Foreign direct investment and incentives to innovate and imitate

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Abstract

We propose a new channel of FDI spillovers on domestic firms in the host country that operates through imitation of original products. We develop a model of heterogeneous firms and allow domestic firms to choose between three alternatives: a) not introduce any new products, b) introduce a new product line (innovate), or c) develop a variety that is a very close substitute to an existing product line developed by another firm (imitate). The presence of foreign firms generates spillovers via increased incentives for imitation, as foreign firms introduce a range of original products that are vertically differentiated with respect to original domestic products. The model generates testable implications that allow us to distinguish empirically between the effects of FDI on true innovation and on imitation. We test the model predictions using firm–level panel data for China and find that, consistent with the model, increased FDI presence in a given industry leads to more imitation, but not necessarily more innovation by domestic firms.

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1 Introduction

The worldwide surge in foreign direct investment (FDI) flows during the past decade has stirred up increasing interest in studying the effects of FDI flows on the performance of domestic firms in host countries. Learning about these effects contributes to the understanding of technological synergies between foreign firms and domestic firms in the processes of innovation, production, and aggregate economic growth. It also provides valuable information to policy makers in deciding whether FDI should be encouraged and foreign firms granted special treatment. The most prominent example is that of China, where a surge of economic growth in the last decade was accompanied by aggressive policies aimed at attracting FDI and a corresponding surge in FDI inflows.

There is a vast body of academic literature that studies, both theoretically and empirically, FDI effects on domestic firms. It can be broadly classified into papers that study pecuniary effects and "demonstration" effects, which we describe briefly below, without attempting to survey it. In this paper we propose a new demonstration channel that operates through vertical differentiation, namely an expansion of the range of quality of product varieties that are available for imitation. We test the empirical relevance of this channel for the case of China, using firm–level survey data, and find empirical support for the predictions of our model.

Pecuniary channels affect the productive capabilities of domestic firms because the entry of multinational firms leads to more severe competition in the host country market. The "competition effect" could be positive, if it provides an incentive for local firms to use their existing resources more efficiently or to search for new technologies, or negative, if local firms suffer a large loss in market share and are not able to keep up technologically, or if their access to inputs and factors of production is restricted.[1]

Demonstration effects of FDI refer to situations in which domestic firms can improve

[1] See Blomstrom and Kokko (1998) for positive competition effects and Aitken and Harrison (1999) for negative competition effects. Hale and Long (2008) provide evidence for negative spillovers in labor markets in China.

their productive efficiency, managerial methods, or product quality, through formal or informal contact with affiliates of foreign firms. Demonstration externalities may take place through different channels, such as direct observation of production processes, hiring workers previously trained by foreign affiliates, and business transactions with foreign suppliers or clients.[2]

We propose an additional channel for FDI spillovers — an expansion in the possibilities of vertical differentiation. We develop a model of heterogeneous firms that differ in their productivity and allow domestic firms to choose between three alternatives: a) not introduce any new products, b) introduce a new product line (innovate), or c) develop a variety that is a very close substitute to an existing product line developed by another firm (imitate). There is a fixed cost associated with each activity and the equilibrium choice depends on the firm's relative productivity. The presence of foreign firms generates spillovers via increased returns on imitation, as foreign firms introduce a range of products that are in some way superior to the products introduced by domestic firms. For the sake of clarity and to isolate imitation effects, we ignore spillovers through changes in innovation, production technology, or other channels identified in the literature. In fact, we find no evidence of spillovers on innovation activity of domestic firms that interact directly with multinationals.

An important feature of our model is that it has empirical implications that allow us to separate innovation and imitation effects of FDI. In particular, we would expect the increase in new product introduction due to FDI to be most prominent for less sophisticated firms that would previously choose not to introduce a new product and now enter the imitation market. This group of firms is likely to increase their R&D expenditures because some R&D is required for imitation. More sophisticated firms, on the other hand, will continue to introduce new products as they did before, but some of them will choose to switch from true innovation to imitation, thus reducing their R&D expenditure.

We test whether the predictions of our model are supported by firm–level data from the

[2]See Wang and Blomstrom (1992), for example.

Chinese manufacturing sector. We use a combination of firm surveys that include measures of product introduction, expenditures on R&D, and firm characteristics, and merge these data with measures of foreign presence at the industry level constructed from manufacturing census. China presents a perfect case study to analyze this empirical question, because it received enormous inflows of FDI and, especially, of R&D FDI in the past decade (Huggins, Demirbag, and Ratcheva, 2007).

We find that a higher proportion of FDI in the industry is associated with higher frequency of new product introduction by domestic firms in the same industry. Moreover, we find two sets of results that support the imitation hypothesis. First, we find that medium–sized, less advanced firms (those with small market share, those that do not export, have unsophisticated labor force, low capital intensity, no imported machinery, and no certified products) experience an increase in the frequency of new product introduction in the presence of FDI, while other firms do not. We also find support for our assumptions that some R&D is necessary to benefit from FDI in terms of new product introduction, but at the same time it is the less sophisticated firms (as measured by the ratio of R&D scientists versus less qualified R&D workers) that benefit more. Second, we find that firms that are not involved in business transactions with multinationals (i.e. that are not clients or suppliers) are more likely to experience positive spillovers in new product introduction from FDI presence in the same industry, suggesting that relationship with multinationals may preclude firms from imitation activity or otherwise lower an incentive to imitate.

The majority of existing empirical studies focus on productivity of local firms, generally defined as total factor productivity and estimated as the residual term in a production function regression. Their results are mixed. In general, positive spillovers are found for developed countries, whereas results are less conclusive in the case of developing economies and seem to favor spillovers taking place through contacts between multinationals and their local suppliers rather than between firms that compete in the same industry.[3] Given

[3]Haskel, Pereira, and Slaughter (2002) consider the case of the U.K., Keller and Yeaple (2003) the U.S., and Peri and D. (2004) Italy and Germany. Haddad and Harrison (1993), Aitken and Harrison (1999), and

the nature of the data and methodology of these studies, it is generally not possible to distinguish between spillovers that materialize through productive efficiency or through improvements in product quality (see Klette and Z. (1996) and Katayama, Lu, and Tybout (2003) for a discussion of general problems with separating between demand–side factors and technology in the estimation of TFP. Bloom, Van Reenan, and Schankerman (2005) discuss the identification of competition effects and technology spillovers from FDI). Our study of the introduction of new varieties has a more straightforward interpretation in that it focuses on measures that are less subject to omitted variable bias.

Studies on innovation and R&D, on the other hand, frequently use measures of patent applications, R&D expenditures and new product introduction as proxies for innovation. The problem is that imitation also requires some R&D, although less than innovation, and that from the firm's point of view an imitation of an existing product produced by another firm is a new product in their product line. Thus, imitation may be mistakenly counted as innovation in empirical analysis, which could lead to inconclusive empirical results with respect to the effect of FDI on innovation (Schneider, 2005). While, like other papers, we do not have separate explicit measures of imitation and innovation, our model allows us to differentiate the effects of FDI on these activities. Specifically, our model shows that the total amount of R&D expenditure by domestic firms is likely to go down or remain the same, while the number of "new" products will increase when the presence of multinationals increases. This is because some firms will switch from true innovation to imitation activity, which requires less R&D, while other firms that did not introduce any new products before would now choose to do so through imitation.

Our ability to distinguish between the effects of introducing new products through innovation versus imitation speaks indirectly to potential effects of FDI on long–run growth. The endogenous growth literature (Romer, 1990) emphasizes the importance of technological

Djankov and Hoekman (2000) do not find positive horizontal spillovers in Morocco, Venezuela and the Czech Republic. While positive vertical spillovers are found by Javorcik (2004) for the case of Lithuania, by Schoors and van der Tol (2001) on Hungary, and by Alfaro and Rodriguez-Clare (2004) on Brazil, Chile, Mexico and Venezuela.

innovation for economic growth, while North–South models such as Grossman and Helpman (1991) focus on technology transfer that allows more backward countries to catch up to the frontier. While true innovation is undoubtedly growth–enhancing, imitation of the new products might not have any long–run growth effects and might in fact lead to negative consequences if copyright infringement is involved. The difference between long–run benefits of innovation and the lack of such benefits from imitation, when technology is transferred via FDI, is demonstrated by Glass and Saggi (1999). Moreover, as Lai (1998) points out, depending on whether technology is transferred through innovation or through imitation, intellectual property rights protection might have opposite effects on wage in the catching–up country.

The remainder of this paper is organized as follows. Section 2 presents the model. Section 3 describes the empirical implications, data, and estimation set-up. Section 4 discusses the empirical results. Section 5 concludes.

2 Model

The purpose of this section is to describe demand–related channels for spillovers from foreign firms to domestic firms in the decision to introduce new products. The channel that we describe is related to consumers' preferences and thus requires structure on the utility function. We start by describing a benchmark model, with a nested CES utility function, and later add to the analysis goods produced by foreign firms.

Our model differs from traditional North-South models of technology transfer (Branstetter, Fisman, Foley, and Saggi, 2007; Helpman, 1993; Lai, 1998; Parello, 2008) in that in our model firms in the South may also choose to innovate. Also, unlike Glass and Saggi (2002a) and Glass and Wu (2007), we do not consider the feedback from imitation to the innovative activities of the foreign firms or to FDI and only focus on the choices faced by domestic private firms in the FDI-target country. We also do not consider potential substitution between imitation that arises as a result of FDI and as a result of trade (Latzer, 2006). We simply take trade–induced imitation as given and consider an incremental effect of an increase in FDI. In addition, unlike Glass and Saggi (1998), we do not distinguish between FDI of different quality but assume it to be homogeneous.

2.1 Benchmark model

The model is static and contemplates only one time period. The decision to introduce new products is modeled as a decision to upgrade quality. When firms enter the market, they are "assigned" a baseline–quality differentiated variety. By paying fixed costs of R&D, firms can choose to upgrade their variety to a higher–quality one, either by creating a new product or by imitating an existing product, as explained in more detail below.

There are $N+1$ composite products available to consumers and indexed by i, from 0 to N. Utility can be written in discrete form as

$$U = \left(\sum_{i=0}^{N} Q_i^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{1}$$

where $\theta > 1$ is the elasticity of substitution. Each product i is a composition of n_i varieties of different quality γ indexed by v that are aggregated with constant elasticity of substitution as well. All baseline–quality varieties (with γ normalized to one) are grouped in product "zero," which is defined as

$$Q_0 = \underbrace{\left(\sum_{v=1}^{n_0} q_v^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}}_{\text{baseline varieties}} \tag{2}$$

The parameter σ satisfies the restriction $\sigma > \theta > 1$, so that elasticity of substitution between varieties of the same product is larger than elasticity of substitution across products.

All other products indexed $i > 0$ are compositions of upgraded, higher–quality, varieties defined as

$$Q_i = \left(\gamma_2 q_{\text{original}}^{\frac{\sigma-1}{\sigma}} + \underbrace{\sum_{v=2}^{n_i} \gamma_1 q_v^{\frac{\sigma-1}{\sigma}}}_{\text{imitations}} \right)^{\frac{\sigma}{\sigma-1}} \quad ; \; i = 1...N \tag{3}$$

Here we distinguish between two types of varieties: the original variety and the imitations (indexed from 2 to n_i). Consumers value original varieties above imitations, which in turn are valued above baseline–quality varieties in group zero, i.e. $\gamma_2 > \gamma_1 > 1$.[4] We can derive the demand for variety v as a function of its own price and quality (γ), the quality–corrected group price index, the overall price index, and exogenous income (see the appendix for equations for the price indexes and demand function).

On the supply side, firms are heterogeneous as in Melitz (2003), with an exogenous distribution of production costs per unit ($1/\psi$). There is a fixed number of firms, M, that enter the market at the same time and learn their unit production cost (or inverse productivity) upon entry. To keep the model simple, we do not allow entry by domestic firms during the time period modeled. The number of firms in the end of the period, however, is endogenous, due to exit of the least productive firms.[5]

Each firm produces only one variety. Once they have learnt their productivity ψ, firms can choose to either exit, stay and produce the existing baseline–quality assigned variety (paying a fixed cost of production F_0), stay and imitate an existing higher–quality variety (paying $F_0 + F_1$), or stay and create an original higher–quality product line (paying $F_0 + F_2$, with $F_2 > F_1$).

Firms that choose to imitate are randomly assigned to a product group in the range

[4]This assumption can also be interpreted as a static short–hand for a dynamic model in which the producer of the original variety enjoys one period of monopoly profits before imitations become available. It can also be interpreted as additional value that consumers attach to brand–name products.

[5]One way to think about the "no entry" assumption, is to assume that in a dynamic version of the model each new firm has to spend one period producing a standard–quality product zero. Allowing entry into this category would not change the implications of the model. For simplicity, we assume that there is no entry at all.

$i > 0$. In equilibrium, there are n_0 firms that choose not to upgrade and produce the baseline–quality varieties in product zero; there are N firms that create an original higher–quality product line $i > 0$; and there are $N * (n-1)$ firms, randomly assigned across groups $i > 0$, that upgrade by imitation. The random assignment to product groups implies that in equilibrium the distribution of imitators is the same across product groups (with the exception of group zero, where by definition there are no imitators).

We make the standard monopolistic competition assumption that firms compete in prices and are small relative to the market. To simplify matters we further assume that the number of groups is small relative to the number of firms, so that each firm, including the innovator, is small within a given group.[6] In practice, this assumption means that the price of one firm exerts no influence on the market price index and on the group price index and it yields the standard constant mark–up result $p_v = \frac{\sigma}{\sigma-1}\frac{1}{\psi_v}$.

Given the optimal price decision above, we can solve the firm problem backwards and find the optimal decision for production, imitation and innovation. For this purpose we need to be able to compare total profits under four alternatives: exit, no upgrades (denoted by 0), imitation (denoted by 1) and innovation (denoted by 2). Firms that choose to exit earn zero profits. To find profits (optimized over prices) of the alternatives that imply staying in the market, we plug the price solution into the variable profit function and subtract the fixed costs of production, imitation or innovation. Let those profits be denoted by V_0, V_1 and V_2, defined as

$$\begin{aligned}
V_0(\psi) &= k\psi^{\sigma} P_0^{\sigma-\theta}\Pi^{\theta-1} - F_0 && \text{no upgrades} \\
V_1(\psi) &= k\gamma_1^{\sigma}\psi^{\sigma} P^{\sigma-\theta}\Pi^{\theta-1} - F_0 - F_1 && \text{imitation} \\
V_2(\psi) &= k\gamma_2^{\sigma}\psi^{\sigma} P^{\sigma-\theta}\Pi^{\theta-1} - F_0 - F_2 && \text{innovation}
\end{aligned} \tag{4}$$

with $k = \frac{(\sigma-1)^{\sigma-1}}{\sigma^{\sigma}}y$. The variables P_0, P, Π and y are the group price index for product

[6] The number of groups is an endogenous variable. The primitive assumption is that the fixed cost of creating an original product line is sufficiently high.

zero, the group price index for all other products, the overall price index, and the exogenous nominal income. [7] See the appendix for the definition of the group and overall price indexes.

The options to exit, produce at baseline–quality, imitate or innovate imply incurring different fixed costs and earning variable profits that are increasing in the productivity level ψ. The result is a sorting on ψ as in Melitz (2003) and Helpman, Melitz, and Yeaple (2004).[8] Intuitively, the higher quality options have higher fixed costs and yield higher variable profits. As productivity increases, firms expand sales and take advantage of higher variable profits more easily. Thus, firms with highest productivity will profit from the highest fixed–cost option.

We can define cutoff values of productivity ψ that allow us to sort firms according to their choices. We denote those cutoffs by ψ_0, ψ_1, and ψ_2. Firms with productivity below ψ_0 choose to exit; firms with productivity between ψ_0 and ψ_1 keep the default baseline–quality; firms with productivity between ψ_1 and ψ_2 upgrade by imitation and get randomly assigned to a group $i > 0$; finally, firms with productivity above ψ_2 upgrade by innovation.[9] The cutoffs are analytically defined as $V_0(\psi_0) = 0$, $V_1(\psi_1) = V_0(\psi_1)$, $V_2(\psi_2) = V_1(\psi_2)$; and yield

[7] Technically the price index for groups $i > 0$ is not the same across groups because of differences in productivity, and equilibrium prices, across innovators (the distribution of imitators, on the other hand, is the same across groups if the number of firms is large enough). Since by assumption all firms are small, including the innovators, the contribution of the innovators to the group price indexes are negligible and can be disregarded, which means that price indexes are approximately the same across groups. Alternatively, we could define P as the expected price index before an imitator is assigned to a group ($P = E(P_i|i > 0)$. The former assumption, however, will make the algebra much more tractable in the case with foreign firms that we discuss in the next subsection.

[8] It is possible to add more dimensions of firm heterogeneity such as efficiency in R&D or in quality provision as in Brambilla (2007), Hallak and Sivadasan (2006), and Kugler and Verhoogen (2008). In this particular setting, however, given that we focus on demand channels for spillovers, a richer description of the technology would not add to the analysis.

[9] Some assumptions on the model primitives are needed to obtain a positive number of firms in each group (Melitz, 2003; Helpman, Melitz, and Yeaple, 2004).

the results

$$\psi_0 = \left(\frac{F_0}{kP_0^{\sigma-\theta}\Pi^{\theta-1}}\right)^{1/\sigma} \tag{5}$$

$$\psi_1 = \left(\frac{F_1}{k\Pi^{\theta-1}(P^{\sigma-\theta}\gamma_1^{\sigma} - P_0^{\sigma-\theta})}\right)^{1/\sigma} \tag{6}$$

$$\psi_2 = \left(\frac{F_2 - F_1}{kP^{\sigma-\theta}\Pi^{\theta-1}(\gamma_2^{\sigma} - \gamma_1^{\sigma})}\right)^{1/\sigma}. \tag{7}$$

The system of equations (5)-(7), together with the definitions of the price indexes (see appendix) can be solved to obtain the equilibrium cutoffs and price indexes. The total number of original products is given by $N = (1 - G(\psi_2)) * M$.

Figure 1 depicts the equilibrium. Net profits from each alternative are plotted as a function of productivity. The solid dots denote the productivity cutoffs. Firms between the origin and the first dot choose to exit; firms between the first two dots stay and do not introduce upgrades; firms between the second two dots imitate; and firms above the third dot innovate. The sorting occurs because the options with the higher fixed costs (measured in the vertical axis) are at the same time the options with higher gross profits per unit (measured by the slope of V).

2.2 Foreign firms

We now introduce foreign firms into the model. Foreign firms are also heterogeneous. There is an exogenously given number M^* of foreign firms that take a productivity draw before making production and innovation decisions. For simplicity we consider a symmetric case where the productivity distribution of foreign firms is the same as domestic firms, and where the fixed costs of production and innovation are also symmetric. We further assume that foreign firms enter the domestic market if and only if they innovate. As a result, we have a number $N^* = (1 - G(\psi_2))\, M^*$ of foreign firms that enter the domestic market and introduce N^* original innovations. Since firms are symmetric, the fraction of original innovations that are of foreign origin is given by $\frac{M^*}{M+M^*}$.

The product lines introduced by foreign firms are vertically differentiated from the product lines introduced by domestic firms. Anecdotal evidence suggests that multinationals are often associated with the production of higher quality goods. Additionally, multinationals often have significant brand–name recognition. Further, they usually spend significant amounts on advertising. Our assumption is that consumers value product groups introduced by multinationals more highly than product lines introduced by domestic firms—by a factor of $\delta > 1$. We also assume that the higher consumer valuation spills over to the imitators in the same group. Advertising could be one channel for valuation spillovers. When foreign firms advertise their own variety, consumers also become more aware of the varieties in the same product group. This valuation spillover raises the profitability of imitation relative to no upgrades and to innovation.

Domestic firms have the same choices as in the benchmark case with no foreign firms: exit, produce a baseline-quality variety in group zero, imitate a high-quality product, or introduce an original high-quality product. Imitators get randomly assigned to product groups, with a probability $\frac{M^*}{M+M^*}$ of being assigned to a group of foreign origin. The profits of not upgrading, imitation, and innovation can be redefined as

$$
\begin{aligned}
V_0(\psi) &= k\psi^\sigma P_0^{\sigma-\theta}\widetilde{\Pi}^{\theta-1} - F_0 \\
V_1(\psi) &= k\gamma_1^\sigma\psi^\sigma P^{\sigma-\theta}\widetilde{\Pi}^{\theta-1} f\left(\tfrac{M^*}{M}\right) - F_0 - F_1 \\
V_2(\psi) &= k\gamma_2^\sigma\psi^\sigma P^{\sigma-\theta}\widetilde{\Pi}^{\theta-1} - F_0 - F_2
\end{aligned}
\tag{8}
$$

with $f\left(\frac{M^*}{M}\right) = \frac{M+\delta^{\left(\sigma\frac{\theta-1}{\sigma-1}\right)}M^*}{M+M^*}$.

The presence of foreign firms affects the profitability of domestic firms through three channels. First, the main spillover channel is an increase in the valuation of the domestic varieties introduced by firms that imitate products of foreign origin, from γ_1 to $\delta\gamma_1$. This implies an increase in expected benefits from imitation. At the same time, we have that the higher consumer valuation brings down the price index in foreign groups, which acts in the opposite direction, reducing expected profits. The net effect is positive. Algebraically, the net increase in expected profits from innovation is captured by the term $f\left(\frac{M^*}{M}\right)$, which depends positively on the share of foreign firms in the total number of firms.

Second, the overall price index is affected by vertical differentiation. A fraction $M^*/(M+M^*)$ of the upgraded product groups (those of foreign origin) are vertically differentiated by a factor δ. The overall price index Π, is redefined taking the vertical differentiation given by δ into consideration; we change the notation to $\widetilde{\Pi}$ to emphasize that its definition has changed (see appendix). The new price index $\widetilde{\Pi}$ is lower than the price index without foreign firms (due to the increase in consumer valuation), which implies a decrease in profits for the three alternatives (no upgrades, imitation, and innovation).

Summing up, we have that the three alternatives (no upgrades, imitation, and innovation) become less profitable relative to exit, because of a decrease in the overall price index. In addition, we have that the relative profitability of imitation goes up because of the probability of being assigned to a higher valuation group. It can be shown that the net effect on the profits from imitation is positive.[10] As a result, we find that as the ratio of foreign firms (M^*/M) increases, the cutoffs ψ_0 and ψ_2 increase, while ψ_1 decreases.

Finally, there is a second order effect whereby all price indexes change due to changes in the cutoffs ψ_0, ψ_1 and ψ_2. In fact, price indexes and cutoffs are jointly determined in equilibrium.

Figure 2 depicts an increase in M^*/M. The slopes of V_0 and V_2 decrease, reflecting the negative effect of the overall price index. These two options become relatively less profitable. At the same time, the slope of V_1 increases due to the positive consumer valuation effect that dominates the negative group price index effect and overall price index effect. As a result, we find that the range of firms that chooses to imitate increases at the expense of firms that innovate, but also at the expense of firms that were not introducing upgrades before—the cutoffs ψ_2 and ψ_1 move to the right and left respectively. There is also an increase in exit.

[10] Calculations are available upon request.

What does an increase in the share of foreign product lines mean in terms of introduction of new varieties and in terms of innovation? While there is a *decrease* in domestic original innovation, there is an *increase* in the introduction of new varieties and upgrading activity, due to imitation. The increase in imitation absorbs firms that switch from innovation and also firms that were not upgrading before, thus, the net (unweighted) increase in the number of varieties is positive. Firms that benefit more from the presence of foreign firms are those in the middle of the distribution, because they can take advantage of the increased profits from imitation. Firms that are on the upper-tail of the productivity distribution, are 'too sophisticated' and their choices to innovate are not affected by foreign firms (even though their profits go down).[11] Firms that are on the lower tail of the distribution are 'not sophisticated enough' to take advantage of the increased imitation opportunities; they cannot afford to pay the fixed costs of imitation. These observations will be useful in our empirical analysis to which we now turn.

3 Empirical specification

Our model predicts that as more foreign firms enter and introduce new products available for imitation, more domestic firms that did not choose to introduce new products before will now choose to imitate, while some of the firms that chose to introduce new products (innovate), will now choose instead to imitate existing product. This is because the return to innovation falls while return to imitation increases. Overall, with a larger foreign presence, we would expect that more firms introduce new products of some kind, and that this overall increase comes from less productive firms that did not introduce new products in the past. Further, if we interpret the difference between fixed costs of each option as additional R&D required, an increase in the number of foreign firms and product groups would lead to an increase in R&D expenditures for firms that did not introduce any new products before and to a decline in R&D expenditures for firms that switch from innovation to imitation. Thus,

[11] We assume $\delta\gamma_1 < \gamma_2$.

the effect of increased FDI presence on average R&D expenditure is ambiguous.

We test the predictions of the model using a combination of firm–level surveys with census data on prevalence of foreign firms by industry, as described below. We use the richness of the survey data to analyze various types of firms and distinguish between the effects of FDI on imitation and innovation activity by domestic firms.

3.1 Data

Before turning to our regression specification, we briefly describe our data. We use a combination of two sources of data. At the firm level, we use data from the World Bank's 2001 and 2003 Investment Climate Surveys. A total of 1500 firms were interviewed during the first survey, in 2001, in five Chinese cities. The second survey was run in 2003 and included 2400 firms in eighteen different cities.[12] The surveys are stratified random samples at the industry level. Of the total number of surveyed firms, 2474 correspond to 47 four digit level industries in the manufacturing sector, while the remaining 1426 firms correspond to Services. The 47 manufacturing industries can be categorized in 7 different groups: Apparel and Leather Goods, Household Appliances, Electronic Equipment, Electronic Components, Vehicles and Vehicle Parts, Metallurgical Products, Food Processing, and Chemical, Bio-tech and Medicine.[13] We work with private domestic firms in the manufacturing sector, which accounts for 1055 firms.

The surveys include data on inputs, output, exports, introduction of new goods, expenditure in R&D, suppliers, competitors, market environment, ownership structure, characteristics of the labor force, use of technology, and interaction with foreign firms located in China. Firms were interviewed only once, but they provided yearly information on many of the accounting variables for a three year period. Firms in the first survey were interviewed

[12]The first survey was run in the cities of Beijing, Tianjin, Shanghai, Guangzhou and Chengdu; while the second survey included firms in Benxi, Changchun, Changsha, Chongqing, Dalian, Guiyang, Haerbin, Hargzhou, Jiangmen, Knuming, Lanzhou, Nanchang, Nanning, Shenzhen, Wenzhou, Wuhan, Xian and Zhengzhou.

[13]Some of the 47 industries were not included in the first survey.

in 2001 and provided information for the years 1998-2000; while firms in the second survey were interviewed in 2003 and their data correspond to 2000-2002. In practice, each survey is a retrospective panel.

The main survey variable that describes the creation of product variety is a binary variable that indicates whether a firm introduced any new product in a given year. As defined in the survey, a new product is a variety that was not previously produced by a given firm, independently of whether a similar variety already existed in the market.[14] The definition of what constitutes a new variety is essentially subjective to the firm; it can refer to a new production line or to the refurbishing of an existing product. However, this subjectivity will not bias the results as long as it is uncorrelated with foreign presence in each industry.

Our second data set includes information on presence of foreign firms at the industry level. We define foreign presence as the share of foreign firms in total industry output, where foreign firms are weighted by their percentage of foreign ownership. The output data have been collected by the Chinese National Bureau of Statistics (NBS) at the firm level and then aggregated up to 600 industries, based on the 4 digit Chinese Industrial Classification. Our sample covers the period 1998 to 2001.[15]

The first and second sources of data can be matched at the industry level. Since we have no foreign-firm output data available for the year 2002, the last year of the 2003 firm survey is not exploited in the analysis. We work with 1055 private domestic firms, which belong to 47 4-digit level manufacturing sectors. We have three years of data for firms in the first survey (1998-2000) and two years of data for firms in the second survey (2000-2001).

This combination of firm-level and industry-level data allows for a rich economic analysis. The firm survey provides information on firm characteristics that are not available in studies that use census data. The industry data allows for consistent and precise measures of foreign

[14] In addition to the binary variable, the surveys provide information on the total number of goods introduced. Unfortunately, firms only report the total number of goods introduced over the whole survey period instead of on a yearly basis. The binary variable, on the other hand, is reported on a yearly basis and thus allows us to exploit the panel nature of the data, which is crucial for our analysis.

[15] We are grateful to Mary Amiti and Beata Javorcik, who generously provided these data. See Amiti and Javorcik (2008) for a more detailed description of the data source and measures.

presence, as the variables are constructed from large samples of firms that are representative of the manufacturing sector. Most studies of the effects of FDI on domestic firms are based either on firm surveys from which both the firm–level variables and the composition of the industry are derived or by census–like data which does not contain much information about the firms.

3.2 Estimation strategy

In order to focus on the effects of presence of foreign firms on domestic firms in the same industry, we estimate variations of equations of the following general form over the sample of domestic firms

$$y_{ijt} = \alpha_i + \alpha_t + \beta\, FOR_{jt} + \mathbf{x}'_{ijt}\gamma + \varepsilon_{ijt}, \tag{9}$$

where i denotes firms, j industries, and t time. In the main specifications, the dependent variable y_{ijt} indicates whether firm i in industry j introduced a new product variety during year t. In alternative specifications, y_{ijt} measures expenditure in R&D divided by total sales. The variable FOR_{jt} is defined as the share of foreign firms in total output in industry j, and, thus, β is the coefficient of interest in our empirical analysis.

As controls, we include firm–level characteristics ($\mathbf{x}_{ijt}$), a set of firm fixed effects (α_i) and year effects (α_t). By including firm fixed effects in the estimation, we identify results through within–firm variations in exposure to foreign firms and the output variable y (introduction of new products or expenditure in R&D), which is crucial and serves two purposes. First, foreign firms are arguably attracted to industries of certain characteristics, which are not observed in the data but could be correlated to the propensity of domestic firms in the industry to introduce new products, thus creating issues of reverse causality. By including firm fixed effects, we control for time-invariant industry characteristics and avoid the problem of endogeneity of FDI. Second, firm fixed effects address the potential change in firm composition within industry: If a given industry is undergoing an evolution which results in both attracting FDI and in increasing the weight of firms that introduce new products, we may find spurious effects. With firm fixed effects the composition is a non–issue because the effect is identified by a within–firm variation.

The fixed effects control for time–invariant firm heterogeneity, but firm behavior may follow different trends according to different initial conditions. To address potential time-varying firm heterogeneity, we include in the vector $\mathbf{x}_{ijt}$ interactions between initial conditions and trends. In particular, we interact a linear trend with the ratio of the number of R&D workers to the total number of skilled workers, with the share of non-production workers in the labor force, as well as with a dummy variable that indicates whether the average education level of production workers is middle school or high school.

We restrict our sample to private firms that are 100 percent domestically owned, because we are interested in the effect of foreign capital inflows on domestic firms and because state-owned enterprises may have different incentives to innovate (Cheung, 2007). We cluster the standard errors at the industry level (Moulton, 1990).

It could be argued that equation (9) can be modeled using non-linear specifications such as probit in the case of introduction of new goods, and tobit in the case of expenditure on R&D. However, firm fixed effects cannot be differenced out in probit and tobit specifications and they create a problem of incidental parameters that invalidates estimates of all coefficients. We adopt a linear specification that allows us to deal with unobserved heterogeneity.[16]

4 Estimation results

Table 1 reports the results of our basic regressions for the effects of FDI presence on new product introduction and on R&D expenditures. In all specifications we include firm and

[16]It is in principle possible to difference out fixed effects using a conditional logit. This estimator, however, relies only on observations in which there is a "switch" in the dependent variable (from 0 to 1, or from 1 to 0). Given our relatively small sample size, it is very costly to lose the valuable information provided by "non-switchers" and the estimates obtained with this method are too imprecise.

year fixed effects. We control for non–parallel trends across firms by including interactions of a linear trend with three different labor quality variables as described above, but do not find statistically significant differences between trends.

The top panel of Table 1 presents the results of regressions where the dependent variable is an indicator of whether a firm introduced a new product in year t. We can see that in all specifications an increase in foreign presence is associated with an increase in the probability of introducing a new good, as we would expect from our model.

The bottom panel of Table 1 presents the results of regressions where the dependent variable is the ratio of R&D expenditures to sales. We fail to find any effect of foreign presence on this variable, regardless of specification used. This failure to find an effect in the full sample is, however, consistent with the predictions of our model: some firms switch from true innovation to imitation and introduce "new" products that are simply copies of those produced by other, in particular foreign, firms and thus lower their R&D expenditures, while other firms that did not introduce new products before now increase their R&D expenditures in order to start imitating.

We next turn to analyzing how the effect of FDI presence on new product introduction differs across firms of different types. Tables 2 and 3 present our results with respect to firm size measured as number of employees or as market share, and firm's exporting status. In Table 2 the dependent variable is new product introduction, while in Table 3 it is R&D expenditures.

In the top panel we split our sample into small, medium and large firms according to their number of employees (below 50, between 50 and 150, and above 150). We find that the effect of FDI presence on new product introduction is *only* present in medium–sized firms. This, again, is consistent with our model: While the largest firms always introduce new products, the increase in FDI presence will likely make them partially switch from innovation to imitation, but not necessarily increase the frequency of product introduction. The smallest firms might be too small to even afford the expense of imitating. The medium firms, however, who would not be able to innovate, now find it easier to introduce new products when imitation is possible, thus an increase in FDI presence in their sector is likely to increase the frequency of new product introduction in these domestic firms. We also note that the magnitude of the effect more than doubles when the sample is not diluted by the firms which do not experience the effect of FDI presence (compared to the results for the full sample reported in Table 1.

The middle panel reports the results separately for firms with small and with large market shares. We find, again consistent with our model, that the effect of FDI presence on product introduction is fully concentrated in small firms — those with less than 5% market share (self–declared in the survey). The intuition for this result is that firms with market power (high market share) can benefit from innovation whether or not they compete with foreign firms in their industry, while firms without market power would not choose to innovate, but would increase their propensity to introduce new products through imitation when FDI presence is higher.

The bottom panel reports the results separately for firms that do and that do not export (self–reported in the survey and cross–checked with another survey entry on the share of foreign sales). We find that the increase in product introduction due to FDI presence is concentrated among non–exporters. This is consistent with the imitation effect of FDI that we conjectured, because exporters are bound by reputation and international agreements on foreign markets and cannot as easily get away with imitation.[17]

Results of the same analysis for the changes in R&D expenses that resulted from changes in FDI in our sub–samples are reported in Table 3. As in Table 1, we do not find any effect of FDI presence on R&D expenditures of domestic firms, regardless of specification. Taken together with results of Table 2, these results support our hypothesis that FDI presence leads to increase in product introduction mainly through an increase in imitation activity and not through innovation, because increased innovation would require higher R&D expenditures.

[17]Everyone knows that Chinese pirated goods are much easier to get in China.

To further distinguish between innovation and imitation effects of FDI presence, in Table 4 we report the results of our regressions of product introduction for firms with different relationships with foreign firms. The survey asks firms many questions about the nature of relationship the firm has with foreign firms. There are, however, many missing values, which limits our sample substantially. Nevertheless, we consistently find that firms that *do not* have relationships with foreign firms are more likely to introduce new products when FDI presence is higher. This result would be inconsistent with the technology transfer hypothesis in which foreign firms make it easier for domestic firms to innovate, because in this case firms with closer ties to foreign firms would be more likely to benefit. This result, however, is quite consistent with the imitation hypothesis — firms that produce or design goods or materials for foreign firms or use their parts would be more hesitant to imitate, fearing repercussions, while firms without such ties find it beneficial to imitate products brought in by FDI.

Next, we look at labor and capital characteristics of firms that are more likely to introduce new products when FDI presence in their sector increases. In Table 5 we show that the effect of FDI on new product introduction is concentrated among less sophisticated firms, which is consistent with our model of imitation effects. In particular, firms with lower share of technical and management personnel (non–production workers), with lower education level of production workers, with lower capital/labor ratio, and without imported machinery increase the probability of introducing new products when FDI presence increases, while other firms do not.

Another way to look at the sophistication of firms is to look at their R&D expenses and the quality of their products. Table 6 reports the results, with dependent variable, again, being the indicator of new products introduction. We find that only for the sub-sample of medium–sized firms, positive R&D expenses are associated with the increase in new product introduction as a result of higher FDI presence. This is consistent with the conjecture that even imitation requires some R&D expenditure. We find, however, in the third panel, that firms with lower share of R&D scientists to R&D workers increase new product introduction as a result of increase in FDI, while firms with a lot of R&D scientists do not. Furthermore, firms without ISO9000 certified products increase the probability of introducing new products in face of higher FDI presence, while firms that have ISO9000 certification do not. These results once again confirm our hypothesis that the new product introduction brought about by higher FDI is not due to true innovation but is driven by increased imitation of existing products.

Our empirical findings are consistent with Girma, Gong, and Görg (2006) who find on average negative effect of FDI on new product introduction by state–owned enterprized (SOEs) in China. However, in contrast to our results, they find that firms that export and are in general more sophisticated, experience positive effects. Most likely, the differences are due to the fact that we include firm fixed effects while Girma, Gong, and Görg (2006) only include industry and region fixed effect. Moreover, we focus on the sample of private firms, while they consider only SOEs. In that respect, our study is complementary to theirs. Our findings are also consistent with those in Buckley, Clegg, and Wang (2002), who, using a large industry–level cross–section, find that higher FDI positively affects new product introduction.

Our findings are at odds with those of Connolly (1998), who does not find any effect of FDI on innovation or imitation by domestic firms in a multi–country panel. This difference could be due to a country–level nature of her study, to the difference in time period considered, or to the difference in choice of variables to proxy for imitation and innovation activity. Our findings are also inconsistent with those in Cheung and Lin (2004), who find positive effect of FDI on the number of domestic patent applications in China. Due to provincial level of their data, however, their results are likely to be biased upwards (Hale and Long, 2007). In fact, when we estimate the relationship between FDI and patent application in our firm–level data, we find no positive effects.[18]

In addition, while we do not find positive effects of FDI presence on R&D in domestic

[18]These results are not reported in the interest of clarity and space but are available from the authors upon request.

firms, our story is consistent with Erdilek (2005), who finds that such effects are positive in Turkey.

5 Conclusion

As Zhao and Zhang (2007) point out, "China can become a global industrial power only if it succeeds in upgrading industry and domestic innovation." In this paper we show that recent surge in FDI flows to China is not a likely source of upgrading in China's domestic innovation activity. Rather, by making a playing field for new ideas more competitive and at the same time making product imitation more attractive, FDI presence is likely to lower incentives for true innovation and increase incentives for imitation. Moreover, our empirical results suggest that imitation technology, while requiring some R&D expense, is not contributing to "industry upgrading" in that less sophisticated firms are found to increase the frequency of new (to them) product introduction when FDI presence in their sector rises.

Two disclaimers are in order here. One is that in no way do we claim that China's domestic industry is not undergoing upgrading. All we can say in this paper is that FDI inflows are not likely contributing to it. The other is that in this paper we focused squarely on the effects of FDI on *domestic* firms and did not analyze the impact of foreign investment on innovation activity of target firms. As the model in Glass and Saggi (2002b) demonstrates and existing empirical studies of this question show, target firms may increase their innovation activity when foreign firms invest into them.

Appendix: price indexes

In this appendix we present more details on the computation of price indexes. Other recent papers using a nested CES framework are Allanson and Montagna (2005), Agur (2007), and Arkolakis and Muendler (2007).

Given the utility specification, the demand function for a product variety q_v within product i is given by

$$q_v = \gamma_v^\sigma \left(\frac{p_v}{P_i}\right)^{-\sigma} \left(\frac{P_i}{\Pi}\right)^{-\theta} \frac{y}{\Pi} \tag{10}$$

where y is exogenously given nominal income, and P_i and P are the product and overall price indexes defined as

$$P_i = \left(\sum_{v=1}^{n_i} \gamma_v^\sigma p_v^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \tag{11}$$

and

$$\Pi = \left(\sum_{i=0}^{N} P_i^{1-\theta}\right)^{\frac{1}{1-\theta}} \tag{12}$$

On the supply side firms choose prices to maximize the function $\left(p_v - \frac{1}{\psi_v}\right) q(p_v, P_i, \Pi)$ which yields the optimal price $p_v = \frac{\sigma}{\sigma-1}\frac{1}{\psi_v}$. Plugging the equilibrium price into the demand equation we get the equilibrium quantity $q_v = \left(\frac{\sigma-1}{\sigma}\gamma_v\psi_v\right)^\sigma P_i^{\sigma-\theta}\Pi^{\theta-1}y$ and variable profits

$$\pi_v = \frac{(\sigma-1)^{\sigma-1}}{\sigma^\sigma}\gamma_v^\sigma\psi_v^\sigma P_i^{\sigma-\theta}\Pi^{\theta-1}y = k\gamma_v^\sigma\psi_v^\sigma P_i^{\sigma-\theta}\Pi^{\theta-1}. \tag{13}$$

The group price index P_i varies because of two reasons: differences in quality and differences in the distribution of prices across groups. To see this more clearly we can write the price index for each group as a function of the distribution of probabilities. Let us start with group zero

$$P_0 = \frac{\sigma}{\sigma-1}\left(\sum_{v=1}^{n_0} \psi_v^{\sigma-1}\right)^{\frac{1}{1-\sigma}} \tag{14}$$

Dividing and multiplying by the number of firms (M) within the parenthesis, and if M is large enough, the sum approximates an integral

$$P_0 = \frac{\sigma}{\sigma - 1} M^{\frac{1}{1-\sigma}} \left(\int_{\psi_0}^{\psi_1} \psi^{\sigma-1} dG(\psi) \right)^{\frac{1}{1-\sigma}} \tag{15}$$

where G is the distribution of productivities ψ and M is the total number of firms that enter the market, including those that exit.

The price index of product $i \neq 0$ involves two types of firms: one innovator (which produces the original variety of the product group) and $n - 1$ imitators

$$P_i = \frac{\sigma}{\sigma - 1} \left(\gamma_2^\sigma \psi_{\text{original}}^{\sigma-1} + \gamma_1^\sigma \sum_{v=2}^{n_i} \psi_v^{\sigma-1} \right)^{\frac{1}{1-\sigma}} \tag{16}$$

which is approximated by the integral

$$P_i = \frac{\sigma}{\sigma - 1} \left(\gamma_2^\sigma \psi_{\text{original}}^{\sigma-1} + \gamma_1^\sigma M \int_{\psi_1}^{\psi_2} \psi^{\sigma-1} dG(\psi) \right)^{\frac{1}{1-\sigma}}. \tag{17}$$

Note that because of the term ψ_{original} the price index varies by product. This is because the productivity of the innovators varies across products (while the distribution of imitators is constant across products).

Each innovator, however, is small relative to the number of varieties in each group, n. Thus, it can be disregarded and the group price index for $i > 0$ can be approximated by

$$P = \frac{\sigma}{\sigma - 1} \left(\gamma_1^\sigma M \int_{\psi_1}^{\psi_2} \psi^{\sigma-1} dG(\psi) \right)^{\frac{1}{1-\sigma}}. \tag{18}$$

Alternatively we can work in expectations, integrating over the distribution of innovators

$$E(P_i | i > 0) = \frac{\sigma}{\sigma - 1} \int_{\psi_2}^{\infty} \left(\gamma_2^\sigma \phi^{\sigma-1} + \gamma_1^\sigma M \int_{\psi_1}^{\psi_2} \psi^{\sigma-1} dG(\psi) \right)^{\frac{1}{1-\sigma}} dG(\phi). \tag{19}$$

To compute the aggregate price index we sum over the different group price indexes

$$\Pi = \left(P_0^{1-\theta} + \sum_{i=1}^{N} P_i(\psi_{\text{original}})^{1-\theta} \right)^{\frac{1}{1-\theta}} \tag{20}$$

which is approximated by integrating over the distribution of innovators

$$\Pi = \left(P_0^{1-\theta} + M \int_{\psi_2}^{\infty} P_i(\psi)^{1-\theta} dG(\psi) \right)^{\frac{1}{1-\theta}} \tag{21}$$

With the addition of foreign firms, we need to include an additional parameter of vertical differentiation, δ, into the price indexes. It can be easily shown that the definition of the price index of group zero remains unchanged; that the price index of groups created by foreign innovators (denoted by $\widetilde{P}$) satisfies

$$\widetilde{P} = \delta^{\frac{\sigma}{1-\sigma}} P, \tag{22}$$

and that the overall price index is given by

$$\Pi = \left(P_0^{1-\theta} + f\left(\frac{M^*}{M}\right)(M + M^*) \int_{\psi_2}^{\infty} P_i(\psi)^{1-\theta} dG(\psi) \right)^{\frac{1}{1-\theta}}. \tag{23}$$

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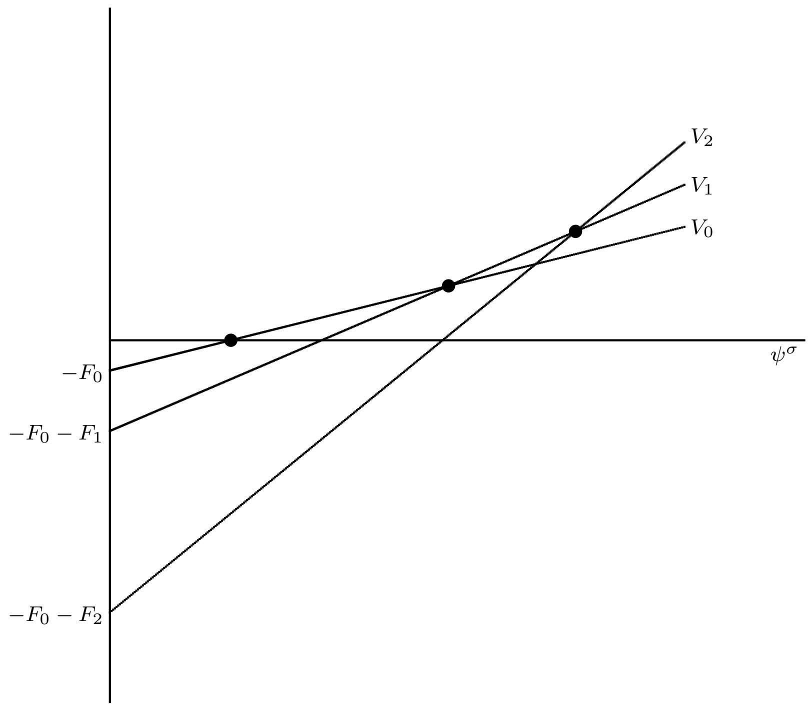
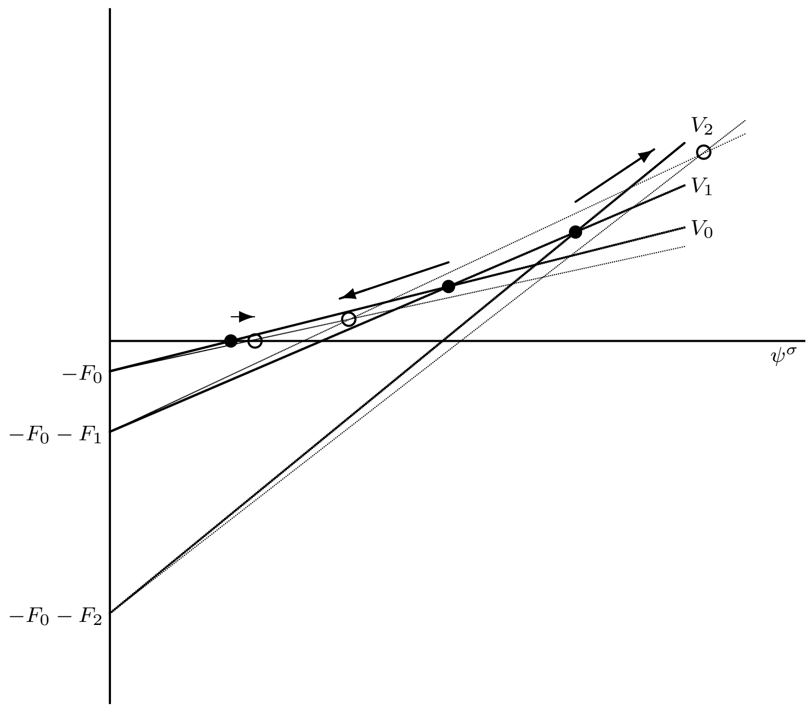
Figure 1
Profits from no–upgrades, imitation and innovation



Net profits from not–upgrading, imitation and innovation are plotted as a function of productivity. The solid dots denote the productivity cutoffs. Firms between the origin and the first dot choose to exit; firms between the first two dots stay and do not introduce upgrades; firms between the second two dots choose to imitate; and firms above the third dot choose to innovate.

Figure 2
Changes in profits and cutoffs due to foreign firms



The figure depicts a shift in net profits and cutoffs due to an increase in M^*/M. The thick lines and solid dots denote the original situation. The thin lines and empty circles denote an increase in M^*/M. The slope of V_0 and V_2 decreases, while the slope of V_1 increases. The arrows indicate the direction in which the cutoffs shift.

Table 1: FDI and innovation: Basic regressions

Dependent variable: Introduction of new products				
Foreign presence	0.011**	0.011**	0.011**	0.0096*
	(0.0051)	(0.0053)	(0.0051)	(0.0052)
Trend*R&D workers	-0.0073	-0.0073	-0.0076	–
	(0.013)	(0.014)	(0.013)	
Trend*Non-prod workers	–	0.0011	–	–
		(0.0042)		
Trend*Education	–	–	-0.0031	–
			(0.026)	
Firms	1027	981	1027	1052
Obs.	2390	2278	2390	2457
R^2	0.05	0.05	0.05	0.05
Dependent variable: R&D/Sales				
Foreign presence	0.029	0.035	0.030	0.029
	(0.030)	(0.035)	(0.030)	(0.029)
Trend*R&D workers	0.037	0.096	0.052	
	(0.030)	(0.087)	(0.043)	
Trend*Non-prod workers		-0.045		
		(0.053)		
Trend*Education			0.19	
			(0.18)	
Firms	1007	964	1007	1022
Obs	2232	2134	2232	2268
R^2	0.003	0.007	0.004	0.002

Sample: private domestic firms. Dependent variables: binary variable indicating the introduction of new products; and expenditure on R&D over total firm sales. Foreign presence: participation of foreign firms in industry output. Trend*R&D workers: Linear trend interacted with the initial share of R&D workers in skilled workers. Trend*Non-prod workers: Linear trend interacted with initial share of non-production workers. Trend*Education: Linear trend interacted with an indicator of whether the average education level is middle school or high school. Other controls (not displayed): firm fixed effects and year effects. Industry-clustered standard errors in parenthesis;* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2: FDI and product introduction: Main firm characteristics

Dependent variable: Introduction of new products

Size (number of workers)[a]	*Small*	*Medium*	*Large*
Foreign presence	0.008	0.025**	0.0021
	(0.010)	(0.013)	(0.0052)
Firms	284	315	428
Obs.	668	718	1004
R^2	0.11	0.08	0.03

Market share (self-reported)	*Below 5%*	*Above 5%*
Foreign presence	0.014***	0.0073
	(0.0054)	(0.0099)
Firms	685	342
Obs.	1528	862
R^2	0.06	0.05

Exporting status	*Non-exporters*	*Exporters*
Foreign presence	0.016**	0.0003
	(0.0075)	(0.0051)
Firms	727	294
Obs.	1651	726
R^2	0.06	0.06

Sample: private domestic firms. Dependent variable: binary variable indicating the introduction of new products. Foreign presence: participation of foreign firms in industry output. Other controls (not displayed): firm fixed effects, year effects, and firm-level trends in initial R&D activity (measured as the ratio of R&D workers over the total number of skilled workers). Industry-clustered standard errors in parenthesis;* significant at 10%; ** significant at 5%; *** significant at 1%.
[a]Small: less than 50 employees; Medium: 50-150 employees; Large: more than 150 employees

Table 3: FDI and R&D: Main firm characteristics

Dependent variable: R&D/Sales

Size (number of workers)[a]	*Small*	*Medium*	*Large*
Foreign presence	-0.0014	0.0841	-0.002
	0.0017	0.0817	0.0031
Firms	276	311	420
Obs.	557	699	976
R^2	0.0192	0.00757	0.0306

Market share (self-reported)	*Below 5%*	*Above 5%*
Foreign presence	0.0504	-0.0023
	0.0519	0.0036
Firms	669	338
Obs.	1430	802
R^2	0.00384	0.022

Exporting status	*Non-exporters*	*Exporters*
Foreign presence	0.0498	-0.0033
	0.0492	0.0034
Firms	721	286
Obs.	1553	679
R^2	0.0039	0.0416

Sample: private domestic firms. Dependent variable: Expenditure on R&D over firm sales. Foreign presence: participation of foreign firms in industry output. Other controls (not displayed): firm fixed effects, year effects, and firm-level trends in initial R&D activity (measured as the ratio of R&D workers over the total number of skilled workers). Industry-clustered standard errors in parenthesis;* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4: Commercial transactions with foreign firms located in China

Produces final products for foreign firms?	*No*	*Yes*
Foreign presence	0.021**	-0.0052
	(0.0088)	(0.0088)
Firms	257	67
Obs.	771	201
R^2	0.08	0.05

Produces parts or inputs for foreign firms?	*No*	*Yes*
Foreign presence	0.020**	0.002
	(0.008)	(0.013)
Firms	263	63
Obs.	789	189
R^2	0.08	0.09

To the specifications of foreign firms?	*No*	*Yes*
Foreign presence	0.019**	0.0097
	(0.0087)	(0.0069)
Firms	202	124
Obs.	606	372
R^2	0.07	0.07

Of its own design?	*No*	*Yes*
Foreign presence	0.018***	-0.021
	(0.0067)	(0.016)
Firms	262	49
Obs.	786	147
R^2	0.07	0.06

Uses parts supplied by foreign firms?	*No*	*Yes*
Foreign presence	0.022***	-0.0036
	(0.0077)	(0.011)
Firms	214	106
Obs.	642	316
R^2	0.09	0.03

Sample: private domestic firms. Dependent variable: binary variable indicating the introduction of new products. Foreign presence: participation of foreign firms in industry output. Other controls (not displayed): firm fixed effects, year effects, and firm-level trends in initial R&D activity (measured as the ratio of R&D workers over the total number of skilled workers). Industry-clustered standard errors in parenthesis;* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5: Skill intensity, capital intensity and equipment

Share of non-production workers in total employment	*Below the sector mean*	*Above the sector mean*
Foreign presence	0.014**	0.0044
	(0.0065)	(0.0076)
Firms	726	255
Obs.	1686	592
R^2	0.06	0.06

Average education of production workers	*Middle school*	*High school*
Foreign presence	0.015**	0.0024
	(0.0062)	(0.0079)
Firms	405	622
Obs.	1146	1244
R^2	0.06	0.05

Capital per worker	*Below the sector mean*	*Above the sector mean*
Foreign presence	0.023**	-0.0001
	(0.011)	(0.0056)
Firms	465	461
Obs.	1056	1061
R^2	0.06	0.03

Imported machinery	*No*	*Yes*
Foreign presence	0.015**	0.0013
	(0.0075)	(0.0058)
Firms	690	318
Obs.	1596	756
R^2	0.07	0.05

Sample: private domestic firms. Dependent variable: binary variable indicating the introduction of new products. Foreign presence: participation of foreign firms in industry output. Other controls (not displayed): firm fixed effects, year effects, and firm-level trends in initial R&D activity (measured as the ratio of R&D workers over the total number of skilled workers). Industry-clustered standard errors in parenthesis;* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 6: R&D and product quality

R&D expenditure	*Zero*	*Positive*
Foreign presence	0.0075	0.0067
	(0.0076)	(0.0077)
Firms	559	371
Obs.	1265	860
R^2	0.06	0.02

R&D expenditure; Medium-sized firms	*Zero*	*Positive*
Foreign presence	0.021	0.032**
	(0.014)	(0.016)
Firms	205	101
Obs.	468	230
R^2	0.11	0.09

R&D scientists/R&D workers	*Above the sector mean*	*Below the sector mean*
Foreign presence	0.015**	0.0071
	(0.0074)	(0.0075)
Firms	628	399
Obs.	1474	916
R^2	0.08	0.02

ISO9000 certified products	*No*	*Yes*
Foreign presence	0.018**	0.0057
	(0.0073)	(0.007)
Firms	520	486
Obs.	1196	1131
R^2	0.06	0.06

Sample: private domestic firms. Dependent variable: binary variable indicating the introduction of new products. Foreign presence: participation of foreign firms in industry output. Other controls (not displayed): firm fixed effects, year effects, and firm-level trends in initial R&D activity (measured as the ratio of R&D workers over the total number of skilled workers). Industry-clustered standard errors in parenthesis;* significant at 10%; ** significant at 5%; *** significant at 1%.