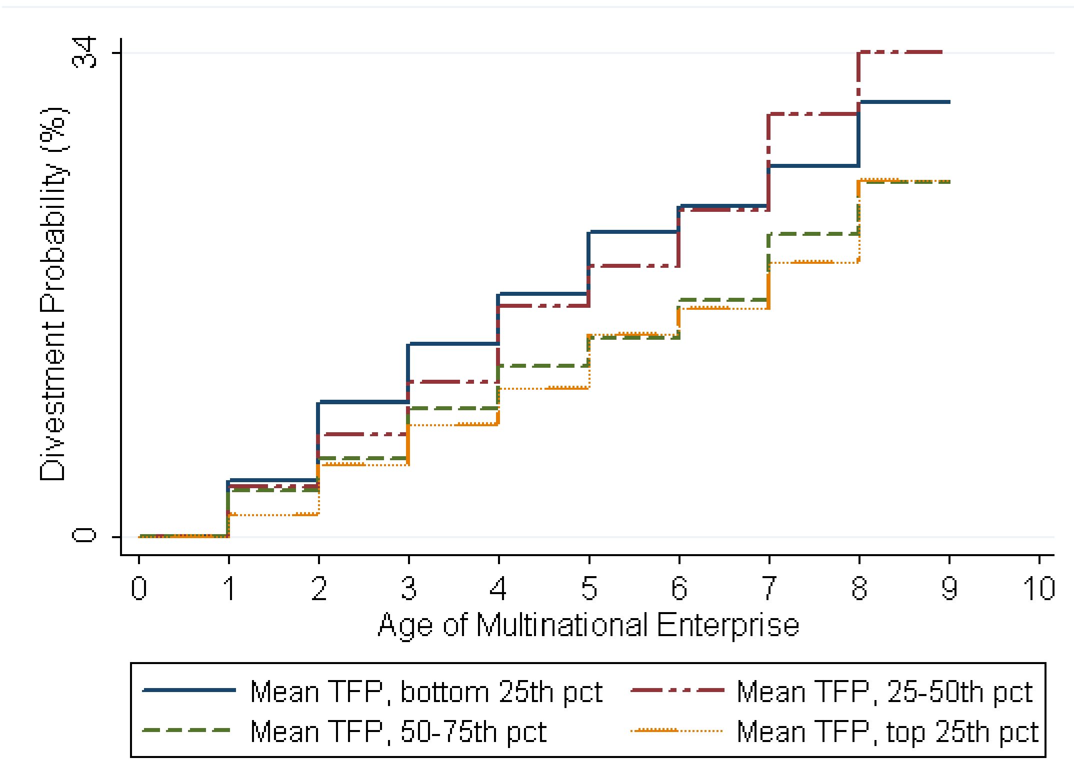


Figure 6: Kaplan-Meier Divestment Plot of MNEs by Level of Joint Productivity



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 A1: The Permissible Set of β's for Various Headquarter Intensities

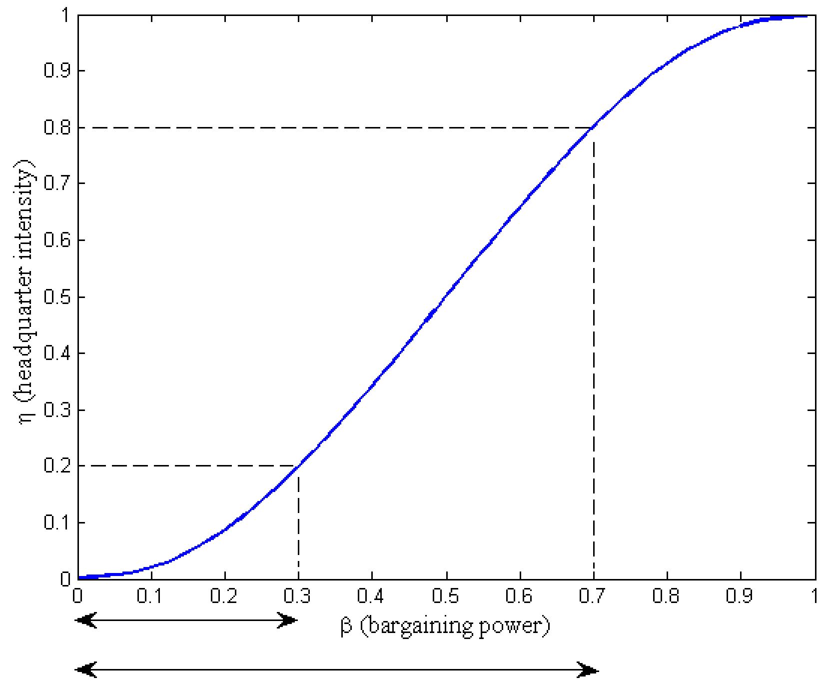
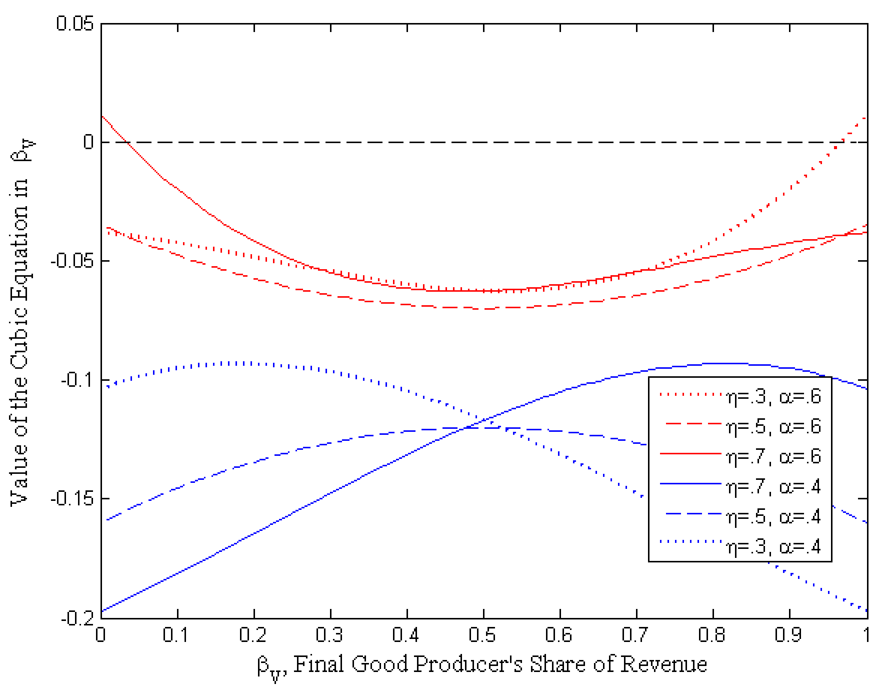


Figure A2: The Sign of the Cubic Equation in β_V for Different Parameter Values



B Data Appendix

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:

$$K_{t+1} = (1 - \delta)K_t + I_t \tag{28}$$

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 (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 B1 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 B1: 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 B2: 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 B3: 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