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ABSTRACT

This paper uses a rich panel dataset of Spanish manufacturing firms (1990-2006) and a propensity score reweighting estimator to show that multinational firms acquire the most productive domestic firms, which, on acquisition, conduct more product and process innovation (simultaneously adopting new machines and organizational practices) and adopt foreign technologies, leading to higher productivity. We propose a model of endogenous selection and innovation in heterogeneous firms that jointly explains the observed selection process and the innovation decisions. Further, we show in the data that innovation on acquisition is associated with the increased market scale provided by the parent firm.

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1 Introduction

The pervasiveness of the large and persistent productivity advantages held by certain firms within narrowly defined industries is a well-established fact that continues to intrigue researchers (see surveys by Syverson, 2010; Ichniowski and Shaw, 2010). One salient example that has attracted much attention in several different fields is that multinational subsidiaries generally outperform domestic firms.[1] Many have argued that this is because multinationals transfer superior technologies and organizational practices –in the form of new product and process innovation –to their foreign subsidiaries.[2] However, since the most prevalent form of multinational entry is through acquisition, rather than through greenfield investment (89 percent in developed countries –Barba Navaretti and Venables, 2004), their superior performance could be due to the selection of higher-performing domestic firms. To date, little is known about the economic determinants driving the extent of innovation and technology transfer upon acquisition or about which domestic firms are selected to become foreign subsidiaries. In this paper, we use a unique panel dataset to analyze both the selection and innovation decisions of multinational firms and propose a new mechanism explaining how these decisions are jointly determined. We argue that one cannot fully understand the relationship between foreign ownership and innovation without explicitly recognizing that the incentives for innovation –to increase firm productivity –and the incentives for foreign acquisition are inherently interdependent.

The data used contain information on an array of internal technological and organizational choices, as well as on foreign ownership and productivity, for around 1,800 Spanish manufacturing firms between 1990 and 2006.[3] The main distinguishing feature of our data is that we can directly observe different productivity-enhancing actions taken within the firm and, hence, do not have to rely on arguably imperfect productivity estimates to show the impact of acquisition. We are able to study precisely what types of innovation the acquired firms implement, such as whether they undertake product or process innovation, assimilate foreign technologies, purchase new machinery or introduce new organizational practices. We identify our effects by looking at within-firm variation

[1] Some examples in this literature are Caves (1974), Doms and Jensen (1998), Helpman, Melitz and Yeaple (2004), Baldwin and Gu, (2005), Ramondo (2009), Criscuolo and Martin (2009), and Arnold and Javorcik (2009).

[2] Prominent examples include Teece (1977), Caves (1996), Bloom and Van Reenen (2010), and Branstetter, Fisman and Foley (2006). See the survey of recent empirical literature in Stiebale and Reize (2010).

[3] Spain has a substantial foreign multinationals presence. In 2005, 16.5% of the firms surveyed in our data were foreign-owned, representing 43% of total sales in Spanish manufacturing. Chislett (2007) reports that in 2005, U.S. firms made up the largest share of the stock of Spanish foreign direct investment (19.9%), followed by France (17.5%), the U.K. (16.3%) and Germany (7.8%), consistent with the fact that over 75 percent of foreign direct investment is between developed countries (Markusen, 2002).

in innovation, using the panel structure of the dataset. In addition, to control for time-varying selection and other sources of endogeneity, we implement a propensity score reweighting estimator to estimate the average treatment effect of foreign acquisition on innovation (Imbens, 2004; Busso, DiNardo and McCrary, 2009).

We first analyze which domestic firms are more likely to be the target of acquisition, a largely unexplored question in the international economics literature.[4] Empirically, our data reveal clear evidence of positive selection: foreign firms buy the most productive firms within industries, i.e. they "cherry-pick." This contrasts with a large strand of the corporate finance merger literature, which asserts that low-performing firms are the most likely to be acquired (Lichtenberg and Siegel, 1992; Jovanovic and Rousseau, 2002). Further, we find that accounting for the positive selection leads to a labor productivity premium associated with foreign acquisition that is one third of the cross-sectional estimate.[5] Nonetheless, after accounting for selection, firm sales increase by 18 percent, labor productivity by 13 percent and total factor productivity by 16 percent following acquisition.

Next, we analyze the type of productivity-enhancing innovations acquired firms implement following acquisition. After controlling for selection using firm fixed effects and the propensity score reweighting estimator, we find that acquisition leads to improvements in firm technology: acquired firms are more likely to engage in process innovation and product innovation.[6] In addition, they are more likely to assimilate new foreign technologies, which suggests that technology is being transferred from the parent to the subsidiary. We are also able to explore a distinction that has long been present in the literature about different types of process innovation. Teece (1977) distinguishes between two types of technology transfer in his seminal study of 26 U.S. multinational subsidiaries: The first is "hardware" such as tooling, equipment, and blue prints. The second is the information that must be acquired if this hardware is to be used effectively –the required methods of organization.[7] Our results indicate that firms do both simultaneously upon acquisition –i.e., they

[4] Existing literature in international economics focuses on which parent firms will chose to engage in FDI (Helpman et al. 2004; Burstein and Monge-Naranjo, 2009). Nocke and Yeaple (2007, 2008) model the mode of foreign entry –greenfield or acquisition –as a function of parent firm characteristics. In contrast, we focus on which domestic firms are acquired.

[5] Relatedly, Criscuolo and Martin (2009) show that the observed U.S. multinational productivity advantage is driven mainly by selection. Arnold and Javorcik (2009) and Ramondo (2009) also document positive selection in Indonesia and Chile, respectively.

[6] These findings are consistent with Arnold and Javorcik (2009), who establish that total investment and investment in new machinery increases under foreign ownership for Indonesian firms. In contrast, Stiebale and Reize (2010) find no evidence of foreign acquisition affecting innovation activities in German firms.

[7] In the literature on the market for corporate control, Jensen and Ruback (1980) argue that the potential synergies prompting efficient mergers could occur through the adoption of more efficient production or organizational technology. More recently, Bloom and Van Reenen (2010) show that the subsidiaries of multinational firms exhibit

purchase new machines and adopt new methods of organizing production at the same time, rather than doing either on its own. This is consistent with the finding that it is optimal for firms to implement new information technology and organizational practices jointly, identified by a number of authors (Black and Lynch, 2001; Bresnahan, Brynjolfsson, and Hitt, 2002; Brynjolfsson and Hitt, 2003; Bartel, Ichniowski and Shaw, 2007).

The observed positive selection and technology upgrading upon acquisition are consistent with the predictions of a simple model in which the optimal amount of innovation upon acquisition depends on the initial characteristics of the acquired subsidiary and the costs and benefits of the innovation process; in turn, the returns to innovation following acquisition determine which firms are acquired. We use the model to illustrate how the selection and innovation decisions are jointly determined and to interpret the empirical results.

In our model, there is a complementarity between the extent of innovation and the acquired firm's initial characteristics reflected in its initial productivity. This could arise for several reasons. For example, a product upgrade is more valuable when the acquired firm is able to sell more units of the good. Additionally, the benefits associated with a superior production process depend on the skill of the operators, and, more generally, on the "absorptive capacity" of the acquired subsidiary (Cohen and Levinthal, 1990). We show in the model that the complementarity between innovation and the acquired firm's initial productivity is amplified when the foreign parent brings lower innovation costs or greater market access.[8] A foreign firm could bring with it lower innovation costs if it has a lower cost of capital (Desai, Foley and Hines, 2004) or access to proprietary technologies (Caves, 1996), but it could also bring larger benefits of innovation. Multinational firms are known to provide access to export markets for acquired subsidiaries (as shown by Hanson, Mataloni and Slaughter (2005) for vertical and by Ekholm, Forslid and Markusen (2007) for horizontal foreign direct investment), thereby increasing firm scale. With either lower innovation costs or greater market access, the model explains both positive selection and increased innovation.

We explore empirically the role of greater market scale granted by the foreign parent in driving innovation decisions. We find that the higher levels of innovation by foreign subsidiaries are, in large part, driven by firms that export through a foreign parent. This is consistent with foreign ownership

more sophisticated managerial practices than domestic firms across the U.S., Europe and Asia.

[8] The complementarity between innovation and market scale is a major theme of the international economics literature. For example, the promise of greater sales in export markets creates an incentive for a firm to invest in productivity-enhancing technologies (Verhoogen, 2008; Bustos, 2010; Lileeva and Trefler, 2010; Aw, Roberts, and Xu, 2010; Atkeson and Burstein, 2010).

facilitating access to larger markets and thereby creating incentives to invest in firm technology. We are able to determine the role of the export channel, as distinct from export status, because firms in our data are asked how they access export markets and, specifically, whether they export through a foreign parent –either using the parent's distribution channels or selling directly to another entity within the multinational. Our findings provide strong evidence that multinationals enjoy greater benefits from innovation due to their existing market scale and not just innovation costs that are lower than domestic firms'. The fundamental link between foreign ownership –in particular, the increase in market access that comes with foreign ownership –and innovation is absent from the existing studies of trade and innovation, as well as from the literature on organizational structure and productivity.

Notice that our empirical results rule out an alternative view of the process of technology transfer –namely, that multinational subsidiaries adopt the same technology level as the foreign parent, independent of their initial productivity.[9] If a multinational were able to transplant its own productivity to any acquired firm, the value added through acquisition would be largest for low-productivity firms, leading to negative selection, that is, multinationals would select to acquire the least productive firms.

Our empirical findings reflect a number of case studies of acquisitions. The instances of foreign multinationals entering the Spanish market by acquiring the most productive or largest firms are very common. Some prominent examples in Spain are Volkswagen acquiring the Spanish car manufacturer SEAT in 1986; Guinness acquiring the major beer manufacturer Cruzcampo in 1991; Cemex acquiring the two main cement companies (Compañía Valenciana de Cementos and Sanson) in 1992; and Allied Domecq acquiring Bodegas y Bebidas, the wine makers of the dominant brands Campo Viejo and Marqués de Cáceres, in 2001. Upon acquisition, these firms underwent changes to their technology and organization; they sometimes introduced new products, and their market share and/or exports generally increased.[10]

The results in this paper on positive selection and increased productivity upon acquisition have direct implications for the relationship between multinational activity and the evolution of the productivity distribution. For firms that become foreign-owned, the productivity distribution shifts to the right. Since our results suggest that multinationals do not purchase a random selection of

[9] This alternative view of technology transfer is consistent with an assumption made in McGrattan and Prescott (2010), Burstein and Monge-Naranjo (2009) and Ramondo and Rodriguez-Clare (2009) that all subsidiaries of a multinational firm operate with the same productivity (up to a discount factor typically modeled as iceberg costs).

[10] For example, Volkswagen retooled the SEAT production line based on the Volkswagen Polo platform, relaunching the SEAT Ibiza that was subsequently sold throughout Europe.

firms but are likely to acquire the initially most productive firms, productivity differences across firms in the economy can be amplified over time. Establishing the mechanism driving multinational entry into a country and subsequent investment decisions is also key for welfare analysis. Intuitively, if entering firms acquire the most productive firms in an industry, the increase in productivity associated with any increase in inward FDI is likely to be lower than if foreign firms acquired the least productive firms and brought them up to international productivity levels. Our paper, therefore, informs the set of assumptions behind macroeconomic models of multinational production and welfare.

Finally, accounting for the links between the innovation and acquisition decisions can shed light on why foreign multinationals acquire larger firms and on the long-standing puzzle of why some firms innovate more than others. Our study suggests that both are determined by the variable costs and benefits of technology transfer. When this is the case, our key insight is that differences in market access alone, and not just in foreign firms' innovation cost advantages, can explain these phenomena. More generally, the fact that firms within an industry may have differential access to markets provides a new rationale for why initial differences in productivity persist, and why not all firms invest in technology and organizational upgrades, which are fundamental questions within the organizational economics field among others (Bloom and Van Reenen, 2007; Syverson, 2010).

The rest of the paper proceeds as follows: Section 2 outlines a simple model illustrating the relationship between acquisition and investment to frame the empirical analysis; Section 3 describes the data; Section 4 presents the empirical strategy and results related to the acquisition decision; Section 5 focuses on the innovation decision and explores the role of the market access mechanism in driving our main results. Section 6 analyzes the effect of foreign acquisition on productivity. Section 7 concludes.

2 Acquisition and Innovation Decisions

In this section, we set up a simple industry-level partial equilibrium model to illustrate the endogenous choices of foreign acquisition and innovation when domestic firms differ in initial productivity, and the complementarities that can emerge among productivity, innovation and acquisition.[11]

[11] In the model, variation in investment levels across firms are optimal choices under complete information, so that persistent productivity differences are not based on any type of market failure, incomplete information or X-inefficiency.

2.1 Structure

Consider a model with heterogeneous domestic firms (Melitz, 2003) with a Constant Elasticity of Substitution (CES) demand structure and increasing returns to scale in a setting of monopolistic competition (Helpman and Krugman, 1985). The initial productivity of firm i is given by φ_i. Forward-looking foreign firms select which domestic firms to acquire, and all firms choose a level of innovation or other productivity-increasing investment, γ_i. Production and profits reflect post-innovation productivity levels, $\gamma_i \varphi_i$, and the firm's marginal cost is given by $\frac{1}{\gamma_i \varphi_i}$.[12]

The price set by each firm is a constant markup over marginal cost, and each variety in an industry is produced by a single firm. Firm i sets a price $\frac{1}{\rho \gamma_i \varphi_i}$, where ρ is the parameter in the CES utility function that defines the elasticity of substitution between varieties $\sigma = \frac{1}{1-\rho} > 1$, assumed to be constant across all markets.[13] Each firm sells $A_i \rho^{\sigma} \left(\gamma_i \varphi_i\right)^{\sigma}$ units, generating revenues of $A_i \rho^{\sigma-1} \left(\gamma_i \varphi_i\right)^{\sigma-1}$, where A_i is a measure of market size for the markets relevant to firm i. The profits generated by each firm are given by:

$$\pi_i = A_i \left(\frac{1-\rho}{\rho}\right) \rho^{\sigma} \left(\gamma_i \varphi_i\right)^{\sigma-1}$$

To simplify, we denote $\chi = \left(\frac{1-\rho}{\rho}\right) \rho^{\sigma}$, and work with an increasing transformation of the innovation level $\lambda_i = \gamma_i^{\sigma-1}$ from now on. The value, V_i, of each firm operating in the domestic market (net of the fixed production cost) is equal to the variable profit it earns, π_i, less the total cost of innovations to increase productivity $C_i\left(\lambda_i\right)$:

$$V_i\left(\lambda_i\right) = A_i \chi \lambda_i \varphi_i^{\sigma-1} - C_i\left(\lambda_i\right) \tag{1}$$

[12] The model's predictions are robust to specifying post-innovation productivity as an additive function of initial productivity and innovation; $(\gamma_i + \varphi_i)$. The multiplicative setup used here is similar to the model in Bustos (2010), where the binary decision about technology investment is related to the export decision. In our case, firms choose whether to invest, but, in addition, they also optimize over the level of investment as a function of innovation costs. Heterogeneous firm productivities could reflect variation in marginal costs for firms using the same technologies or variation in the quality of output produced, allowing more productive firms to charge higher prices.

[13] The representative consumer's utility function is given by $U = [\int_0^N q(i)^{\rho} di]^{\frac{1}{\rho}}$ where $\rho \in (0,1)$. The demand for a particular variety of the product sold by a given firm is $q(i) = \frac{E_i}{P_i}(\frac{p(i)}{P_i})^{-\sigma}$, where E_i is total expenditure in the relevant market for good i on all varieties in the industry, and P_i is a weighted average of variety prices in the relevant market. The subindex i on E_i and P_i captures the fact that firms can sell in different markets. We assume that doing so does not incur transport costs. We define $A_i = E_i P_i^{\sigma-1}$. See Dixit and Stiglitz (1977) for further details.

2.2 The Innovation Decision

We allow the total cost of investment in productivity to be the sum of a fixed and a variable cost of innovation:

$$C_i(\lambda_i) = a_i + b_i f(\lambda_i)$$

where λ_i measures the improvement in productivity following the investment. We do not impose any specific functional form on $f(\lambda_i)$.[14] At any given point in time, there is an upper bound on the level of technology that a firm can attain by innovating that represents the "state of the art" technology in a given industry. We denote this productivity level $\Phi_{\max}$.

The firm chooses a level of innovation λ_i^* that maximizes the value of the firm. When the optimal level of innovation is at an interior solution, which we refer to as Case 1 in what follows, the firm innovates up to the level where the marginal benefit equals marginal cost:[15]

$$A_i \chi \varphi_i^{\sigma-1} = b_i f'(\lambda_i^*) \tag{2}$$

Equation (2) shows that, ceteris paribus, at an interior solution, $\lambda_i^* = \lambda^*(A_i, b_i, \varphi_i)$, a firm with a higher initial productivity level φ_i, greater market size A_i, or lower costs of technology investment b_i, will make a greater investment in productivity. Figure 1 provides an illustration of the positive relationship between λ_i^* and φ_i for two possible values of $\left(\frac{A_i}{b_i}\right)$.[16] When $\left(\frac{A_i}{b_i}\right)$ is higher, the optimal level of innovation, λ_i^*, is greater for any level of φ_i. This illustrates two important economic mechanisms: the complementarity between innovation and initial productivity, as well as the complementarity between larger market size (or lower innovation) costs and innovation. $\underline{\varphi}_D$ ($\underline{\varphi}_F$) is the value of φ_i at which a firm with a low (high) value of $\left(\frac{A_i}{b_i}\right)$ would find it worthwhile to invest in innovation.

[14] We require only that the technology total cost function $C_i(\lambda_i)$ has a continuous first derivative and is strictly positive whenever $\lambda_i > 1$. Notice that we do not impose a technological complementarity between innovation and initial productivity which could reflect an assumption that absorptive capacity is increasing in φ_i. One way to do this would be to specify b as a decreasing function of φ_i. The current specification is general enough to include this possibility.

[15] This first order condition gives the optimal level of investment when b_i is sufficiently high that the firm does not find it optimal to innovate up to $\varphi_{\max}$. This is for $b_i > \frac{A_i \chi \varphi_i^{\sigma-1}}{f'((\frac{\varphi_{\max}}{\varphi_i})^{\sigma-1})}$

To ensure positive innovation, a_i must be sufficiently low so that firm value under (optimal) investment is larger than firm value under no investment. This is true when $a_i \leq b_i\left((\lambda^* - 1) f'(\lambda^*) - f(\lambda^*)\right)$. In the interior optimum $\lambda^* > 1$, (since $V'_\lambda|_1 = A_i \chi \varphi^{\sigma-1} - b_i f'(1) > 0$ as $f'(1) = 0$ where we have imposed marginal cost continuity). The interior optimum is guaranteed to be a maximum as long as marginal cost (or, equivalently, f') is a continuous increasing function of λ. For λ^* to be unique, f' should also be strictly increasing for $\lambda > 1$.

[16] The first order condition (2) does not separately identify A_i and b_i. Access to larger markets and lower marginal costs of investment in technology have similar effects on the choice of λ_i. Either assumption is sufficient.

The solution in Case 1 takes into account the costs and benefits of innovation and the firm's initial productivity to determine the interior solution. However, a common assumption in the literature on multinational production is that subsidiaries operate at the same productivity level as their parent, independent of their initial characteristics. We represent this possible assumption on the technology transfer process by allowing for any acquired firm to find it optimal to innovate up to the "state of the art" technology level, and refer to this special case as Case 2 in what follows. This could arise if productivity-enhancing innovation incurred only a fixed cost, i.e. $b_i = 0$, in which case the optimal innovation is at a corner solution for all initial levels of productivity. This implies $\lambda_i^* = \left(\frac{\Phi_{\max}}{\varphi_i}\right)^{\sigma-1}$, which is a decreasing function of initial productivity. Figure 2 provides an illustration of the relationship between λ_i^* and φ_i in this case (represented by λ_F in the figure). Unlike in Figure 1, the amount of innovation is independent of A_i.

2.3 The Acquisition Decision

We denote V_i^* as the value of the firm, given by equation (1), at the optimal investment level λ_i^* for firm i. We now turn to how foreign ownership affects innovation and firm value under each case governing the innovation process and, hence, how foreign firms select whom to acquire.

We allow foreign acquisition to affect two model parameters. The trade literature has shown that foreign ownership provides access to larger markets. If A_D measures the size of the domestic market, we allow foreign-acquired firms to have access to an additional larger market, (denoted A^*) so that the total market for a foreign-acquired firm is $A_F = A_D + A^*$, where $A_F \geq A_D$. Foreign ownership may also bring with it lower innovation costs (access to proprietary technologies, lower costs of financing, etc.) such that $b_F \leq b_D$ or $a_F \leq a_D$ (these costs can remain at their original level or fall). We assume throughout that $0 \leq b_F \leq b_D$ and, for simplicity, that the domestic firm is always at the interior solution given by the first order condition in equation (2).

Given the parameter values relevant for the ownership structure of the firm, the optimal level of innovation under foreign ownership is λ_i^{*F}, and under domestic ownership is λ_i^{*D}. Using equation (1) for firm value under each ownership structure, the incremental value of the firm under foreign acquisition can be written as:

$$V_i^{*F} - V_i^{*D} = \left(A_F\lambda_i^{*F} - A_D\lambda_i^{*D}\right)\chi\varphi_i^{\sigma-1} - (a_F - a_D) - \left(b_F f\left(\lambda_i^{*F}\right) - b_D f\left(\lambda_i^{*D}\right)\right) \tag{3}$$

Under the assumptions that $A_F \geq A_D$, $b_F \leq b_D$ and $a_F \leq a_D$, and at least one of these inequalities is strictly true, expression (3) is positive. $\left(V_i^{*F} - V_i^{*D}\right)$ represents the value created by the acquisition.

We assume that the price paid by a foreign firm if it were to acquire firm i, R_i, divides the value created through the acquisition between the buyers and the sellers. This assumption underpins the theory of efficiency-based M&A activity (Ravenscraft and Scherer, 1987), and suggests that $R_i = V_i^{*D} + (1-\alpha)\left(V_i^{*F} - V_i^{*D}\right)$, where $(1-\alpha)$ is the share of the surplus going to the domestic owners of the firm and α is the share going to the acquiring parent. $\alpha \in [0,1]$ can be thought of as reflecting the relative bargaining weights of each party in the transaction.[17] We assume that there is a fixed cost to a foreign firm of making an acquisition, K, representing the fixed search and administrative costs related to the acquisition process.

The model predicts that a firm is acquired in anticipation of a positive future payoff to the acquiring firm, whenever $V_i^{*F} - (V_i^{*D} + (1-\alpha)\left(V_i^{*F} - V_i^{*D}\right)) - K \geq 0$. That is, the foreign firm has an incentive to make an acquisition whenever:

$$\alpha\left(V_i^{*F} - V_i^{*D}\right) \geq K \tag{4}$$

Now we can investigate the relationship between acquisition incentives and initial firm productivity. The nature of this relationship depends on the process by which λ_i^{*F} is determined.

In Case 1, the optimal amount of innovation satisfies the first order condition given in equation (2).[18] Applying the envelope theorem to the value of the firm under foreign and domestic control yields $\frac{d(V_i^{*F} - V_i^{*D})}{d\varphi_i^{\sigma-1}} = \chi\left(A_F\lambda_i^{*F} - A_D\lambda_i^{*D}\right) > 0$. That is, the value created by foreign acquisition is increasing in initial productivity, and more productive domestic firms are more likely to be acquired. This result arises from the complementarity between foreign firm characteristics (larger markets and/or lower costs of innovation), innovation and the acquired firm's productivity. A given innovation is more valuable in more productive firms; and this value is greater under foreign control due to, for instance, the access to distribution networks granted by the foreign firm, which means that the innovation can be leveraged in a larger market and, hence, is more profitable.

An alternative scenario emerges if the process by which λ_i^{*F} is determined is governed by Case 2, when multinationals find it optimal to transplant their own superior level of technology, $\Phi_{\max}$,

[17] We assume α is fixed for all potential acquisition targets. If a larger number of foreign firms were competing to acquire the most productive domestic firms, this might suggest that α decreases in φ_i. This would make positive selection less likely in the data, and hence by itself cannot explain our findings.

[18] Case 1, in practice, represents a world where the innovation process is costly, and achieving a higher productivity level requires greater expenditure. For example, installing a technology with better machinery or more talented managers is likely to be more expensive; and we might think that there is an increasing opportunity cost of allocating scarce MNC resources to a particular acquired firm.

regardless of who they buy. In this scenario, the value of the firm under foreign ownership, $V_i^{*F} = A_F \chi \Phi_{\max}^{\sigma-1} - a_F$, is independent of its initial characteristics and, in particular, independent of φ_i. This means that there are no sources of complementarity between the characteristics of the acquired firm and the implemented technology. Since the value of the firm had it remained under domestic control, V_i^{*D}, is an increasing function of φ_i, the value added by acquisition is decreasing in φ_i, $\frac{d(V_i^{*F} - V_i^{*D})}{d\varphi_i^{\sigma-1}} = -A_D \chi \lambda_i^{*D} < 0$, and less productive domestic firms are more likely to be acquired.

In our model, the identity of the acquiring firm is irrelevant for the optimal choice of innovation. We require only the possibility that the parent brings a lower cost of innovation and/or a larger market than the firm would have had under domestic control. Hence, heterogeneity among parents does not affect the predictions arising in the model for innovation and acquisition decisions.[19]

Figures 1 and 2 illustrate the different relationships between λ_i^* and φ_i, highlighting the role played by selective foreign acquisition in Case 1 and Case 2 –that is, under the two different possible processes determining λ_i^{*F}. In each case, the bold line shows the predicted relationship between initial productivity and innovation within an industry for a given K. In Figure 1, firms above $\widetilde{\varphi}_1$ are acquired and innovate; firms between $\underline{\varphi}_D$ and $\widetilde{\varphi}_1$ remain domestic and innovate; and firms below $\underline{\varphi}_D$ remain domestic and do not make any investments. In Figure 2, firms below $\widetilde{\varphi}_2$ are acquired and implement the innovation required to raise the productivity level of the acquired firm to $\Phi_{\max}$. Firms above $\widetilde{\varphi}_2$ remain domestic, and the most productive of these may choose optimally to innovate.

3 Data Description

The results in this paper are based on the *Encuesta de Estrategias Empresariales* (ESEE), a panel dataset of Spanish manufacturing firms collected by the Fundación SEPI (a non-government organization) and the Spanish Ministry of Industry every year since 1990. It is designed to be representative of the population of Spanish manufacturing firms and includes around 1,800 firms per year (aiming to survey all firms with more than 200 employees and a stratified sample of smaller firms). The response rate in the survey is 70 to 80 percent and, new firms are re-sampled over time to ensure that the panel remains representative.[20]

Our data span the years 1990 to 2006. 83.5 percent of the firms are domestic in the first year

[19] A natural extension of the paper would be to examine the implications of the mechanism for bilateral FDI flows and the resulting assortative matching between heterogeneous foreign parents and domestic firms.

[20] Details on the survey characteristics and data access guidelines can be obtained at http://www.funep.es/esee/sp/sinfo_que_es.asp.

they appear in the data, and 16.5 percent are foreign-owned. We define a firm as foreign-owned if it reports that a foreign company owns at least 50 percent of its capital. 91 percent of firms report either being 0 or 100 percent foreign-owned. Since 50 percent is a sufficient indicator for foreign control, we have favored this definition of "acquisition" (the results are robust to specifying other thresholds). Markusen (2002) defines foreign direct investment through acquisition as an investment in which the firm acquires a substantial controlling interest in a foreign firm. We restrict our sample to firms that are not owned by a foreign company in the first year they appear in the data, since the model generates predictions about which domestic firms will be acquired. The data do not record any further characteristics of the parent firm. However, our dataset is unique in that, in addition to recording ownership status, it reports a large number of variables that reflect the productivity-enhancing innovation activity undertaken by each firm. The data include variables indicating whether the firm undertook process innovation, product innovation, and whether the firm made efforts to assimilate foreign technologies in a given year.

The variables recorded in our data allow us to distinguish between process innovation related to the introduction of new machinery and new methods to organize production, reflecting the distinction in Teece (1977). The ESEE bases its survey questions on an OECD publication, the Oslo Manual, which was designed to formalize guidelines for collecting and using data on industrial innovation. It acknowledges the fine line between an organizational innovation and other types of process innovation by noting that "a starting point for distinguishing process and/or organizational innovations is the type of activity". In particular, "organizational innovations deal primarily with people and the organization of work." Accordingly, the ESEE asks respondents whether their firm has undertaken a process improvement that involves the use of new machines and/or the use of new methods to organize production. Some examples of the latter are "practices to improve knowledge sharing," "education and training systems," "new methods for distributing responsibilities and decision making" and "management systems for general production or supply operations."

The data also contain other information on the activities of these firms that will allow us to shed light on the mechanisms at work in our model. In particular, we know whether a firm exports and its volume of exports. Importantly, we also observe whether the firm uses the foreign parent as a channel for its exports, or via other means (this information is available only every four years). We do not know of any other dataset that includes all these detailed variables for a large panel of firms over an extended period of time (17 years in our data).

We also use the ESEE data to define three different variables that measure firm productivity. The first is the natural log of the firm's real sales, relative to the industry mean (similar to Verhoogen, 2008). The second is labor productivity defined as the natural logarithm of real value added per worker, relative to the industry mean (similar to Lileeva and Trefler, 2010). The third is Total Factor Productivity (TFP) obtained using the method outlined in Olley and Pakes (1996).[21] The ESEE categorizes firms into 20 industries, based on the two-digit NACE classification. Summary statistics are given in Table 1, and variable definitions are included in the notes to this table.

4 The Acquisition Decision

4.1 Estimation Strategy

The first set of predictions arising from the model sheds light on which domestic firms are likely to be the targets of foreign acquisitions. As we saw in Section 2, two very different selection mechanisms can arise as a function of the process through which the level of innovation is determined upon acquisition. In Case 1, foreign firms acquire the most productive firms in the economy (those with higher φ_i), so that there is positive selection. In Case 2, foreign firms transfer their own productivity level to the domestic firm, regardless of who they buy. Under this innovation process, there will be negative selection: foreign firms acquire the least productive firms (those with lower φ_i).

We estimate the type of selection at work in the data in the following way. Rearranging inequality (4), we denote $F_{it}^* = \alpha \left(V_i^{*F} - V_i^{*D}\right) - K$. The binary outcome of the acquisition decision F_{it} can be seen as reflecting a threshold rule for the underlying latent variable F_{it}^*, so that $F_{it} = 1$ if $F_{it}^* \geq 0$ and $F_{it} = 0$ if $F_{it}^* < 0$. We also allow the average probability of acquisition to vary by year and industry by including year (d_t) and industry (d_s) dummies. Given these assumptions, the probability that a given firm i in industry s is acquired in year t can be estimated with the following linear approximation:

$$F_{it} = \alpha + \beta\varphi_i + d_t + d_s + \nu_{it} \tag{5}$$

We will first measure φ_i as the productivity of firm i in the base year (the first year the firm appears in the data, which we subsequently exclude from the analysis). We then allow for a time-varying measure of productivity, φ_{it}, –namely, lagged productivity. Empirically, lagged and initial

[21] The Olley-Pakes (1996) approach and other frequently-used solutions to the endogeneity of input levels to unobserved productivity shocks in calculating the values of factor coefficients in measures of TFP rely on the assumption that productivity evolves as an AR(1) process. To the extent that this approach does not allow firms to choose the optimal level of investment in productivity-enhancing technology as a function of observable characteristics, it is less well-suited to our research question. This is why we chose to present three productivity measures.

productivity are highly positively correlated, but the ordering of firms based on lagged productivity may better reflect the attractiveness of any one firm at the time of potential purchase. F_{it} is an indicator variable that equals 1 if the firm is foreign-owned in period t. A probit model gives similar results to the linear probability model.

In Case 1, $\widehat{\beta}$ is predicted to be positive. In contrast, in Case 2, with negative selection, $\widehat{\beta}$ is expected to be negative. Note that the observed selection effect offers insight about the actual nature of the potential technology transfer from multinational parents to domestic subsidiaries.

4.2 Foreign firms select the most productive domestic firms

Before turning to the regression analysis, we first use our dataset to explore the patterns of selection graphically. Figure 3 plots the distribution of initial productivity for two groups of firms: those that are acquired by a foreign firm four years after our baseline productivity is computed and those that remain domestic. One can clearly see that the distribution of acquired firms (solid line) lies to the right of those that remain domestic. Since our measure of productivity is demeaned relative to the industry, this does not reflect differences in firm size by industry. Figure 4 reproduces Figure 3 by industry. A striking pattern emerges: positive selection is present in every industry. These two figures provide prima facie evidence that the positive selection predicted by Case 1 in our model dominates in the Spanish data.

We now turn to a more systematic regression analysis and estimate equation (5) to establish this first fact. The results are shown in Panels A and B of Table 2. The dependent variable in all columns is the indicator for foreign ownership, and this is regressed on our three proxies for initial productivity. These are the logarithm of real firm sales (Columns 1 to 3), the logarithm of labor productivity (Columns 4 to 6) and the logarithm of TFP (Columns 7 to 9), all relative to their industry mean. All regressions include time dummies, industry dummies, and industry trends, so they can be interpreted as within-industry differences in the probability of acquisition as a function of initial productivity, controlling for possible differential trends in acquisitions by industry. The regressions in Panel A use baseline (initial) productivity measured by these three variables, while those in Panel B use the lagged value of the productivity measures.

Regardless of the productivity measure used, we find that more productive firms are more likely to become foreign-owned. For example, the coefficient of 0.0228 in Column 1a implies that, conditional on being domestic in any given year, one standard deviation higher initial sales is associated with a 3.9 percentage points higher probability of being acquired the year after. The coefficient (0.0226) is very similar in Column 1b, which uses lagged sales, reflecting the fact that these two measures are highly correlated. Given that 4.6 percent of all the firms in our sample of initially domestic firms become owned eventually, this explains a significant fraction of the cross-sectional variation in acquisition probabilities.[22]

Columns 2, 5 and 8 do not restrict the relationship between initial productivity and acquisition to being linear and replace the productivity variable with indicator variables capturing the productivity quartile the firm is in. For example, in Column 2a, which uses initial productivity measured by sales, being in the second quartile increases the probability of being foreign-owned by 2.5 (1.5 in Column 2b, using lagged sales) percentage points relative to firms in the first quartile; being in the third quartile by four percentage points (4.01 in Column 2b); and being in the highest productivity quartile by 9.9 percentage points (9.6 in Column 2b). A similar pattern emerges when using labor productivity or TFP as the productivity measure. Therefore, firms at the upper end of the productivity distribution are substantially more likely to become foreign-owned, and the effect is increasing in firm productivity, with the upper quartile having a much higher probability of acquisition.

Finally, Columns 3, 6 and 9 explore the possibility that foreign firms are selecting exporters (because, for example, exporting firms have less exchange rate exposure), and exporting is positively correlated with initial productivity. We introduce a dummy variable for exporting status (the variable equals one if the firm reports exporting in the base year in Panel A, and equals one if the firm is exporting in the previous year in Panel B) and interact it with initial productivity. Initial productivity always remains positively related to the probability of being acquired, regardless of export status. There is also evidence that multinationals are more likely to target exporters. In addition, we find some evidence of higher positive selection among exporters (positive significant coefficient on the interaction of the export dummy and the productivity measures in Panel B). So, overall, even though some firms may be acquired because of their exporter status, positive selection persists, and multinationals are more likely to acquire the most productive firms among both exporters and non-exporters.

Table 2, therefore, reinforces the results from Figures 3 and 4 and shows that, within our cross-section of firms, the more productive domestic firms are more likely to become foreign-owned –evidence of positive selection and the presence of "cherry-picking." These selection patterns are inconsistent with a model in which foreign firms always find it optimal to transfer their superior

[22] Table 1 shows that 3.5 percent of our observations are firms under foreign ownerhsip. This corresponds to the 4.6 percent of firms being acquired during the sample (that appear in the data both before and after acquisition).

technology across international (or firm) borders to any domestic firm, as is commonly assumed.

While the results in a number of papers point to the presence of positive selection by foreign firms in other countries (e.g., for Chile, Ramondo, 2009; for Indonesia, Arnold and Javorcik, 2009; for the U.K., Criscuolo and Martin, 2009), to the best of our knowledge, no prior studies have explained this empirical regularity. When viewed within the context of our model, our finding suggests that acquisition patterns reflect an underlying complementarity between the initial productivity of the acquired firm and the extent of innovation post-acquisition. As we will see later, this finding has significant implications for the relationship between multinational activity in a country and the evolution of the productivity distribution.

5 The Innovation Decision

5.1 Estimation Strategy: Fixed Effects and Propensity Score

After having established that foreign firms positively select domestic firms as targets, we now test the set of predictions relating productivity-enhancing investments to acquisition –namely, that upon being acquired, foreign subsidiaries invest more in innovation than they would have done had they remained domestic. Our model suggests that in either Case 1 or Case 2 –and therefore regardless of whether selection is positive or negative –acquired firms undertake more investment activity, controlling for the initial productivity of the acquired firm. This can be seen in Figures 1 and 2 as the difference between λ_i^F and λ_i^D.

In Case 1, the optimal level of investment under each ownership structure is determined by the first-order condition given in equation (2). In this case, innovation can increase upon acquisition for several reasons. The foreign firm could provide access to a larger market and/or bring with it lower innovation costs, such that $(\frac{A_i}{b_i})^F > (\frac{A_i}{b_i})^D$. In Case 2, foreign firms transfer their own superior level of technology to the domestic firm upon acquisition. This means that innovation will increase upon acquisition.

Our innovation variables are based on the firm-level responses to the questions of whether the firm made specific types of innovation in that year, which we interpret as improvements to firm technology. We are interested in how the firm's technology, which is the result of successive innovations, changes with foreign ownership. Since at any point in time, the firm's technology can be characterized as the sum of innovations made up to that point, we use the yearly variables on firm-level innovation described in Section 3 to measure the firm's technology at time t as: $I_{it} = \sum_{j=t_0}^{t} I_{ij}$, where t_0 is the year the firm entered the data.[23] Any differences in technology across firms in the year they enter the data will be captured by the firm fixed effects in our empirical specifications. As a result, all the variation in a firm's innovative activity, and the resulting technology level, that we relate to changes in the firm's ownership structure is variation that occurs within the sample.[24]

Empirically, we first estimate the effect of acquisition on technology using the panel structure of the dataset and including year fixed effects as follows:

$$I_{it} = \alpha + \gamma F_{it} + d_t + \eta_i + \epsilon_{it} \tag{6}$$

where I_{it} is a proxy for productivity-enhancing innovation. The fact that the level of productivity φ_i affects investment directly for foreign-owned firms is absorbed by the firm fixed effects, along with any other permanent unobserved characteristics of firms. Including firm fixed effects, η_i, implies that the estimated parameter $\widehat{\gamma}$ is a measure of the change in investment after being acquired, controlling for the fact that foreign firms select to acquire higher initial productivity firms, and this is predicted to be positive.

The fixed effects specification controls for selection based on time-invariant firm characteristics (e.g., initial productivity). However, it is important in the context of our 17-year panel to acknowledge that firm characteristics may evolve differently over time (for reasons outside the model) and impact multinational selection decisions differentially. In particular, selection may be driven by lagged firm characteristics and decisions that could be correlated with future innovation. To address this, we use a propensity score estimator to reweight firms in equation (6) to reflect differences in the probability of being acquired based on prior characteristics.

We calculate the propensity score for each firm in the following way. For each year, we consider firms acquired in that year as treated observations and firms that are never acquired as control observations. We pool treated and control observations across all years, to estimate the probability that a firm is acquired as a function of a number of characteristics (see Lechner, 1999). This estimated probability is the propensity score, $\widehat{p}$. The characteristics used to obtain the propensity score are lagged productivity (measured both by log firm sales and log labor productivity), lagged sales growth, lagged export status, lagged average wage, lagged innovation, lagged log capital per employee, lagged log capital and a year trend. We also allow for this relationship to vary across

[23] We have allowed the stock of innovation to depreciate at different rates over time. The results are qualitatively similar to the ones presented with this –the simplest –specification.

[24] Supplemental Appendix Table S1 shows that each measure of the stock of innovation I_{it}, enters the production function as a significant shifter of productivity.

industries by estimating the propensity score separately for each industry.[25]

One can transform the propensity score estimates into weights such that the propensity score reweighted regression yields a consistent estimate of a parameter of interest (Dehejia and Wahba, 1997; Busso, DiNardo and McCrary, 2009). We will obtain the Average Treatment Effect (ATE) of acquisition on innovation in a specification like equation (6), using the weights derived from the propensity score (Rubin, 2001). Specifically, the weight for each treated firm is $1/\widehat{p}$, and the weight for each control firm is $1/(1-\widehat{p})$.[26] We restrict the analysis to firms that fall within the common support. Busso, DiNardo and McCrary (2009) show that the finite sample properties of this propensity score reweighting estimator are superior to the propensity score matching techniques (where each treated firm is matched to one or several controls).

The propensity score reweighting estimator obtained by reweighting observations in equation (6), allows us to control not only for selection on time-invariant characteristics of firms (just like the equal-weighted fixed effects regression), but also for time-varying characteristics through the propensity score. The underlying assumption in the estimation is that, conditional on observable time-varying and any time-invariant characteristics that affect selection, treatment is random. Hence, outcomes for the treated are attributable only to treatment status (this is typically referred to as the ignorability assumption, or selection on observables).

5.2 Acquired firms undertake more innovation

Since we have detailed information on the types of innovation implemented within domestic firms upon foreign acquisition, our data will allow us to shed light on the actual process of technology adoption by domestic firms, and precisely what types of innovations are more likely to be adopted/transferred.

Our measures of innovation are specific actions related to the implementation of product and process innovation, and the assimilation of foreign technology. All columns of Table 3 reflect regressions of an innovation variable on the lagged foreign ownership variable. Reflecting the fact that it takes some time for firm strategies to change after acquisition, we observe empirically that innovations take place mainly with a one-year lag. Lagging this independent variable also minimizes

[25] We also performed the standard tests to check that the balancing hypothesis holds within each industry. We found that all covariates are balanced between treated and control observations for all blocks in all industries.

The relationship between each of these variables and the probability of being acquired is shown in Supplemental Appendix Table S2. Lagged log firm sales is the most significant predictor of acquisition, consistent with our model.

[26] Since never-acquired control firms may be used as controls more than once, we sum the control weights by firm to obtain the weight for the control firm (Lechner, 1999). We also winsorize the weights at one percent because of extreme outliers in the weights. The results are not sensitive to the exact outlier cut-off.

possible concerns about reverse causation.

In Table 3, we report the results for each investment proxy variable: process innovation (Panel A), product innovation (Panel B) and assimilation of foreign technologies (Panel C). The first column in each panel includes only firm fixed effects; the second also includes a control for sales growth in the year prior to acquisition (to control for possible differences in innovation related to previous firm growth); and the third allows for industry-level trends in investment. The fourth column presents the propensity score reweighted estimates.

The fixed effects specifications in Columns 1 to 3 of Panel A show that process innovation is positively and significantly associated with foreign ownership. Column 1a shows that a foreign-acquired firm is 57-percent more likely to have undertaken a process innovation while foreign-owned, relative to a firm that stays domestic. This estimate is robust to controlling for lagged sales growth (Column 2a) and industry trends (Column 3a). Column 4a shows the propensity score reweighted regressions that allow us to control for time-varying selection and other forms of endogeneity. The coefficient 0.645 is similar to earlier columns and also highly significant, implying that firms undertake more process innovation upon acquisition.

There is also some evidence that foreign-acquired firms conduct more product innovation and are also more likely to assimilate foreign technology. However, while the coefficients are positive and significant in Columns 1b and 1c, standard errors are larger when controls for lagged sales growth and industry trends are included, as is also true for the propensity score estimation. Nonetheless, the coefficient values on lagged foreign ownership remain similar in magnitude for each variable in these specifications, and is significant at the ten-percent level for the assimilation of foreign technologies in the propensity score estimation of Column 4b.[27] This suggests that the foreign parent is transferring new technologies upon acquisition.

Table 4 shows the effect of foreign ownership on the disaggregated measures of process innovation. We distinguish between firms that report to have invested only in new machines (Panel B), only in new methods of organizing production (Panel C) or in both simultaneously (Panel A). The results reveal some interesting contrasts. While foreign-acquired firms are not significantly more likely to only introduce new machinery or only introduce new ways of organizing production, the simultaneous introduction of new machinery and new organizational process is significantly associated with foreign acquisition (Teece, 1977). Panel A shows this result. Both the fixed effects

[27] Note that the variable indicating the assimilation of foreign technologies is available only every four years, reducing the number of observations in these specifications and, hence, reducing the power of the fixed effects results since we have, at most, five observations within a firm for this variable.

specifications of Columns 1a to 3a and the propensity score estimation of Column 4a show that upon acquisition, firms are more likely to introduce new machines and new organizational methods simultaneously. This is an interesting result since we might have expected that foreign firms would also be more likely to introduce either type of process innovation independently. It is consistent with the complementarities found by Black and Lynch (2001), Bresnahan et al. (2002), Brynjolfsson and Hitt (2003) and Bartel et al. (2007) between different types of technology upgrading. Since firms appear to introduce both types of innovations jointly, it is important to allow for the effect of both actions when quantifying the multinational productivity advantage.

5.3 The Role of Market Access Provided by the Foreign Parent

These findings on increased innovation following acquisition, together with our positive selection results, are consistent with a world in which multinationals choose to acquire the most productive firms since that is where the returns to their investment are highest. This could arise because the foreign firm gives access to technology at a cost (b_i) that is lower than the innovation costs for the firm had it remained under domestic control, as previously proposed in the literature on the sources of multinational advantage (see Caves, 1996). We highlight an alternative reason for our findings, based on a key feature of multinationals: they often grant their subsidiaries access to a larger global market.

Tables 5 and 6 explore whether innovation decisions are related to whether foreign ownership brings with it access to foreign markets. We regress the innovation variables on indicator variables for whether the firm exports, and for whether the firm exports through the foreign parent. Exporting through the foreign parent may mean that the firm uses the distribution channels and the networks of the foreign firm to export, or that it sells its goods directly to the foreign parent (as part of a global production system). The base category is that the firm exports via any other channel such as through its own means, using a Spanish specialized intermediary or cooperative export agreements with other firms.

Table 5 presents the results for overall process innovation (Panel A) and for process innovation that involves the simultaneous introduction of new machines and new methods of organizing production (Panel B). Column 1a reveals that starting to export is positively associated with investment in process innovation, consistent with the findings of previous studies (Verhoogen, 2008; Bustos, 2010; Lileeva and Trefler, 2010; Aw et al., 2010). This result holds controlling for foreign ownership (Column 2a), which is also significant, suggesting that the ownership mechanism outlined in this paper offers an explanation for acquired firms' increased process innovation that is separate from the export channel.

Columns 3a and 4a introduce our key variable of interest, showing fixed effects regressions using process innovation as a dependent variable, where we include the indicator variables for whether the firm exports via the foreign parent. Notably, we find that starting to export through a foreign parent has a large and significant coefficient. This suggests that the market access provided by the foreign parent is a key driver of the increased process innovation associated with acquisition.

Since we can distinguish between different types of process innovation, we evaluate the type of process innovation exporters are more likely to undertake. Although exporting is, on average, not significantly associated with the simultaneous introduction of new machines and new forms of organizing production (Column 1b), foreign-owned firms are more likely to engage in this type of process innovation (Column 2b). Column 3b shows that, similar to the process innovation results in Column 3a, innovation is driven mainly by those foreign-owned exporters that export via the foreign parent. In contrast, we find that exporting is significantly associated with the introduction of new machines exclusively, while exporting through a foreign parent is not (unreported). This reinforces our findings in Table 4, which suggest that foreign ownership leads to a specific type of product innovation, which involves both new machines and new methods of organizing production.

Columns 5 to 8 in Table 5 present the propensity score results for the market access channel, allowing us to control for time-varying selection and endogeneity. Here, we consider the treatment to be starting to export through the foreign parent, and we recalculate the propensity score and the associated weights for each firm as described in Section 5.1. Column 5 shows that exporting through a foreign parent leads to more process innovation (Column 5a) and, in particular, to innovation that involves the introduction of new machines and organizational practices simultaneously (Column 5b).[28] This result holds when controlling for lagged foreign ownership (Column 6), exporting status, and their interaction (Columns 7 and 8).

Table 6 shows the effect of market access through the foreign parent on product innovation and the assimilation of foreign technologies. Both using fixed effects and the propensity score estimator, we find that exporting via a foreign parent leads to more product innovation and the adoption of foreign technologies. These results shed light on those in Table 3, where we found a statistically weaker relationship between foreign ownership and these two variables. Once we distinguish between foreign-owned firms that export via a foreign parent and those that do not, we see that those that

[28]Interestingly, we find that exporting through a foreign parent does not lead to the introduction of new machines or new organizational practices separately (results unreported).

use the parent as an export platform and, hence, have access to larger markets also invest in new products and adopt new foreign technologies.

Taken together, these results imply that when firms are acquired by a foreign parent, they increase innovation particularly when the parent firm provides access to export markets. The observed relationship between market access and innovation activity offers further support for the mechanism outlined in Case 1, since only in that case is there a role for market access as a driver of innovation decisions. It also indicates that market access can itself provide a sufficient reason for acquisition (even when foreign and domestic firms face similar variable innovation costs) when larger market access increases the potential benefits from investment activity.

5.4 Exports and Wages

Finally, in Table 7, we show other changes that take place within firms as a consequence of foreign ownership. We study how the share of exports in total sales (Panel A), the logarithm of total exports for exporters (Panel B) and the logarithm of average firm wage (computed as the total wage bill divided by the number of employees, Panel C) change with foreign acquisition. Columns 1 to 3 show the equal weighted fixed effects specification, and Column 4 shows the propensity score reweighted results.

We find that the proportion of exports in total sales increases significantly following foreign acquisition. The propensity score estimate in Column 4a shows that the share of exports is, on average, five percentage points higher in each year for firms that are acquired compared to similar firms that are not acquired. We also find that the volume of exports for exporters is 25-percent higher for exporters under foreign ownership (Column 4b). Finally, Panel C shows that average firm wage increases by six percent following acquisition. This result is driven by an increase in the total wage bill, rather than by a change in the number of employees (results unreported). This suggests that firms are increasing their wages and/or upgrading the skill of the workforce following foreign acquisition. Again, this result, is interesting in itself and consistent with the technology upgrading identified in the previous sections, to the extent that worker skill and technology are complements in the production function.

6 Foreign Ownership and Productivity Evolution

Section 4.2 showed that there is positive selection of target firms by foreign multinationals, consistent with Case 1, and Section 5.2 established that, upon acquisition, firms upgrade their technology by doing more process innovation and, in particular, by investing simultaneously in new machines and in new methods to organize production. Now we investigate the effect of acquisition on firm productivity directly, as well as its consequences for the evolution of the distribution of productivity within industries.

Under the assumption that the investment activities described above are indeed productivity-enhancing, the increased levels of these activities upon acquisition are predicted to lead to higher productivity for acquired firms. Table 8 shows the results of estimating equation (6) with our measures of productivity as the dependent variable. Column 1 in Panels A to C (for each productivity measure) estimate equation (6) without firm fixed effects; Columns 2 and 3 include firm fixed effects and industry trends, respectively; and Column 4 shows the propensity score reweighting estimates.

The point estimates are much larger in the cross-sectional estimation of Column 1 relative to any of the other columns that include fixed effects and better control for selection and endogeneity using the propensity score. This reflects the fact that the positive selection identified earlier will lead to substantial over-estimation of the productivity advantage in cross-sectional analysis (as also demonstrated by Criscuolo and Martin, 2009). However, we also find that acquisition is significantly positively associated with increased productivity, controlling for selection. The propensity score reweighted specifications in Column 4 imply that, after acquisition, real sales increase by 18 percent, on average, for acquired firms. In turn, labor productivity is 13-percent higher and TFP is 16-percent higher for acquired firms.

There are a number of concerns about using measures of productivity based on accounting variables that this paper shares with most of the productivity literature. If there are changes in how some costs (e.g., management) are allocated between establishments in a firm, or in how input or output prices are accounted for (e.g., when using transfer pricing), the accounting-based measures of productivity can be problematic. One advantage of our paper is that we are able to measure actual changes in the technology that goes directly into the production function (our measures of innovation and technology adoption in Section 5), such that we do not have to rely exclusively on productivity measures to evaluate the effects of foreign ownership. Note, also, that the introduction of transfer pricing upon acquisition would make it harder for us to find any productivity effects of acquisition since the transfer price within a multinational is likely to be smaller than the market price, reducing reported sales volumes. In any case, the productivity results in Table 8 confirm the results that we obtained in Table 3 using direct measures of the changes in the technologies entering the production function and affecting productivity.[29]

Finally, we discuss the implications of our findings for the evolution of the distribution of productivity within industries. We showed that foreign firms are more likely to acquire the most productive firms within industries (Table 2), and that, upon acquisition, firms innovate (Table 3), increasing productivity (Table 8). This set of results implies that acquisition activity can lead to an increase in the dispersion of the productivity distribution.[30] One can see this in Figure 5, which shows the distribution of firm productivity in the base year, and four years after that, for firms that are domestic in that first year but will be foreign-owned four years later. The distribution is shifted to the right, indicating that productivity increased for firms following the acquisition, over the whole distribution of firm initial productivity. Figure 6 shows the distribution of productivity in the base year and four years later for firms that remained domestic. While there is a slight increase in productivity (productivity is generally known to increase over time), it is much less pronounced than for foreign-acquired firms. Thus, Figures 5 and 6 provide evidence that the dispersion in the productivity distribution will increase with foreign entry. This is an important consequence of our earlier findings since it has implications for the evolution of within-industry productivity distributions as more foreign firms enter an industry. Under this mechanism, foreign entry does not lead to productivity convergence, but, on the contrary, could lead to further divergence. Of course, there could be other reasons (such as spillover effects or other externalities) why multinational entry may improve less productive firms' productivity. However, the direct effect of the foreign acquisition process is an increase in productivity heterogeneity.

7 Conclusion

In this paper, we use rich and detailed data on Spanish manufacturing firms to establish that foreign firms acquire the best firms within industries ("cherry-picking"), but, nonetheless, also invest more in a number of innovation activities upon acquisition. In particular, controlling for the selection effect, firms increase both their process innovation (with the simultaneous introduction of new

[29] All our results are robust to the analysis of firms that report no change in reporting unit throughout the time they are in the sample, as well as restricting the sample to firms that report no changes in the number of establishments. This rules out the concern that the definition of the reporting unit changes following acquisition.

[30] If multinational entry also serves to raise the threshold level of productivity at which firms exit the domestic market (as in Helpman et. al., 2004), the resulting productivity distribution will shift to the right, but the increase in dispersion following multinational entry will be less pronounced.

machines and organizational practices) and their product innovation. Firms also report that they assimilate more foreign technologies upon acquisition.

We develop a simple model that illustrates how these two facts are fundamentally related. The model relies on standard assumptions about firm production, heterogeneity, consumer demand and market competition (Helpman and Krugman, 1985; Melitz, 2003) and incorporates two well-known characteristics of multinational firms: multinationals grant access to larger markets and/or have lower technology implementation costs. Since the incentives for innovation and acquisition are increasing in initial productivity, foreign firms would find it more profitable to acquire the most productive firms, and innovate more on acquisition.

The observed positive selection suggests that there are complementarities between innovation activity and the initial characteristics of the acquired firm that could go beyond any possible technological complementarity between firms with similar productivity levels. Our results also suggest there is a complementarity between market access and innovation. Taken together, these findings can explain a number of important facts: first, why more productive firms innovate more; second, why foreign firms acquire the most productive firms within industries; and third, why foreign-owned firms increase their innovation upon acquisition.

It is, perhaps, not surprising that integration into a foreign multinational is associated with higher levels of innovation since transaction costs theories of the firm suggest that the reason for integration in the first place is to achieve the efficiently high levels of investment that arm's length transacting would preclude.[31] Our contribution is to illustrate the drivers of the innovation process and to highlight that superior or proprietary technologies are not necessary to generate the prediction that a given firm finds it optimal to invest more under foreign control than under domestic control.

In addition, the complementarity between market scale and innovation offers one explanation for why all firms do not imitate the practices of high productivity firms in the market and why productivity differences persist. To the best of our knowledge, we are the first to link market scale to the jointly determined acquisition outcomes and innovation incentives. Finally, while we focus on the multinational firm's acquisition choice, the economic mechanism we emphasize should also be relevant for purely domestic integration decisions when the acquirer facilitates access to larger markets.

[31] The reason why a foreign firm chooses to enter via acquisition rather than through an arm's length relationship is the subject of a large literature and typically requires some form of contractual incompleteness. While our model allows for this possibility, our predictions hold even without contractual incompleteness around the technology transfer in itself.

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Figures and Tables

Figure 1: Productivity Growth as a Function of Initial Productivity with Significant Variable Costs of Innovation (Case 1).

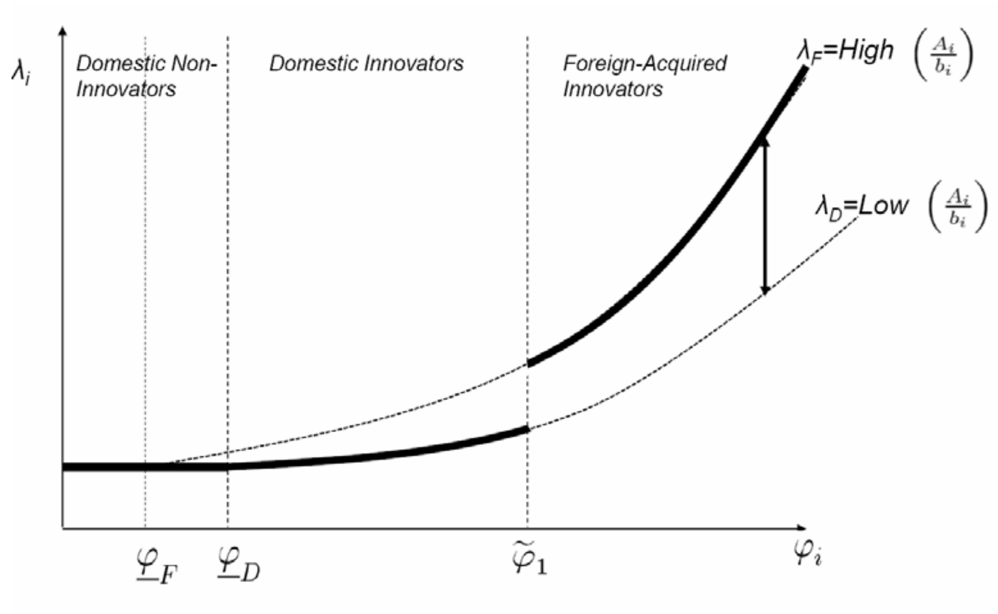


Figure 2: Productivity Growth as a Function of Initial Productivity with Negligible Variable Costs of Innovation (Case 2).

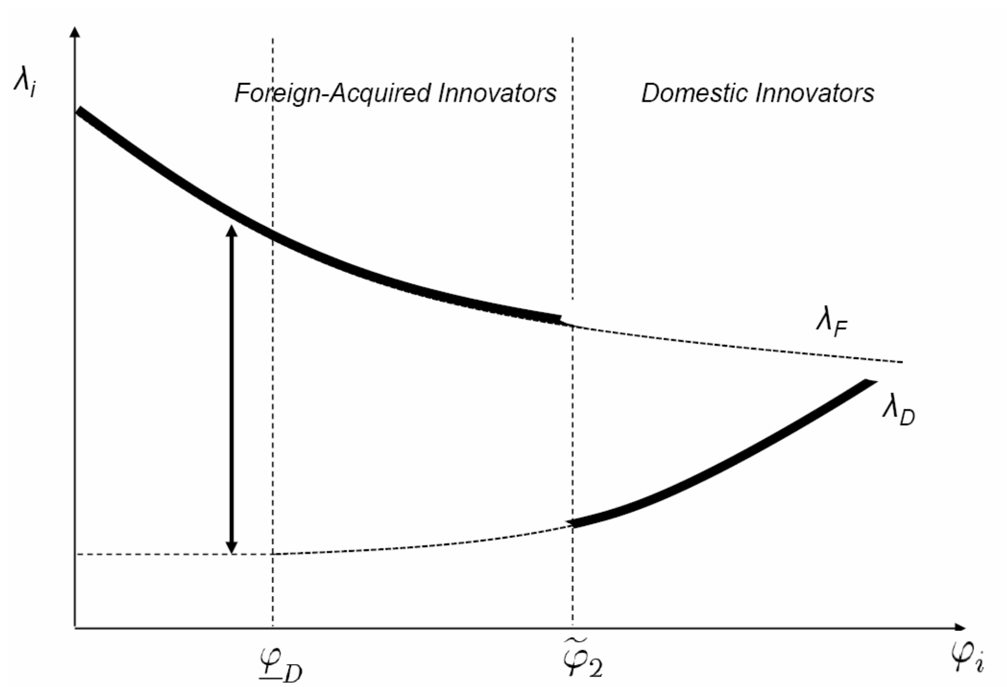
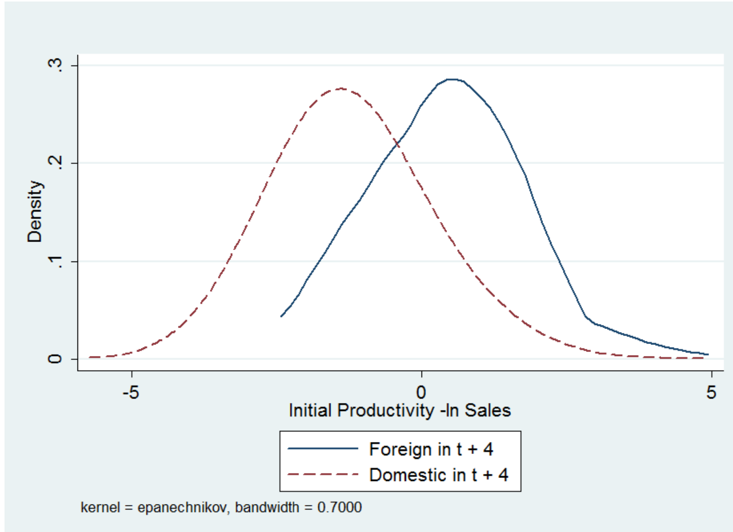
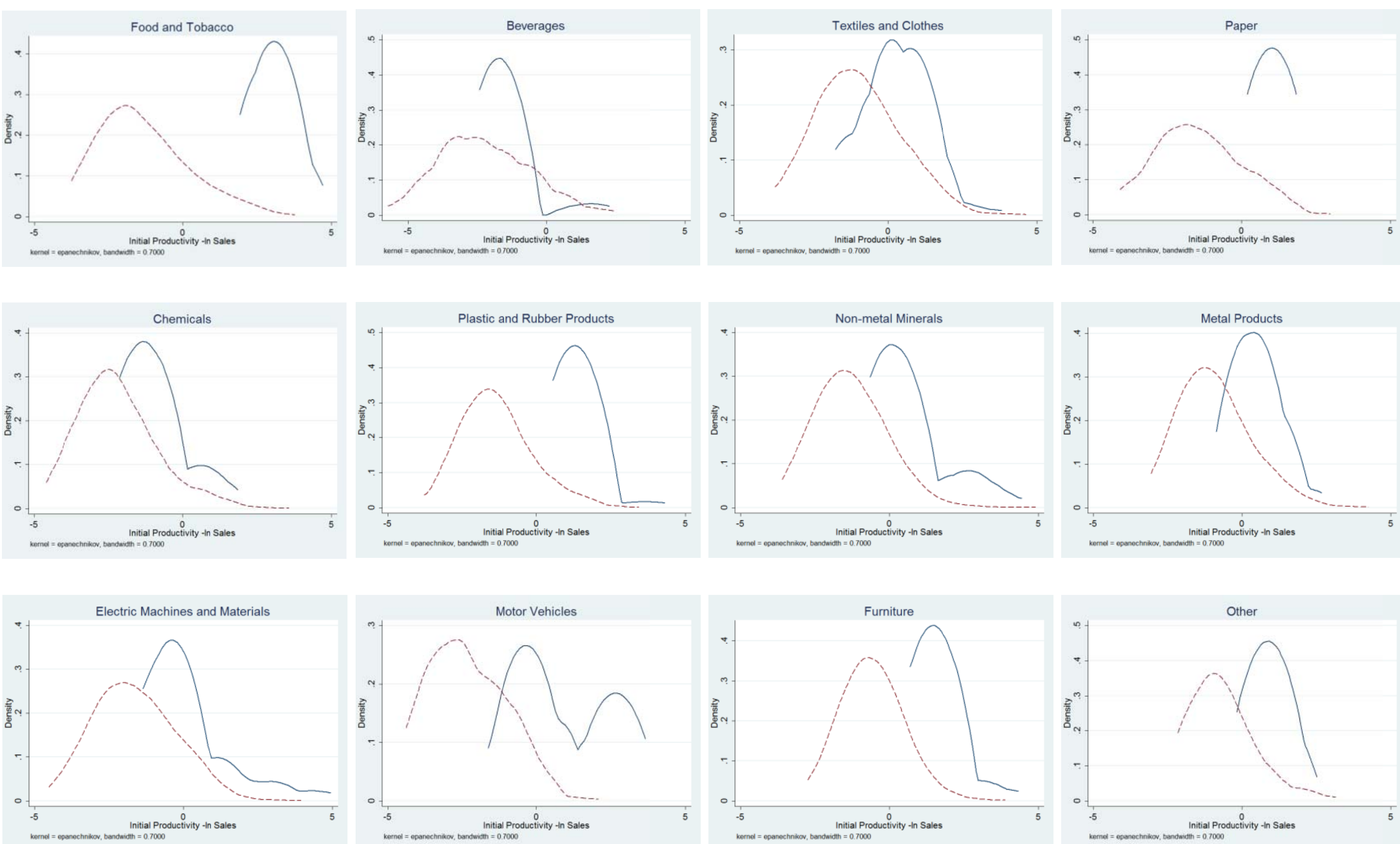


Figure 3: Distribution of Initial Productivity for Acquired and Non-Acquired Firms.



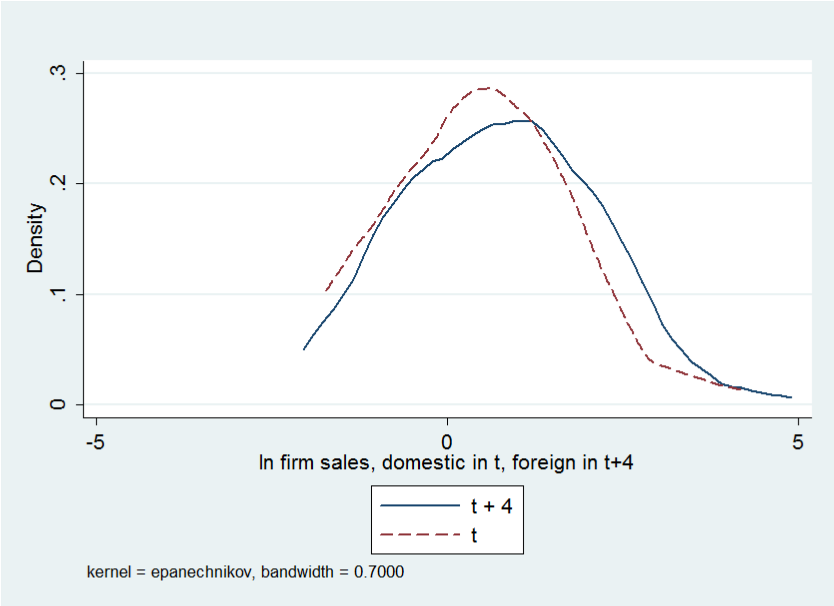
Note: The dashed line shows the empirical pdf of initial productivity (measured by log sales demeaned by industry) of firms that are domestic at time t and will stay domestic at time t+4. The bold line shows the empirical pdf of initial productivity of firms that are domestic at time t, but will become foreign-owned by time t+4.

Figure 4: Selection by Industry.



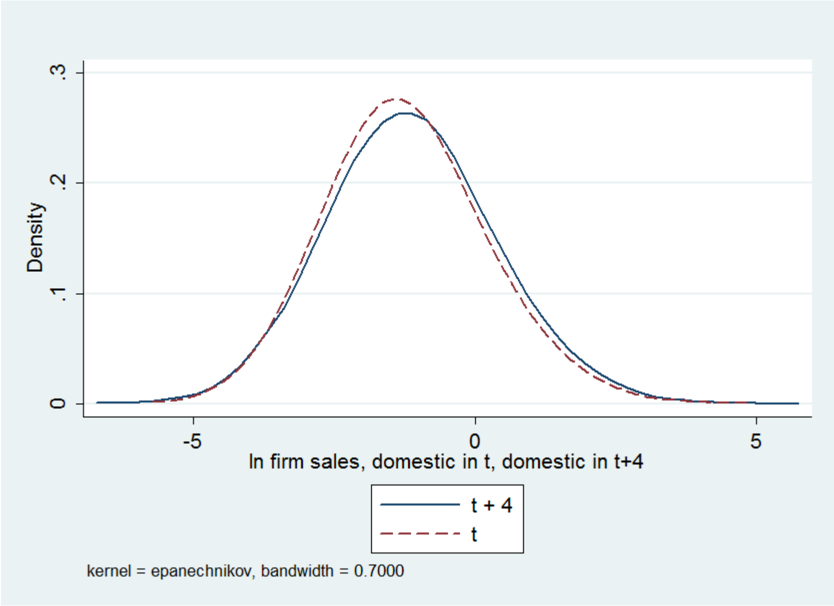
Note: Figure 4 reproduces Figure 3 for each industry separately.

Figure 5: Distribution of Productivity for Acquired Firms, Before and After the Foreign Acquisition.



Note: The dashed line shows the empirical pdf of initial productivity (measured by log sales demeaned by industry) of firms that are domestic at time t, but will become foreign-owned by time t+4. The bold line shows the empirical pdf of productivity of these firms at time t+4 (i.e., after acquisition).

Figure 6: Distribution of Productivity for Non-Acquired Firms, Change over Four Years.



Note: The dashed line shows the empirical pdf of initial productivity (measured by log sales demeaned by industry) of firms that are domestic at time t and will stay domestic at time t+4. The bold line shows the empirical pdf of productivity of these firms at time t+4.

Table 1. Descriptive Statistics

Variable	Mean	Std. deviation	N
Foreign	0.035	0.184	20896
ln Sales	15.372	1.862	20845
Base year ln Sales (demeaned by industry)	-0.563	1.723	20845
ln Labor productivity	10.399	0.680	20527
Base year ln Labor prod. (demeaned by industry)	-0.166	0.638	20203
ln TFP (Olley Pakes)	8.418	0.599	18806
Base year ln TFP (Olley Pakes)	8.387	0.629	18475
Process Innovation	2.236	2.720	20896
Product Innovation	1.700	2.635	20896
Assimilation of Foreign Technologies	0.350	0.694	5555
New Machines	0.980	1.550	20896
New Methods of Organizing Production	0.305	0.773	20896
Both (new machines and new methods of org.)	0.837	1.677	20896
Export	0.530	0.499	20860
Export channel:			
Export via foreign parent	0.016	0.125	5543
Exports/Sales	0.139	0.232	20803
ln Exports	13.927	2.612	11042
ln Average wage	10.029	0.447	20841
Lag Sales growth	0.024	0.299	17848

Notes: The sample includes all firms in the ESEE (1990-2006) that are not foreign-owned (potential acquisition targets) in their first year in the sample. Foreign is an indicator variable that equals one if the firm has at least 50-percent foreign ownership. Ln Sales is the natural logarithm of the firm's real sales. Base year ln Sales is the natural logarithm of firm's real sales, relative to the industry mean, in the first year the firm appears in the sample. Ln Labor productivity is the natural logarithm of real value added per worker (where valued added is calculated by ESEE as the sum of sales plus change in inventory, less purchases and costs of goods sold). Base year ln Labor productivity is the natural logarithm of real value added per worker, relative to the industry mean, in the first year the firm appears in the sample. Ln TFP is the natural logarithm of total factor productivity and Base year ln TFP is the natural logarithm of total factor productivity in the base year, calculated using the approach of Olley and Pakes (1996), relative to the industry mean, in the first year the firm reports it. Process Innovation, Product Innovation, Assimilation of Foreign Technologies, New Machines, New Methods of Organizing Production, and Both are all defined in a similar way, and reflect the stock of reported innovations of each type the firm has done during the sample period (see Sections 3 and 5 for more details). Export is an indicator variable that equals one if the firm exports any goods. Export via foreign parent is an indicator variable that equals one if the firm declares it exports through a foreign parent. Exports/Sales is the share of exports over total sales. Ln Exports is the natural logarithm of exports. Ln Average wage is the natural logarithm of the total wage bill per worker. All nominal variables are in 1990 euros (deflated using the industry-level producer price index – Indice de Precios Industriales).

Table 2. The Selection Decision

Productivity Measure		ln Sales			ln Labor Productivity			ln TFP (Olley Pakes)	
Panel A	1a	2a	3a	4a	5a	6a	7a	8a	9a
Base year productivity	0.0228***		0.0196***	0.0238***		0.0157***	0.00878*		0.00625**
	(0.00259)		(0.00433)	(0.00524)		(0.00476)	(0.00503)		(0.00268)
2nd quartile Base year productivity		0.0250***			0.0111			0.00955	
		(0.00720)			(0.00811)			(0.00973)	
3rd quartile Base year productivity		0.0400***			0.0236***			0.0106	
		(0.00840)			(0.00895)			(0.00940)	
4th quartile Base year productivity		0.0985***			0.0375***			0.0120	
		(0.0111)			(0.00975)			(0.00982)	
Exporting firm in base year			0.01000			0.0414***			0.0468***
			(0.00998)			(0.00789)			(0.00760)
Exporting in base year*Base year p			0.00372			0.00309			-0.00604
			(0.00574)			(0.0124)			(0.0131)
Observations	20845	20845	20845	20203	20203	20203	18475	18475	18475
R-squared	0.067	0.061	0.067	0.028	0.027	0.039	0.025	0.025	0.042
Panel B	1b	2b	3b	4b	5b	6b	7b	8b	9b
Lagged productivity	0.0226***		0.0150***	0.0320***		0.0164***	0.0223***		0.0117***
	(0.00255)		(0.00303)	(0.00518)		(0.00455)	(0.00497)		(0.00382)
2nd quartile Lagged productivity		0.0153***			0.0108***			0.00689*	
		(0.00514)			(0.00384)			(0.00382)	
3rd quartile Lagged productivity		0.0401***			0.0294***			0.0192***	
		(0.00773)			(0.00559)			(0.00538)	
4th quartile Lagged productivity		0.0959***			0.0599***			0.0410***	
		(0.0107)			(0.00890)			(0.00798)	
Lag Exporting firm			0.00987			0.0369***			0.0370***
			(0.00715)			(0.00618)			(0.00615)
Lag Exporting firm*Lagged produc			0.0116**			0.0153*			0.00856
			(0.00454)			(0.00902)			(0.00875)
Observations	20671	20671	20631	20331	20331	20291	18949	18949	18914
R-squared	0.068	0.061	0.069	0.034	0.038	0.043	0.028	0.031	0.038
Industry FEs and industry trends	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Foreign is an indicator variable that equals one if the firm has at least 50-percent foreign ownership. Base year (lagged) ln Sales is the natural logarithm of firm's real sales, relative to the industry mean, in the first year the firm appears in the sample (one year prior to the dependent variable). Base year (lagged) labor productivity is the natural logarithm of real value added per worker, relative to the industry mean, in the first year the firm appears in the sample (one year prior to the dependent variable). Base year (lagged) ln TFP is the natural logarithm of total factor productivity, calculated using the approach of Olley and Pakes (1996), relative to the industry mean, in the first year the firm reports it (one year prior to the dependent variable). Exporting firm in base year equals one if the firm was an exporter in the first year it appears in the sample. Lag Exporting firm equals one if the firm was an exporter the previous year. The first year the firm appears in the sample is dropped from all regressions. All columns include year fixed effects. Standard errors are clustered by firm. * indicates 10% significance; ** 5% significance; *** 1% significance.

Table 3. Foreign Ownership and Innovation

	Process Innovation			
Panel A	1a	2a	3a	4a
Lag Foreign	0.574***	0.496**	0.419**	0.645**
	(0.190)	(0.206)	(0.180)	(0.254)
Observations	20671	17714	20671	16048
R-squared	0.499	0.490	0.527	0.528

	Product Innovation			
Panel B	1b	2b	3b	4b
Lag Foreign	0.387*	0.274	0.293	0.239
	(0.205)	(0.216)	(0.202)	(0.306)
Observations	20671	17714	20671	16048
R-squared	0.368	0.361	0.410	0.384

	Assimilation of Foreign Technologies			
Panel C	1c	2c	3c	4c
Lag Foreign	0.144*	0.127	0.111	0.147*
	(0.0736)	(0.0774)	(0.0705)	(0.0797)
Observations	5434	4612	5434	3961
R-squared	0.160	0.161	0.200	0.199
Firm FEs	yes	yes	yes	yes
Control Lag Sales growth		yes		
Industry trends			yes	
Propensity score weighting				yes

Notes: Foreign is an indicator variable that equals one if the firm has at least 50-percent foreign ownership. The dependent variables are our measures of innovation (see Section 3 for details). All columns include year fixed effects. Standard errors are clustered by firm. * indicates 10% significance; ** 5% significance; *** 1% significance.

Table 4. Foreign Ownership and Innovation: New Machines and New Methods of Organizing Production

	Both (new machines and new methods of organizing production)			
Panel A	1a	2a	3a	4a
Lag Foreign	0.430***	0.329*	0.360**	0.448**
	(0.156)	(0.169)	(0.144)	(0.218)
Observations	20671	17714	20671	16048
R-squared	0.244	0.237	0.296	0.271

	New Machines			
Panel B	1b	2b	3b	4b
Lag Foreign	0.0273	0.0505	-0.0126	-0.0337
	(0.0871)	(0.0935)	(0.0891)	(0.132)
Observations	20671	17714	20671	16048
R-squared	0.346	0.338	0.368	0.377

	New Methods of Organizing Production			
Panel C	1c	2c	3c	4c
Lag Foreign	0.117	0.116	0.0710	0.231*
	(0.0995)	(0.109)	(0.0929)	(0.124)
Observations	20671	17714	20671	16048
R-squared	0.146	0.138	0.186	0.154
Firm FEs	yes	yes	yes	yes
Control Lag Sales growth		yes		
Industry trends			yes	
Propensity score weighting				yes

Notes: Foreign is an indicator variable that equals one if the firm has at least 50-percent foreign ownership. The dependent variables are our measures of innovation (see Section 3 for details). All columns include year fixed effects. Standard errors are clustered by firm. * indicates 10% significance; ** 5% significance; *** 1% significance.

Table 5. Access to Export Channel and Process Innovation: Evidence from Panel Data and Propensity Score Weighting

	Process Innovation							
Panel A	1a	2a	3a	4a	5a	6a	7a	8a
Export via foreign parent			0.628**	0.512*	0.610**	0.623*	0.623*	0.612**
			(0.284)	(0.276)	(0.273)	(0.321)	(0.321)	(0.287)
Export	0.172**	0.160**	0.203*	0.183				0.0510
	(0.0711)	(0.0715)	(0.111)	(0.119)				(0.146)
Lag Foreign	0.579***	0.509*	0.378				0.601	0.314
	(0.193)	(0.279)	(0.291)				(0.481)	(0.427)
Observations	20860	20686	5422	4633	4900	4823	4823	4823
R-squared	0.498	0.500	0.482	0.517	0.515	0.521	0.521	0.552
	Both (new machines and new methods of organizing production)							
Panel B	1b	2b	3b	4b	5b	6b	7b	8b
Export via foreign parent			0.540**	0.446*	0.517**	0.542**	0.542**	0.509**
			(0.252)	(0.238)	(0.221)	(0.259)	(0.259)	(0.202)
Export	0.0508	0.0444	0.0924	0.0765				-0.0392
	(0.0491)	(0.0492)	(0.0732)	(0.0749)				(0.0972)
Lag Foreign		0.441***	0.186	0.221			0.320	0.199
		(0.158)	(0.211)	(0.218)			(0.297)	(0.256)
Observations	20860	20686	5422	4633	4900	4823	4823	4823
R-squared	0.243	0.244	0.234	0.296	0.275	0.278	0.278	0.357
Firm FEs	yes	yes	yes	yes	yes	yes	yes	yes
Industry trends				yes				yes
Propensity score weighting					yes	yes	yes	yes

Notes: Export is an indicator variable that equals one if the firm exports any goods. Export via foreign parent is an indicator variable that equals one if the firm declares that it exports through a foreign parent. Foreign is an indicator variable that equals one if the firm has at least 50-percent foreign ownership. The dependent variables are our measures of innovation (see Section 3 for details). All columns include year fixed effects. Standard errors are clustered by firm. * indicates 10% significance; ** 5% significance; *** 1% significance.

Table 6. Access to Export Channel, Product Innovation and Assimilation of Foreign Technologies: Evidence from Panel Data and Propensity Score Weighting

	Product Innovation					
Panel A	1a	2a	3a	4a	5a	6a
Export via foreign parent	0.517**	0.528**	0.469**	0.662***	0.662***	0.694***
	(0.238)	(0.250)	(0.227)	(0.244)	(0.244)	(0.238)
Export	0.0318	0.0455				-0.0518
	(0.105)	(0.105)				(0.117)
Lag Foreign	0.0361	0.00286			-0.193	-0.349
	(0.311)	(0.351)			(0.384)	(0.365)
Observations	5422	4633	4900	4823	4823	4823
R-squared	0.346	0.395	0.379	0.382	0.382	0.432
	Assimilation of Foreign Technologies					
Panel B						
Export via foreign parent	0.259***	0.249**	0.184*	0.196*	0.196*	0.179*
	(0.0977)	(0.0981)	(0.0942)	(0.102)	(0.102)	(0.0921)
Export	0.0104	0.0137				-0.0119
	(0.0219)	(0.0231)				(0.0298)
Lag Foreign	0.0843	0.0298			0.0450	0.00954
	(0.0729)	(0.0717)			(0.0903)	(0.0835)
Observations	5410	4632	4899	4822	4822	4822
R-squared	0.167	0.208	0.225	0.224	0.224	0.268
Firm FEs	yes	yes	yes	yes	yes	yes
Industry trends		yes				yes
Propensity score weighting			yes	yes	yes	yes

Notes: Export is an indicator variable that equals one if the firm exports any goods. Export via foreign parent is an indicator variable that equals one if the firm declares that it exports through a foreign parent. Foreign is an indicator variable that equals one if the firm has at least 50-percent foreign ownership. The dependent variables are our measures of innovation (see Section 3 for details). All columns include year fixed effects. Standard errors are clustered by firm. * indicates 10% significance; ** 5% significance; *** 1% significance.

Table 7. Foreign Ownership and Exports

	Exports/Sales			
Panel A	1a	2a	3a	4a
Lag Foreign	0.0422***	0.0324**	0.0422***	0.0512**
	(0.0155)	(0.0161)	(0.0155)	(0.0234)
Observations	20630	16373	20630	17811
R-squared	0.041	0.035	0.053	0.076

	ln Exports			
Panel B	1b	2b	3b	4b
Lag Foreign	0.206*	0.227*	0.206*	0.245*
	(0.118)	(0.126)	(0.119)	(0.144)
Observations	10907	8780	10907	10173
R-squared	0.165	0.156	0.177	0.234

	ln Average wage			
Panel C	1c	2c	3c	4c
Lag Foreign	0.0238	0.0323**	0.0274*	0.0563***
	(0.0152)	(0.0159)	(0.0152)	(0.0216)
Observations	20667	16399	20667	17837
R-squared	0.427	0.394	0.430	0.431
Firm FEs	yes	yes	yes	yes
Control Lag Sales growth		yes		
Industry trends			yes	
Propensity score weighting				yes

Notes: Foreign is an indicator variable that equals one if the firm has at least 50-percent foreign ownership. Exports/Sales is the share of exports over total sales. Ln Exports is the natural logarithm of exports. Ln Average wage is the natural logarithm of the total wage bill per worker. The first year the firm appears in the sample is dropped from all regressions. All columns include year fixed effects. Standard errors are clustered by firm. * indicates 10% significance; ** 5% significance; *** 1% significance.

Table 8. Foreign Ownership and Firm Productivity

	ln Sales			
Panel A	1a	2a	3a	4a
Lag Foreign	2.042***	0.165***	0.120**	0.175***
	(0.161)	(0.0621)	(0.0599)	(0.0543)
Observations	20671	20671	20671	16048
R-squared	0.072	0.100	0.147	0.122

	ln Labor productivity			
Panel B	1b	2b	3b	4b
Lag Foreign	0.367***	0.126***	0.109**	0.133***
	(0.0496)	(0.0466)	(0.0449)	(0.0506)
Observations	20359	20359	20359	15827
R-squared	0.031	0.014	0.031	0.016

	ln TFP (Olley Pakes)			
Panel C	1c	2c	3c	4c
Lag Foreign	0.254***	0.168***	0.147***	0.162***
	(0.0471)	(0.0494)	(0.0487)	(0.0494)
Observations	18754	18754	18754	14844
R-squared	0.015	0.007	0.024	0.012

Firm FEs		yes	yes	yes
Industry FEs	yes	yes	yes	yes
Industry trends			yes	yes
Propensity score weighting				yes

Notes: Foreign is an indicator variable that equals one if the firm has at least 50-percent foreign ownership. ln Sales is the natural logarithm of firm's real sales. Ln Labor productivity is the natural logarithm of real value added per worker. Ln TFP (Olley Pakes) is the natural logarithm of total factor productivity, calculated using the approach of Olley and Pakes (1996). The first year the firm appears in the sample is dropped from all regressions. All columns include year fixed effects. Standard errors are clustered by firm.
* indicates 10% significance; ** 5% significance; *** 1% significance.

SUPPLEMENTAL APPENDIX:

Table S1: Productivity Regressions Including Innovation Variables

	ln Value Added	ln Value Added	ln Value Added
	(1)	(2)	(3)
ln Capital	0.0998***	0.106***	0.104***
	(0.0137)	(0.0136)	(0.0243)
ln Labor	0.719***	0.727***	0.774***
	(0.0298)	(0.0295)	(0.0544)
Process Innovation	0.0213***		
	(0.00426)		
Product Innovation		0.0109***	
		(0.00394)	
Assimilation of foreign technologies			0.0692**
			(0.0305)
Firm Fixed Effects	yes	yes	yes
Observations	18806	18806	4982
R-squared	0.265	0.263	0.295

Column 1 presents univariate probit regressions of the Foreign ownership dummy on the set of lagged variables used in the propensity score estimation, on all industries pooled (for the results shown in the paper, we estimate the propensity score by industry, to allow for different coefficients on the included variables). Column 2 presents the multivariate probit regression using the same variables, on all industries pooled. All regressions include industry dummies. The right-hand side variables are highly correlated, so that when we run the multivariate regression many of them become insignificant. Notice that lagged firm sales is the most significant determinant, consistent with our model.In the paper, the propensity score weights are obtained by estimating the multivariate regression for each industry separately. All regressors are balanced in all industries using the set of covariates in Column 2. When we used a more parsimonious specification, with fewer variables, some of the regressors were not balanced across blocks in some industries. These results are shown in Table S3, for a simpler specification of the propensity score.

Table S2: Probit model for propensity score estimation

	Foreign	Foreign
	Univariate	Multivariate
	1	2
Lag ln sales	0.238***	0.178**
	(0.0245)	(0.0904)
Lag labor productivity	0.252***	-0.110
	(0.0619)	(0.0837)
Lag Sales growth	-0.0856	-0.159
	(0.118)	(0.147)
Lag exports	0.500***	0.105
	(0.0890)	(0.108)
Lag average wage	6.11e-07	1.26e-07
	(3.79e-07)	(6.09e-07)
Lag Innovation	0.245***	0.00367
	(0.0747)	(0.0837)
Lag ln capital	0.212***	0.0454
	(0.0216)	(0.0932)
Lag ln capital per worker	0.278***	0.0918
	(0.0388)	(0.0936)
Year		-0.0268***
		(0.00981)
Industry Dummies	yes	yes
Observations	15046	15046
Pseudo R-squared	na	0.14

This Table re-estimates the propensity score regressions in the paper, using a parsimonious specification for the propensity score that only includes Lagged firm sales, Lagged labor productivity and year as controls when calculating the score. The score is again calculated by industry, to allow for differences across industries in the coefficients. In this case, the covariates are not balanced in some industries and blocks, which is why we chose a richer specification for the paper, where all covariates are balanced. However, as can be seen in the table, the results are fairly robust when using this simpler specification for the score.

Table S3: Propensity score estimation when using only Lag Sales and Lag Labor Productivity in the score

	Process Innovation	Product Innovation	Assimilation of Foreign Tech.
Corresponding Col in Paper	Table 3 Col 4a	Table 3 Col 4b	Table 3 Col 4c
Lag Foreign	0.531***	0.152	0.111*
	(0.206)	(0.225)	(0.0619)
Observations	18780	18780	4944
R-squared	0.525	0.384	0.190
	Both (New Machines and Org.)	New Machines	New Organization
	Table 4 Col 4a	Table 4 Col 4b	Table 4 Col 4c
Lag Foreign	0.412**	-0.106	0.225**
	(0.164)	(0.0983)	(0.113)
Observations	18780	18780	18780
R-squared	0.274	0.371	0.148
	ln Sales	ln Labor Productivity	ln TFP
	Table 8 Col 4a	Table 8 Col 4b	Table 4 Col 4c
Lag Foreign	0.112**	0.0744	0.141**
	(0.0555)	(0.0616)	(0.0649)
Observations	18780	18504	17065
R-squared	0.103	0.018	0.017
Firm FEs	yes	yes	yes
Propensity score weighting	yes	yes	yes