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Openness and Technological Innovations in Developing Countries

Evidence from Firm-Level Surveys*

Rita Almeida
The World Bank
and
Ana Margarida Fernandes
The World Bank

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Abstract

This paper analyzes the role of international technological diffusion for firm-level technological innovations in several developing countries. Our findings show that, after controlling for firm, industry, and country characteristics, exporting and importing activities are important channels for the diffusion of technology. We also find evidence that majority foreign-owned firms are significantly less likely to engage in technological innovations than minority foreign-owned firms or domestic-owned firms. We interpret this finding as evidence that the technology transferred from multinational parents to majority-owned subsidiaries is more mature than that transferred to minority-owned subsidiaries. This finding supports the idea that equity joint ventures maximize technology transfers to local firms.

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JEL Classification codes: F1, F2, O3.

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1. Introduction

Growth theory has for long established that improvements in technology have an effect on long-run growth (Romer, 1990; Aghion and Howitt, 1998). Moreover, differences in technology have been found to be an important determinant of differences in total factor productivity across countries (Hall and Jones, 1999; Klenow and Rodriguez-Clare, 1997) and across firms (Griliches, 1998; Parisi et al., 2006). While most firms improve their technology by simply imitating or adapting existing production techniques to local conditions, other firms are truly engaged in the creation of new technologies. Even though this is true for firms worldwide, this is particularly important in developing countries. There, the adoption of existing technologies from abroad can occur through the contacts with foreign partners, foreign suppliers and/or foreign clients or through the direct trade in technologies (e.g., licensing). Most empirical studies on the international diffusion of knowledge provide indirect evidence on the importance of different channels by documenting a link between trade or FDI and firm-level productivity. In this paper, we use firm-level data on the adoption of new technology in several developing countries to provide new evidence on the incentives of firms to adopt new technology and on the importance that trade and foreign direct investment (FDI) have as channels for the diffusion of technology.[1]

New technologies can be transmitted across countries through different activities. Foreign direct investment is one possible channel. Multinational parents, endowed with a more advanced technology, usually transfer their knowledge and technology to their subsidiaries. However, there is some debate on the quality of the technology that is actually transferred from multinational parents. Throughout the world, many policies to attract FDI are based on the premise that joint ventures between foreign and domestic-owned firms are more fruitful than fully-owned foreign subsidiaries because they induce a greater technology transfer. This view is not consensual, though, as there is some evidence that multinational parents

[1] The international diffusion of technology to firms integrated into global markets may subsequently spill over to other domestic firms in the same region or industry not directly engaged in international activities. The latter could happen through demonstration effects, labor turnover, or reverse engineering. This paper will focus only on technology transfers to firms integrated into global markets, not on spillovers.

have an incentive to transfer older technologies to their subsidiaries in developing countries than to those in developed countries to avoid the risk of expropriation (Mansfield and Romeo, 1980). Others find that technology transfers from parent firms to fully-owned subsidiaries are higher than those to minority-owned subsidiaries (Ramachandran, 1993). Alternatively, the international transmission of technology can occur through trade. If new knowledge is embodied in imported capital goods or intermediate inputs, we would expect importers to be more innovative than firms that source only in the domestic market. Importers can improve their technology by incorporating in their production processes these state-of-the-art inputs or machinery, which may not be available domestically (Grossman and Helpman, 1991). Similarly, exporters can learn about new technologies or products through their interaction with more knowledgeable foreign buyers in external markets. Alternatively, they may be exposed to more competitive markets and hence be forced to improve their technology frequently. If the exposure to export markets is indeed a channel promoting innovations, we would expect exporters to be more likely to adopt new technologies than firms selling exclusively to the domestic market. Finally, firms can engage in the direct trade of knowledge, through technological licensing agreements, to acquire new technology. These channels are not necessarily used in isolation. For example, the use of licensing and FDI are often complementary channels for the international transmission of technology.

Perhaps the biggest difficulty in the analysis of the international transmission of technology is to gather good indicators on the adoption of new technology. How one exactly defines a technological innovation depends on the specificities of each firm and its production process. Most of the empirical work using micro data uses information on firm-level research and development (R&D) expenditures or the number of patented technologies.[2] However, the R&D activities of the firm are only one type of research inputs in the process of generating new technologies and they do not necessarily lead to a successful and applicable new technology. Moreover, the propensity to patent varies widely across industries and is likely to be more important for the creation of new knowledge than for the adoption and adaptation

[2] One exception is Comin et al. (2006) that use a cross-country dataset on the adoption of specific technologies.

of existing knowledge. The firm-level dataset we use allows us to construct a broad measure of technological innovation, which includes the creation of new production processes but also the adoption and adaptation of existing technologies to local conditions. In particular, the survey collects information on whether firms introduced recently new technology that substantially changed their main process of production. This measure of technological innovation is more likely to reflect advances of the firm towards the country's knowledge frontier, rather than movements of the technological frontier itself. This is arguably a better measure to study technological innovations and their international diffusion, especially in the context of developing countries. Also important to our analysis, the survey collects very detailed information on firm characteristics, including their export and import activities and foreign ownership.

Using this firm-level dataset covering 43 developing countries, we will analyze the following questions. First, which firms have a larger incentive to engage in technological innovations? Second, is the firm's integration into global markets an important channel for the acquisition of new technologies? Which specific channels for the transfer of new technology are explored by those firms that engage in trade or have some foreign ownership?

Our paper relates to two strands of literature. First, it relates to the large micro literature that studies the determinants of innovation, which originated in the work by Schumpeter (1942) (e.g., Cohen and Levin, 1989; Cohen, 1995; Aghion et al., 2005). Particularly related to our work is Criscuolo et al. (2005). Like us they explore firm-level data to compute a broad measure of innovation and relate the firm's propensity to innovate with its integration into global markets. Their findings show that those UK. firms that are more integrated into global markets are more likely to innovate, but that most of the difference is explained by the number of scientists and researchers used. Vishwasrao and Bosshardt (2001) also find that foreign-owned firms in India are more likely to adopt new technology than domestic-owned firms.[3]

Second, our paper relates to the vast literature on the effects of integration into global

[3]The cross-country evidence also points to a positive correlation between trade openness and the speed at which countries adopt new technologies (Comin and Hobijn, 2004) or invest in R&D (Lederman and Maloney, 2003).

markets on productivity (Tybout, 2000; Keller, 2005). One possible channel through which the integration into global markets results in higher productivity is through technological transfers and the resulting access to a wider knowledge base (e.g., Grossman and Helpman, 1991). While most empirical studies look at the effect of the participation in international activities on firm-level productivity, there is little evidence on the actual effect that these activities have on firm-level technological innovations. The evidence available suggests that firm level productivity is higher for those firms integrated into global markets through exports, FDI, or imports of intermediate inputs. In the literature studying the link between firm performance and exports there is strong evidence of self-selection of the most productive firms into exporting (Clerides et al., 1998; Bernard and Jensen, 1999) but there is also evidence of a learning-by-exporting effect (Alvarez and Lopez, 2005; Fernandes and Isgut, 2006). The latter is consistent with the contacts of exporting firms with more knowledgeable foreign buyers generating an increased access to (or demand for) better technologies. Also, firms may be forced to frequently improve their technological capabilities in order to face strong competition in export markets. There is also evidence that firms with FDI tend to be more productive than domestic firms (e.g., Djankov and Hoekman, 2000; Arnold and Javorcik, 2005).[4] Finally, there is also some evidence that imports of intermediate inputs are positively correlated with firm and aggregate productivity (Kasahara and Rodrigue, 2005; Coe et al., 1997; Lumenga-Neso et al., 2005).[5]

The main findings of our paper can be summarized as follows. First, we find that there is a lot of heterogeneity at the firm-level in the acquisition of new technology, even after controlling for differences across countries and industries (accounting for approximately 13% of the total variation). Part of this heterogeneity is explained by the size of the firm and its human capital. For example, medium and large firms are 13 and 18 percentage points more likely to adopt new technology than micro firms, respectively. Second, we find a very

[4] Arnold and Javorcik (2005) find that a firm's total factor productivity increases significantly following its acquisition by foreign multinationals in Indonesia.

[5] Coe et al. (1997) and Lumenga-Neso et al. (2005) find that foreign knowledge embodied in imported inputs (from countries with large R&D stocks) has a positive effect on aggregate total factor productivity in developing countries.

strong positive correlation between trade and technological innovation. All else constant, importers and exporters are 4.3 and 7.3 percentage points more likely to report technological innovations than firms that do not engage in each of these activities, respectively. While it is possible that these estimates are biased upwards due to the selection of the more competitive firms (and hence more prone to adopt new technologies) into these activities, in our sample this problem does not seem to be too severe for exports. Firms that started exporting more than 10 years prior to the survey are still 4.2 percentage points more likely to report technological innovations than firms that do not export. Third, we find strong evidence that in low-tech industries majority foreign-owned firms are significantly less likely to engage in technological innovations than domestic-owned firms.[6] This finding holds when we compare firms with similar managerial education and access to finance operating in the same region and industry. Moreover, majority foreign-owned firms are less likely to engage in technological innovation than minority foreign-owned firms. We interpret this finding as evidence that the technology transferred from multinational parents to majority-owned subsidiaries is more mature than the technology transferred to minority-owned subsidiaries. This provides some support to the idea that equity joint ventures maximize the quality of the technology transferred to local firms. Around the world, policies to attract FDI have been based on this presumption although the little empirical evidence available supports the contrary (Mansfield and Romeo, 1980; Ramachandran, 1993; Javorcik, 2006).

The paper proceeds as follows. Section 2 describes the data and provides summary statistics. Section 3.1 describes our main findings on the profile of firms that engage in technological innovations and the importance of the different channels for the international transfer of knowledge. Section 3.2 tests the robustness of the results and Section 4 concludes.

[6] To the extent that foreigners select the best-performing firms and we are unable to fully account for this through our firm, industry and country controls, our negative point estimate could still be biased upwards.

2. Data

We use a firm-level dataset collected by the World Bank across 43 developing countries (Investment Climate Surveys).[7] The surveys were conducted between 2002 and 2005 and the samples were designed to be representative of the population of firms according to their industry and location within each country. Although only one wave of data is available for each country, the information available in the survey has several advantages for analyzing technological innovations. First, it is based on a common questionnaire across a large set of countries, which yields comparable information on several firm-level variables. Among others, the survey collects information on whether the firm recently adopted new technology, the main channels used to acquire technological innovations, its ownership structure, age, size, human capital composition, and whether it participates in international trade. The survey also collects information on the firm's R&D activities and technology licensing. Table A.1 defines in detail all the variables used in the analysis and Table A.2 reports the summary statistics. The final sample includes 17,723 firms distributed across a wide set of manufacturing industries - auto and auto components, beverages, chemicals, electronics, food, garments, leather, metals and machinery, non-metallic and plastic materials, paper, textiles, wood and furniture - in 43 countries in Africa, Asia, Eastern Europe, and Latin America.[8] Second, the survey allows us to use a broad definition for technological innovation. Specifically, we define *technological innovation* as a dummy variable equal to one if a firm reports having introduced new technology that substantially changed the way in which its main product

[7] The Investment Climate Surveys were conducted in 68 developing countries. We use data for only 43 countries, due to the lack of information on the main variables of interest for the remaining countries. We focus the analysis on manufacturing firms only. The information collected in the surveys is based on a 1.5-2 hours interview with the firm manager. Detailed information on the surveys can be obtained at: http://iresearch.worldbank.org/ics/jsp/index.jsp. In what follows, we will refer to firms as being the unit of analysis but the unit of data collection was actually an establishment or plant.

[8] The countries included in the dataset are Albania (2005), Armenia (2005), Belarus(2005), Bosnia and Herzegovina (2005) Brazil (2003), Bulgaria (2005), Chile (2004), China (2003), Croatia (2005), Czech Republic (2005), Ecuador (2003), Egypt (2004), El Salvador (2003), Estonia (2005), Georgia (2005), Guatemala (2003), Honduras (2003), Hungary (2005), Indonesia (2003), Kazakhstan (2005), Kyrgyzstan (2005), Latvia (2005), Lithuania (2005), Madagascar (2005), Malaysia (2003), Moldova (2005), Nicaragua (2003), Philippines (2003), Poland (2005), Romania (2005), Russia (2005), Serbia and Montenegro (2005), Slovakia (2005), Slovenia (2005), South Africa (2003), Tajikistan (2005), Thailand (2004), Turkey (2005), Ukraine (2005), Uzbekistan (2005), Vietnam (2005), and Zambia (2002). The year in parentheses indicates when the survey was conducted in each country.

is produced in the three years prior to the survey.[9] Defining a technological innovation in this way is particularly important in the context of developing countries to understand how firms catch-up to the world technological frontier.[10] This variable will capture not only the creation of new knowledge but also the adoption and adaptation of production processes, which although new to the firm, may not be new to the country nor to the world. In our sample, 48% of firms report having conducted R&D activities and, of these, 63.4% report having adopted new technology.[11] The fact that 25% of the firms in our sample report having adopted new technology without having conducted any R&D activities reinforces the importance of using alternative measures of technological innovation. Third, the survey collects detailed information on the major channels used by firms to acquire technological innovations. On average, 71% of firms in the sample report that their new technology was either embodied in new machinery, developed/adapted within the firm, transferred from the parent company, or developed by key personnel or by consultants. A lower share of firms (32%) reports that technology was acquired or developed in coordination with supplier/clients (including licensing or turnkey operations from domestic or international sources, developed in cooperation with client firms, or developed with equipment and machinery suppliers) and only 13% of firms report that technology was developed in coordination with other institutions (including universities and public institutions, business or industry associations, trade fairs or study groups).

One shortcoming of our data is that it captures only the intensive margin of technological

[9] There is some arbitrariness in this definition which could introduce measurement error in the dependent variable in the regressions in Section 3. If this measurement error is classic, this is not a problem. However, biases could result if the measurement error is systematically related to firm characteristics. For example, if smaller firms report more often that they change their technology, the estimated coefficient for small firms would be biased downwards.

[10] The survey also collects information on whether the firm developed new major product line(s) or upgraded existing product line(s) in the three years prior to the survey. However, since the focus of this paper is on technological innovations and the channels for technology diffusion, we do not focus on product innovations. Nevertheless, in Table A.4, we estimate our main specifications using as a dependent variable a dummy variable equal to one if the firm engages in technological innovation *or* product innovation. Those results provide evidence on the importance of different channels for international knowledge diffusion for the firm's propensity to innovate.

[11] The finding that almost half of the firms in our sample conduct some R&D activities suggests that managers very likely consider as R&D those activities that relate to the adaptation of technologies to local conditions (in contrast to considering only frontier research activities as R&D).

innovation, but does not have information on the extensive margin. This contrasts with the information available in the Community Innovation Surveys (CIS) recently conducted in most European countries by the OECD (e.g., OECD, 1992; Evangelista et al., 1997; Criscuolo et al., 2005; Mohnen et al., 2006). Nevertheless, relative to the CIS datasets, our data has the advantage of collecting information on firm characteristics for all the firms in the sample while in most countries CIS datasets collect that information only for firms that innovate.[12]

Table 1 reports the average share of firms engaged in technological innovations across continents and industries and Figure 1 shows this average for each country in our sample. The evidence shows that a large share of firms report being engaged in technological innovations (56.1%) but also that there is significant heterogeneity across countries.[13] Egypt and Uzbekistan show up as the countries with the lowest frequency of technological innovations while Thailand and Brazil report the highest frequencies in our sample. Table 1 also shows substantial heterogeneity in the degree of technological innovation across industries. Traditional industries tend to have fewer innovative firms while high-tech industries tend to have more. The most innovative industries are electronics and auto-parts while the least innovative are paper and food.[14]

To assess whether our innovation measure is economically meaningful, we analyze its correlation with relevant firm outcomes. Figure 2 plots the kernel density of labor produc-

[12] One exception is the CIS dataset for the UK, used by Cricuolo et al. (2005), which collects information on firm characteristics for all firms, regardless of their innovation status.

[13] Firms in our sample are more likely to engage in product innovation (68.8%) than in technological innovation (56.1%). This finding holds across industries and countries, with the exceptions of electronics and auto-parts as well as China, Malaysia, and Thailand. But different firms engage in the two types of innovation since the average propensity to engage in technological *or* product innovation is 77.6%. The average share of firms that engage in both types of innovation is 47.5%, while the probability of engaging in product innovation for firms that have also introduced technological innovations is 84.7%. The latter shows that technological innovations are likely to result in changes in product design and quality and thus new or improved products. However, engaging in technological innovations does not result in product innovation with certainty.

[14] Using the CIS datasets for 10 countries, Evangelista et al. (1997) find that the average propensity of European firms to introduce process (technological) or product innovations is 53%. The comparable average in our sample is much higher, 78%. This difference holds even within industries. In European countries, the average propensity to innovate in the electronics (textiles) industry is 67% (33%), which compares with an average of 82% (77%) in our sample. The ranking of industries is very similar across the two samples. This difference in the propensity to innovate across the two samples can be explained by managers in developing countries being more likely to report small changes in technology or products as being an innovation than managers in developed countries.

tivity (measured as value added per employee) for firms that are engaged in technological innovations and for firms that are not. Figure 2a reports evidence for the country with the lowest frequency of technological innovations, Egypt, while Figure 2b reports evidence for the country with the highest frequency of technological innovations, Brazil. Both figures show that firms that adopt new technology have higher labor productivity than those that do not. This positive correlation suggests that our technological innovation measure captures an economically important activity.

Table 2 reports the average frequency of technological innovations for different types of firms. While only 54% of domestic-owned firms report having adopted new technology, foreign-owned firms are substantially more innovative in this respect, particularly those with minority foreign ownership whose propensity to adopt new technology is 74.1%. Also, the share of firms reporting technological innovations is much higher for exporters (64.8%) and for importers (62.7%) than for the full sample.[15] These statistics suggest that trade and FDI are associated with more dynamic firms in developing countries. Note that firms integrated into global markets also report higher innovation inputs, measured by the propensity to engage in R&D activities. Hence, it is possible that their higher probability of technological innovation is simply explained by their higher probability of conducting R&D activities. Alternatively, there may be other important factors influencing technological innovation such as the size of the firm.[16] This issue will be investigated in the next section.

We turn next to the differences across firms engaged in global activities in the channels used to acquire technological innovations. Table A.3 reports the results from probit regressions of each of the sources of technological innovations (shown as column headings) on the foreign ownership variables, and exporter and importer status, controlling for industry fixed effects and for countries' per capita GDP in 1995. For minority and majority foreign-owned firms, transfers from the parent company are significantly more important as

[15] The higher propensity to adopt new technology of importers and exporters is verified also within industries and countries.

[16] Table 2 also reports the association between size categories (based on total employment) and technological innovations. Large firms are substantially more prone to adopt new technologies than smaller firms and the relationship is monotonic.

a source of technological innovations than for other firms. The development in cooperation with client firms is a significantly more important source of technological innovations for minority foreign-owned firms than for domestic-owned firms, while the reverse is true for majority foreign-owned firms. Moreover, for majority foreign-owned firms the acquisition of technological innovations from any of the external institutions is significantly less important than for other firms. For exporters, development in cooperation with client firms and equipment or machinery suppliers is a significantly more important source of technological innovations, but so is the development and adaptation within the firm. Finally, for importers there is a significantly more important role of technology embodied in new machinery and equipment relative to non-importers and a less important role of technology development with client firms.

In sum, the findings in this section show interesting patterns in technological innovations and their sources for firms that are integrated into global markets. The rest of the paper tests whether the bivariate correlations found so far resist more rigorous econometric estimation.

3. Empirical Findings

3.1. Main Estimates

Our empirical framework considers profit maximizing firms deciding whether or not to engage in technological innovation. A firm decides to innovate if this decision is expected to increase its profits or, in other words, if the benefits from this decision are larger than the costs. Let π^*_{ijc} be the profits of a firm i in industry j in country c. Then, we assume that:

$$Innov_{ic} = \begin{cases} 1 \text{ if } \pi^*_{ijc} > 0 \\ 0 \text{ otherwise.} \end{cases} \tag{3.1}$$

where $Innov_{ijc}$ is a dummy variable that equals one if firm i reports engaging in technological innovation. Since π^*_{ijc} is unobserved, Equation (3.1) cannot be estimated directly. Therefore, we assume that π^*_{ijc} is a function of firm, industry, and country characteristics. In particular, we assume a linear form so that $\pi^*_{ijc} = \beta X_{ijc} + I_j + \gamma I_c + \varepsilon_{ijc}$, where X_{ijc} is a vector of firm characteristics, I_j are industry fixed effects, I_c are country-level variables, and ε_{ijc}

captures unobserved firm, industry, and country characteristics. For this functional form, the probability that firm i innovates is given by:

$$\Pr(Innov_{ijc} = 1) = \Pr(\varepsilon_{ijc} > -\beta X_{ijc} - I_j - I_c). \tag{3.2}$$

Assuming that ε_{ijc} are normally distributed, we can estimate Equation (3.2) by maximum likelihood (probit). Standard errors are clustered to allow for the possibility that the ε_{ijc} are correlated across firms within country-industry cells. Table 3 reports the results from estimating different versions of Equation (3.2) which add progressively firm characteristics to X_{ijc}. For each regressor, we report the marginal effects on the propensity to engage in technological innovation, at mean values. We include in all specifications industry fixed effects to control for differences in the production technology, product demand, and market competition across industries that could facilitate or require a firm to adopt new technology more frequently (Cohen and Levin, 1989).[17]

Column (1) reports that within industries, foreign-owned firms are more likely to engage in technological innovations than domestic-owned firms. In column (2), when we control for export and importing activities, there is still evidence that minority foreign-owned firms are significantly more likely to innovate but majority foreign-owned firms are now as likely as domestic-owned firms to adopt new technology. Moreover, within industries, exporters and importers are significantly more likely to adopt new technology than firms that do not trade. Since globally-integrated firms may be larger or have better workers than other firms and these advantages may be driving their higher propensity to adopt new technology, columns (3) and (4) include in the regression firm age, size, a public ownership dummy, and proxies for the quality of the firm's human capital. The main findings of a strong positive association between minority foreign ownership, exports, and imports on the one hand, and the propensity to adopt new technology on the other hand are maintained. Controlling for these variables, majority foreign-owned firms are now significantly less likely to adopt new

[17] There could also be differences across industries in what is defined as a technological innovation. For example, in an industry where there is continuous change, a small technological change may not be considered an innovation.

technology than minority foreign-owned or domestic-owned firms.

Countries with a more favorable environment for innovation may also offer better export and import opportunities, receive more FDI, and have a more educated workforce. Since several policy and institutional dimensions could be relevant for international activities and could also affect innovation, we control for countries' per capita GDP in 1995 and for country fixed effects in columns (5) and (6), respectively.[18] The relationship between firm-level openness and technological innovations remains robust and the magnitude of the effects does not change much relative to the previous columns. The magnitude of the effects in our preferred specification (column (6)) is economically significant. Firms that export are 4.3 percentage points more likely to innovate than firms selling only to the domestic market while importers are 7.6 percentage points more likely to innovate than firms using only domestic suppliers.[19] Firms with a minority foreign participation are 6.1 percentage points more likely, while majority foreign-owned firms are 4.4 percentage points less likely to adopt new technology than domestic-owned firms.

The findings in this table also show other interesting patterns. First, there is a negative relation between the propensity to engage in technological innovations and the age of the firm. This finding could be the result of some "creative destruction" as young firms are more innovative and dynamic than older firms with weaker learning possibilities (Schumpeter, 1942).[20] Second, larger firms are more likely to engage in technological innovations. In our preferred specification, in column (6), small, medium, and large firms are 6.4, 13.3, and 18.3 percentage points more likely to report technological innovations than micro firms, respectively. This size advantage can be the result of economies of scale in the adaptation or development of new technology (e.g., Cohen and Klepper, 1996) or it can reflect the greater capacity of large firms to finance innovation projects in the presence of imperfect financial

[18] We include past GDP per capita, since current GDP per capita could be correlated with omitted variables in our specification also affecting innovation.

[19] Our findings are robust to changing the definition of exporters (importers) to those firms that export (import) more than 10% of their output (intermediate inputs). These results are available upon request.

[20] Klepper (1996) develops a model that yields a negative relation between age and the propensity to innovate. To the extent that technological innovations improve the probability of survival, the negative point estimate reported in Table 3 would be an upper bound relative to the true effect of firm age on innovation (Audrestch, 1995).

markets.[21] Finally, the results in Table 3 show that the firm's human capital - measured by the incidence of on-the-job training and the percentage of the workforce with more than secondary education - is positively related with the propensity to adopt new technology.[22] These results are in line with the idea that a more qualified workforce improves the firm's absorptive capability and reduces the costs of adopting or creating new technologies (Cohen and Levinthal, 1989). Table 3 also shows that public-owned firms are less likely to adopt new technology, although the effect is not statistically significant. This finding could reflect the fact that public-owned firms tend to operate in more protected markets and thus have smaller incentives to innovate.

In sum, the main results in this section suggest an important role of trade and FDI for technological innovations at the firm level. The technological advantage of exporters could be the result of their access to more and better knowledge through the interactions with foreign buyers or it could simply reflect a higher pressure to innovate driven by the strong competitive pressures felt in foreign markets.[23] Similarly, the technological advantages of importers could reflect a process of reverse engineering of higher quality foreign inputs. This mechanism would allow firms to learn about the embodied technological knowledge which may not be available domestically (e.g., Grossman and Helpman, 1991; Keller, 2005). Minority foreign-owned firms are also more likely than domestic-owned firms to adopt new technology while majority foreign-owned firms are less likely.[24] This evidence sheds some doubts on the dynamism imparted by the technology that multinational parents transfer to their fully-owned or majority-owned subsidiaries in developing countries. This finding could be suggesting that parent multinationals transfer more mature technologies less prone to

[21] Cohen (1995) also finds an innovation advantage for larger firms in developed countries. Cohen and Klepper (1996) develop a model where larger firms have more incentives to innovate since they face lower average fixed (innovation) costs per unit of output.

[22] A positive correlation between innovation or technology adoption and human capital is documented at the aggregate level by Comin and Hobjn (2004), Lederman and Maloney (2003), and Keller (2005).

[23] Exporters may also benefit from scale economies in innovation due to their access to larger foreign markets. Hobday (1997) provides evidence for the electronics industry that the large size of export orders received by firms in Asian countries played an important role in encouraging them to undertake R&D.

[24] Our findings seem to differ from those in Criscuolo et al. (2005) for the UK, where foreign-owned firms are more innovative (in the sense of being more likely to introduce new processes or products) and those in Vishwasrao and Bosshardt (2001) for India, where foreign-owned firms are more likely to adopt foreign technology than domestic-owned firms.

adaptations and improvements to their majority-owned subsidiaries than to their minority-owned subsidiaries.[25] Thus, our evidence provides some support to the idea that equity joint ventures transfer a more dynamic technology to local firms. This idea has been at the center of policies to attract FDI across many developing countries that favor joint ventures with local partners over majority foreign ownership. However, the evidence so far has been of stronger technology transfers to majority-owned subsidiaries (Mansfield and Romeo, 1980; Ramachandran, 1993; Javorcik, 2006).[26]

3.2. Robustness

Our findings in Table 3 identify important associations between international technology diffusion through trade and FDI and firm-level technological innovations in developing countries. However, some of the estimates may be biased. First, if multinational parents tend to acquire the best - more innovative and productive - domestic firms, then the coefficients on foreign ownership could be biased upwards. This problem is particularly relevant for the coefficient on minority foreign ownership. Second, if technological innovations improve a firm's ability to enter and remain in foreign markets or to buy from foreign suppliers, then our point estimates of the coefficients on exporter and importer status could also be biased upwards. Finally, it is possible that some unobserved variables, such as, e.g., managerial ability, that are correlated with the propensity to innovate also affect the firm's global engagement. Since we do not observe firms for more than one period and valid instruments for our variables of interest are difficult to obtain, we address these selection and omitted variables' problems making use of the rich set of information available in each cross-section of the survey and show the results in Table 4.

The effect of international activities on innovation may simply reflect better managerial

[25] The multinational parents' fear of leakage of proprietary knowledge and of the imminent threat of imitation by domestic-owned firms in countries with weaker property rights mentioned by Saggi (2002), seems to influence the nature of the technology transfers to majority-owned subsidiaries but not so much of those to minority-owned subsidiaries.

[26] Mansfield and Romeo (1980) find that U.S. multinational parents transfer more advanced technologies to fully-owned subsidiaries than to minority-owned subsidiaries. Ramachandran (1993) finds higher technology transfers from multinational parents to fully-owned subsidiaries than to minority-owned subsidiaries in India. Javorcik (2006) finds that multinationals with the most advanced technologies tend to enter into Eastern European countries through majority foreign ownership rather than minority foreign ownership.

quality in the firms that are engaged in those activities. More entrepreneurial managers are more likely to engage in technological innovations more often but are also more likely to export or import. In column (1), we add to our baseline specification (column (6) of Table 3) a dummy variable that equals one if the manager has a college or a post-graduate degree. This variable, which proxies for managerial ability, has a positive and significant effect on the firm's propensity to innovate. More importantly, the effects of technology diffusion through trade and FDI on technological innovation are robust to the control for managerial quality.

Alternatively, foreign-owned firms or exporters may have easier access to finance through their multinational parents or due to export-promoting policies. If firms are credit constrained, lower costs or increased access to finance can increase their ability to innovate.[27] Hence, the estimated effects of openness on innovation could be largely due to open firms' better access to finance. The findings in column (2) show that access to finance is indeed positively correlated with the propensity to innovate.[28] The effects of minority foreign ownership, exports, and imports on innovation are maintained, suggesting that it is not just a better access to finance that underlies those effects, but likely it is the access by more open firms to a richer knowledge base.

Some industries and regions with a large presence of firms integrated into global markets may provide a particularly dynamic environment for innovation to flourish. Thus, it is possible that both the engagement of the firm but also the engagement of other firms in the same industry and region in international activities matter. In column (3), we control for this external effect by including in the regression the share of firms in the industry-region that export and the share of firms in the industry-region that import. It is reassuring to see that the effects of minority foreign ownership, exports, and imports on innovation are robust to this control. The effects of these "spillover" variables are positive and significant for importers, but negative for exporters, suggesting some possible market-stealing effects.

[27] King and Levine (1993) argue that the development of financial intermediaries reduces the costs of identifying entrepreneurs more capable of generating innovations. Increased access to finance for firms can affect innovation through an improved screening of the quality and probability of success of the projects that are financed as well as through their effects on innovation inputs.

[28] Qualitatively similar findings are obtained by Ayyagari et al. (2006) using a smaller sample of countries from the Investment Climate Surveys.

More generally, in column (4) we address the problem of potential unobservable policy or geographical factors that could affect the degree of firm openness and the propensity to innovate, by controlling for industry-region fixed effects. Again our main findings are robust. To the extent that the degree of competition is constant across industries and regions, this specification controls for the degree of competition faced by firms. However, it is possible that different firms face different competitive pressures. In particular, it is likely that firms operating in more competitive markets face stronger pressures to innovate and may also be more engaged in international activities. To address this possibility, we include an explicit measure of competition in the regression shown in column (5). Based on the total number of competitors, we construct dummy variables indicating whether the firm faces no competition, weak, medium, or strong competition in the domestic market. Even though we find a positive effect of competition on technological innovation (stronger when the number of competitors is between 4 and 21 firms), the findings for the main variables of interest remain robust.[29]

A firm's geographical location in the country's capital city may enhance its innovation prospects due to the proximity to other firms, suppliers, clients, and other institutions, while also facilitating its access to global markets through exports and imports and increasing its attractiveness for FDI. The association between openness and innovation could therefore be spuriously due to location. However, the effects of minority foreign ownership, exports, and imports on innovation are qualitatively unchanged in column (6) when our main specification is estimated using the sample of firms located outside their country's capital city. Similar results are found when considering only those firms located outside each country's capital and second major cities.

The findings in Table 3 show that industries with a higher degree of technological sophistication (high-tech) face and take advantage of more innovation opportunities than traditional industries with a lower degree of technological sophistication (low-tech). So far, we have controlled for such differences using industry fixed effects. More generally, there may be differences in the role of technology diffusion through trade and FDI for firm-level innova-

[29] A non-monotonic relation between innovation and competition is also found for the UK. Aghion et al. (2004) show that the effect of concentration on innovation has an inverted "U"-shape.

tion depending on the degree of technological sophistication of the industry. In columns (7) and (8), we report the results from estimating our main specification separately for firms in high-tech industries and low-tech industries, respectively. In both high-tech and low-tech industries, importers have a significantly higher propensity to innovate and the coefficients are similar to those in column (6) of Table 3. Exporters also have a higher propensity to innovate in both high-tech and low-tech industries, but the effect is stronger in high-tech industries. In high-tech industries, foreign-owned firms are not more innovative than domestic-owned firms. Finally, in low-tech industries, there is strong evidence that majority foreign-owned firms are less likely to innovate than domestic-owned firms, while minority foreign-owned firms are more likely to innovate than domestic-owned firms, as in Table 3. For our developing countries, these findings suggest that in low-tech industries multinational parents invest in majority-owned subsidiaries to take advantage of the availability of cheap labor, using them simply as export platforms. For this purpose, they set-up and use their more advanced technology to produce but do not devote more efforts to technological innovation than domestic-owned firms. In contrast, the technology transfers to the local partner by multinational parents that invest in minority-owned subsidiaries generate significantly more innovation.

While the effect of exports on technological innovations is robust to the control for firm and industry-region characteristics, it may still be biased due to reverse causality. Exports may be facilitated by a firm's past technological choices which in turn may also influence its current technological innovation. We try to address this problem in column (9) by comparing non-exporters with those firms that have entered export markets more than 10 years prior to the survey. For such exporters, the causal effect is more likely to run from exports and the resulting knowledge diffusion to innovation, rather than the reverse. The point estimate in column (9) is very close to that shown in column (6) of Table 3, suggesting that the reverse causality problem may not be too severe. Similar results (available upon request) are obtained when considering only the firms that have entered export markets more than 20 years prior to the survey.

As a robustness check to our main findings, we consider a broader measure of innovation which is a dummy variable equal to one if the firm reports having substantially changed its production process (technological innovation) or if the firm reports having introduced a new product line or upgraded an existing product line (product innovation). The results from regressions using this broader measure of innovation are shown in Table A.4. Across all specifications, there is evidence of a strong positive correlation between trade and the propensity to innovate. We also find a strong positive effect of minority foreign ownership on the propensity to innovate, which contrasts with the negative effect of majority foreign ownership.

Finally, we investigate to what extent differences in the sources of technology adoption across firms can explain why firms that are more integrated into global markets tend to innovate more. The baseline regression is our preferred specification in column (6) of Table 3. In column (1) of Table 5 we control for the firm's R&D efforts. The R&D activities within the firm may directly improve the likelihood of technological innovation, or may improve the firm's capacity to absorb external knowledge or technology (Cohen and Levinthal, 1989). Even after controlling for differences in R&D activities across firms, we find that the effects of trade and FDI on innovation are robust and similar to those reported in column (6) of Table 3. Moreover, the effect of R&D on technological innovations is positive and significant: firms that engage in R&D activities are 8.8 percentage points more likely to innovate. In column (2), we add to the previous specification a dummy variable for whether the firm has any technological license. The prior here is that firms that directly engage in the trade of knowledge or technology through licenses would be more likely to report technological innovations, all else constant. Although our data does not differentiate whether these licensing agreements are of domestic or foreign origin, for a smaller set of countries we have information on the use of technology licensed from a foreign-owned firm. The results for this smaller sample are reported in column (3). In both cases, the sign and the magnitudes of the trade and FDI variables remain robust. These results suggest that the use of foreign licenses matters for technological innovations but does not differ much for firms that engage in global activities relative to firms that do not.[30]

[30]This was also shown in column (4) of Table A3, where firms with foreign participation, exporters, or

In sum, the findings in this section show that there is a very robust positive association between trade (either exports or imports) and technological innovations. Minority foreign participations are also a better channel for technology diffusion than majority foreign participations. Furthermore, majority foreign-owned firms are significantly less likely to innovate technologically than domestic-owned firms, especially in low-tech industries. Although we do not analyze technological spillovers to domestic firms, this finding is consistent with minority foreign participations bringing greater benefits to the domestic economy than majority foreign participations. These patterns do not seem to be driven by innovation inputs such as R&D activities or the use of licensed technology that directly affect technological innovation.

4. Conclusion

This paper uses a firm-level dataset for a large number of developing countries to provide new evidence on the importance of technology diffusion through trade and FDI for technological innovations. Unlike most previous studies, we are able to identify whether firms have recently adopted new technology, which is arguably a better measure of a technological innovation for the firm than its R&D activities or its use of patents. Our findings show a very strong positive correlation between trade and technological innovations at the firm level. Importers and exporters are 4.3 and 7.3 percentage points more likely to adopt new technology than firms that do not engage in each of these activities, respectively. While these effects may be biased due to the selection of the more competitive firms (and hence more prone to adopt new technologies) into these activities, our evidence suggests that this problem is not too severe. We also find strong evidence that, all else constant, majority foreign-owned firms are significantly less likely to engage in technological innovations than domestic-owned firms with similar managerial education and access to finance operating in the same region and industry. This result is particularly strong in low-tech industries. We interpret this finding as evidence that the technology transferred from multinational parents to majority-owned subsidiaries is more mature than that transferred to minority-owned subsidiaries. This finding supports the idea that equity joint ventures transfer a more dynamic technology to local firms, which

importers do not differ systematically in the use of licenses from abroad.

contrasts with previous empirical evidence and provides a rationale for the policies followed around the world to attract FDI.

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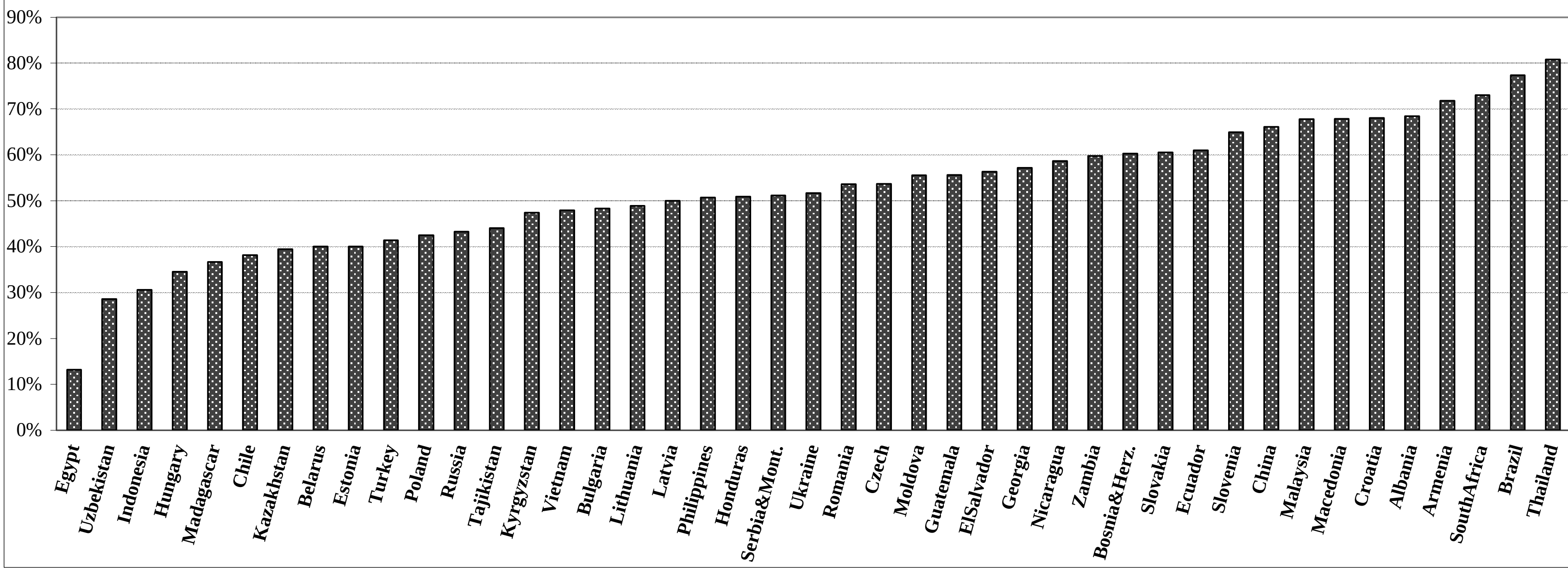
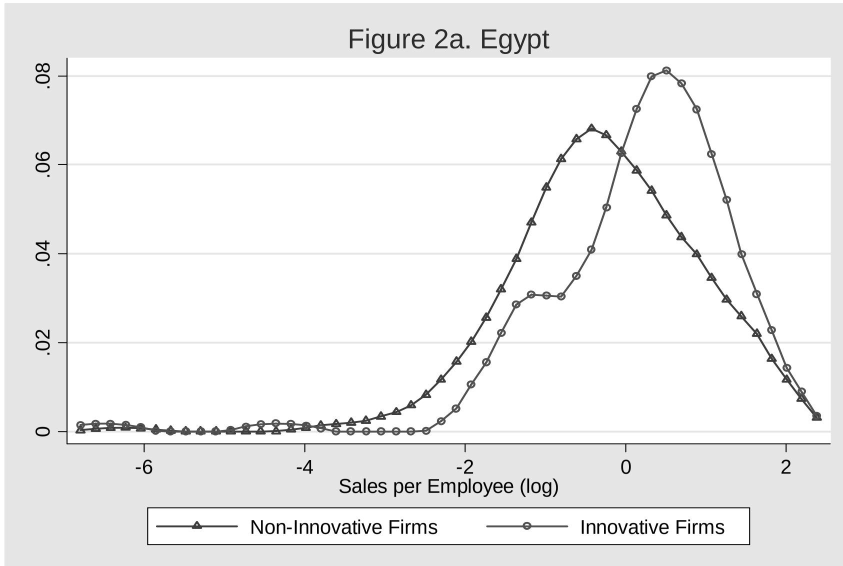
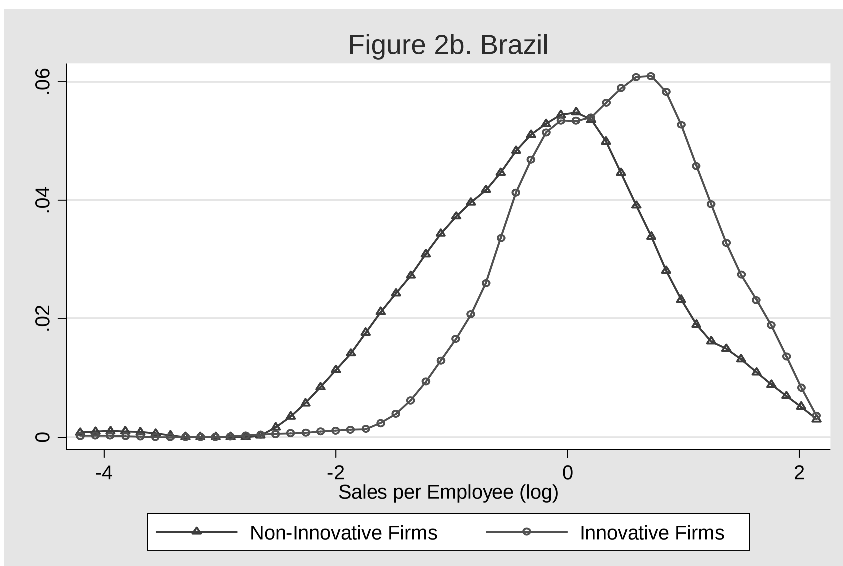
Figure 1. Percentage of Firms Engaged in Technological Innovation



Source: Authors' calculations using data from the Investment Climate Surveys.
Note: Technological innovation is defined in Table A.1.

Figure 2. Labor Productivity and Innovation





Source: Authors' calculations using data from the Investment Climate Surveys.

Notes: The graphs use Epanechnikov kernels with optimal bandwiths to smooth the distribution of the logarithm of labor productivity for innovative and non-innovative firms (defined based on technological innovation). For each country, the observations in the top and bottom 5% of the distribution of labor productivity are excluded from the kernel density estimation. All variables are defined in Table A.1.

Table 1. Propensity to Innovate by Continent and Industry

	Obs.	Percentage of Firms Engaged in Technological Innovation
Continent:		
Africa	2,032	37.8%
Asia	8,460	59.9%
Eastern Europe	2,577	49.0%
Latin America	4,654	60.9%
Industry:		
Auto and Auto Components	977	72.5%
Beverages	834	52.2%
Chemicals and Pharmaceuticals	975	54.7%
Electronics	1,526	73.4%
Food	2,494	50.0%
Garments	2,779	53.9%
Leather	455	60.0%
Metals and Machinery	2,848	55.2%
Non-Metallic and Plastic Materials	1,425	52.2%
Other Manufacturing	402	54.7%
Paper	381	45.5%
Textiles	1,143	51.5%
Wood and Furniture	1,484	55.0%
Full Sample	17,723	56.1%

Source: Authors' calculations using data from the Investment Climate Surveys.
Note: All variables are defined in Table A.1.

Table 2. Firm Characteristics, Technological Innovation, and R&D

	Percentage of Firms Engaged in Technological Innovation	Percentage of Firms Doing R&D
Full Sample	56.1%	48.0%
Majority Foreign-Owned	63.7%	55.4%
Minority Foreign-Owned	74.1%	57.3%
Domestic	54.0%	46.2%
Exporter	64.8%	57.2%
Importer	62.7%	57.3%
Micro	41.4%	34.2%
Small	49.1%	40.2%
Medium	63.0%	52.7%
Large	68.4%	63.0%

Source: Authors' calculations using data from the Investment Climate Surveys.
Note: All variables are defined in Table A.1.

Table 3. Determinants of Technological Innovation

	(1)	(2)	(3)	(4)	(5)	(6)
Majority Foreign-Owned	0.068	-0.014	-0.048	-0.058	-0.053	-0.044
	[0.021]***	[0.020]	[0.020]**	[0.019]***	[0.018]***	[0.017]***
Minority Foreign-Owned	0.179	0.126	0.100	0.091	0.091	0.061
	[0.025]***	[0.024]***	[0.025]***	[0.024]***	[0.023]***	[0.022]***
Exporter		0.113	0.063	0.049	0.042	0.043
		[0.018]***	[0.016]***	[0.016]***	[0.015]***	[0.012]***
Importer		0.092	0.079	0.067	0.065	0.076
		[0.016]***	[0.015]***	[0.015]***	[0.015]***	[0.011]***
Age			-0.001	-0.001	-0.002	-0.001
			[0.000]***	[0.000]***	[0.000]***	[0.000]***
Small Firms			0.077	0.074	0.072	0.064
			[0.027]***	[0.023]***	[0.023]***	[0.020]***
Medium Firms			0.184	0.151	0.152	0.133
			[0.027]***	[0.024]***	[0.024]***	[0.021]***
Large Firms			0.223	0.173	0.181	0.183
			[0.027]***	[0.023]***	[0.024]***	[0.021]***
Public-Owned			-0.051	-0.062	-0.020	-0.015
			[0.028]*	[0.028]**	[0.023]	[0.018]
Training				0.213	0.208	0.151
				[0.016]***	[0.016]***	[0.011]***
Workforce More Second. Educat.				0.079	0.096	0.108
				[0.030]***	[0.026]***	[0.019]***
Observations	17,622	17,407	17,165	16,697	16,697	16,697
Industry Dummies Included?	Yes	Yes	Yes	Yes	Yes	Yes
Log Past per Capita GDP Included?	No	No	No	No	Yes	No
Country Dummies Included?	No	No	No	No	No	Yes

Source: Authors' calculations using data from the Investment Climate Surveys.

Notes: The dependent variable is technological innovation. The table reports the marginal effects (at mean values) on the firm's propensity to innovate from probit regressions. Clustered standard errors by industry and country are in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%. All variables are defined in Table A.1. Micro firms (with than 10 employees) is the omitted size group.

Table 4. Determinants of Technological Innovation - Robustness

	Full Sample	Full Sample	Full Sample	Full Sample	Full Sample	Sample Excluding Firms in Country's Capital City	Sample of High-Tech Industries	Sample of Low-Tech Industries	Sample of Exporters for More than 10 Years and Non-Exporters
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Majority Foreign-Owned	-0.039	-0.042	-0.042	-0.036	-0.055	-0.050	-0.037	-0.055	-0.040
	[0.019]**	[0.017]**	[0.017]**	[0.018]**	[0.021]***	[0.018]***	[0.031]	[0.019]***	[0.018]**
Minority Foreign-Owned	0.073	0.063	0.063	0.068	0.049	0.057	0.018	0.091	0.050
	[0.023]***	[0.023]***	[0.023]***	[0.025]***	[0.025]**	[0.024]**	[0.043]	[0.027]***	[0.023]**
Exporter	0.038	0.042	0.049	0.055	0.046	0.040	0.059	0.034	0.042
	[0.013]***	[0.012]***	[0.011]***	[0.012]***	[0.013]***	[0.014]***	[0.018]***	[0.016]**	[0.013]***
Importer	0.068	0.073	0.071	0.069	0.075	0.082	0.079	0.070	0.082
	[0.012]***	[0.011]***	[0.011]***	[0.013]***	[0.012]***	[0.012]***	[0.018]***	[0.013]***	[0.012]***
Manager College Educat. or More	0.051								
	[0.014]***								
Access to External Finance		0.031							
		[0.010]***							
Share of Exporters in Region-Industry			-0.063						
			[0.031]**						
Share of Importers in Region-Industry			0.100						
			[0.031]***						
Weak Competition					0.044				
					[0.021]**				
Medium Competition					0.081				
					[0.019]***				
Strong Competition					0.068				
					[0.022]***				
Observations	13,208	14,609	16,697	15,808	13,743	12,039	5,966	10,731	14,582
Industry Dummies Included?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Country Dummies Included?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Log Past per Capita GDP Included?	No	No	No	Yes	No	No	No	No	No
Industry-Region Dummies Included?	No	No	No	Yes	No	No	No	No	No

Source: Authors' calculations using data from the Investment Climate Surveys.

Notes: The dependent variable is technological innovation. The table reports the marginal effects (at mean values) on the firm's propensity to innovate from probit regressions. Clustered standard errors by industry and country are in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%. All regressions include also firm age, size dummies, a public-owned dummy, a training dummy, and the percentage of the workforce with more than secondary education. No competition is the omitted competition category in column (5). In column (9), the sample includes all non-exporters but only the exporters that began exporting more than 10 years prior to the survey year. All variables are defined in Table A.1.

Table 5. Technological Innovation, R&D, and Licenses

	(1)	(2)	(3)
Majority Foreign-Owned	-0.041	-0.048	-0.041
	[0.016]**	[0.018]***	[0.021]*
Minority Foreign-Owned	0.059	0.051	0.056
	[0.022]***	[0.025]**	[0.028]**
Exporter	0.041	0.039	0.033
	[0.012]***	[0.013]***	[0.015]**
Importer	0.070	0.066	0.047
	[0.011]***	[0.011]***	[0.012]***
R&D	0.088	0.066	0.092
	[0.015]***	[0.012]***	[0.013]***
Technology Licensing		0.212	
		[0.023]***	
Foreign Technology Licensing			0.099
			[0.021]***
Observations	16,697	15,238	10,204
Industry Dummies Included?	Yes	Yes	Yes
Country Dummies Included?	Yes	Yes	Yes

Source: Authors' calculations using data from the Investment Climate Surveys.

Notes: The dependent variable is technological innovation. The table reports the marginal effects (at mean values) on the firm's propensity to innovate from probit regressions. Clustered standard errors by industry and country are in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%. All regressions include also firm age, size dummies, a public-owned dummy, a training dummy, and the percentage of the workforce with more than secondary education. All variables are defined in Table

Table A1. Variable Definitions

Variable Name	Definition
Technological Innovation	Dummy variable equal to 1 if the firm introduced a new technology that substantially changed the way the main product was produced in the three years prior to the survey.
Majority Foreign-Owned	Dummy variable equal to 1 if more than 50% of the firm's capital is owned by foreigners.
Minority Foreign-Owned	Dummy variable equal to 1 if more than 0% but less than 50% of the firm's capital is owned by foreigners.
Domestic	Dummy variable equal to 1 if 100% of the firm's capital is owned by domestic entities.
Exporter	Dummy variable equal to 1 if the firm exports directly or indirectly.
Importer	Dummy variable equal to 1 if the firm imports some of its intermediate inputs and supplies directly or indirectly.
Age	Year of the survey minus the year when the firm started operations.
Micro, Small, Medium, and Large	Dummy variables equal to 1 if the total number of employees in the firm is between 1 and 10, between 11 and 50, between 51 and 150 or greater than 150, respectively.
Public Ownership	Dummy variable equal to 1 if the share of the firm's capital owned by the government or state is positive.
Training	Dummy variable equal to 1 if the firm provides internal or external training to its workers.
Workforce with More than Secondary Education	Percentage of the firm's workforce which has finished secondary, college, or post-graduate education.
Manager with College Education or More	Dummy variable equal to 1 if the firm's manager has some university training, college, or post-graduate education.
Access to External Finance	Dummy variable equal to 1 if a firm finances its investments through commercial banks or leasing arrangements.
Share of Exporters (importers) in Region-Industry	Percentage of exporters (importers) in the total number of firms in the firm's industry-region, excluding the own firm.
No, Weak, Medium, and Strong Competition	Dummy variables equal to 1 if the firm faces 0, between 1and 3, between 4 and 20, and more than 20 competitors in the domestic market within its main product line, respectively.
High-Tech Industries	Auto and auto-components, chemicals and pharmaceuticals, electronics, and metals and machinery.
Low-Tech Industries	Beverages, food, garments, leather, non-metallic and plastic materials, paper, other manufacturing, textiles, and wood and furniture. These definitions follow Parisi et al. (2006).
R&D	Dummy variable equal to 1 if the firm has design and R&D expenditures (e.g., labor costs with R&D personnel, materials or subcontracting costs).
Technology Licensing	Dummy variable equal to 1 if the firm obtained a new technology licensing agreement in the three years prior to the survey.
Foreign Technology Licensing	Dummy variable equal to 1 if the firm uses technology licensed from a foreign-owned company.
Technology Acquired Internally	Dummy variable equal to 1 if one of the most important ways in which the firm acquires technological innovations is either embodied in new machinery or equipment, related to the hiring of key personnel or consultants, developed and adapted within the firm, or transferred from the parent company.
Technology Acquired from Supplier/Clients	Dummy variable variable equal to 1 if one of the most important ways in which the firm acquires technological innovations is either through licensing or turnkey operations from domestic or international sources, developed in cooperation with client firms, or developed with equipment and machinery suppliers.
Technology Acquired from Institutions	Dummy variable equal to 1 if one of the most important ways in which the firm acquires technological innovations is either from universities and public institutions, from business or industry associations, or from trade fairs or study groups.
Product Innovation	Dummy variable equal to 1 if the firm introduced new product line(s) or ugraded existing product line(s) in the three years prior to the survey.
Value Added per Employee (log)	Firm's nominal sales minus materials costs divided by total number of workers in the firm converted from local currency units to 2000 USD using the country's GDP deflator (Source: World Development Indicators) and the exchange rate of the local currency relative to the US dollar in 2000 (Source: International Financial Statistics, IMF).
GDP per Capita (log)	Values in 1995 in constant 2000 USD (Source: World Development Indicators)

Note: The source is the Investment Climate Surveys unless otherwise stated

Table A2. Descriptive Statistics

	Obs.	Mean	Standard Deviation
Technological Innovation	17,667	0.56	-
Majority Foreign-Owned	17651	0.13	-
Minority Foreign-Owned	17,651	0.04	-
Exporter	17,723	0.40	-
Importer	17,483	0.48	-
Age	17,658	18.26	17.02
Total Employment	17,433	226.33	652.07
Micro	17,433	0.16	-
Small	17,433	0.36	-
Medium	17,433	0.21	-
Large	17,433	0.27	-
Public-Owned	17,723	0.08	-
Training	17,723	0.54	-
Workforce with More than Secondary Education	17,106	0.22	0.25
Access to External Finance	15,722	0.67	-
Manager with College Education or More	14,101	0.75	-
Share of Exporters in Region-Industry	17,667	0.37	-
Share of Importers in Region-Industry	17,667	0.37	-
No Competition	14,409	0.13	-
Weak Competition	14,409	0.13	-
Medium Competition	14,409	0.37	-
Strong Competition	14,409	0.38	-
R&D	17,723	0.48	-
Technology Licensing	16,051	0.10	-
Foreign Technology Licensing	10,842	0.13	-
Technological Innovations Embodied in New Machinery or Equipment	10,022	0.53	-
Technological Innovations Acquired By Hiring Key Personnel	10,022	0.10	-
Technological Innovations Developed or Adapted Within Establishment	10,022	0.12	-
Technological Innovations Acquired from Licensing or Turnkey Operations from International Sources	10,022	0.02	-
Technological Innovations Acquired from Licensing or Turnkey Operations from Domestic Sources	10,022	0.01	-
Technological Innovations Transferred from Parent Company	10,022	0.04	-
Technological Innovations Developed in Cooperation with Client Firms	10,022	0.07	-
Technological Innovations Developed with Equipment or Machinery Supplier	10,022	0.05	-
Technological Innovations Acquired from Business or Industry Association	10,022	0.01	-
Technological Innovations Acquired from Trade Fairs and Study Groups	10,022	0.03	-
Technological Innovations Acquired from Consultants	10,022	0.01	-
Technological Innovations Acquired from Universities or Public Institutions	10,022	0.00	-
Technological Innovations Acquired Internally	10,022	0.71	-
Technological Innovations Acquired from Suppliers/Clients	10,022	0.32	-
Technological Innovations Acquired from Institutions	10,022	0.13	-
Product Innovation	17,723	0.69	-

Source: Authors' calculations using data from the Investment Climate Surveys.
Note: All variables are defined in Table A.1.

Table A3. Sources of Acquisition of Technological Innovations

	Embodied in New Machinery or Equipment	By Hiring Key Personnel	Developed or Adapted Within Establishment	Licensing or Turnkey Operations from International Sources	Licensing or Turnkey Operations from Domestic Sources	Transferred from Parent Company	Developed in Cooperation with Client Firms	Developed with Equipment or Machinery Supplier	From Business or Industry Association	Trade Fairs and Study Groups	Consultants	From Universities or Public Institutions
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Majority Foreign-Owned	-0.081	-0.009	0.006	-0.004	-0.058	0.191	-0.017	-0.017	-0.004	-0.011	-0.008	-0.004
	[0.019]***	[0.012]	[0.005]	[0.003]	[0.012]***	[0.021]***	[0.009]*	[0.007]**	[0.005]	[0.003]***	[0.003]***	[0.001]***
Minority Foreign-Owned	-0.059	-0.002	0.010	0.000	-0.039	0.096	0.026	0.006	-0.002	-0.008	-0.004	-0.002
	[0.027]**	[0.014]	[0.008]	[0.006]	[0.016]**	[0.029]***	[0.015]*	[0.013]	[0.005]	[0.006]	[0.004]	[0.002]
Exporter	-0.039	-0.008	0.008	0.000	0.003	0.002	0.015	0.013	0.005	-0.004	0.001	0.001
	[0.016]**	[0.008]	[0.004]**	[0.003]	[0.010]	[0.003]	[0.006]**	[0.006]**	[0.003]*	[0.003]	[0.002]	[0.002]
Importer	0.049	-0.012	0.005	0.000	-0.014	0.007	-0.025	-0.005	-0.009	0.006	-0.002	-0.001
	[0.017]***	[0.009]	[0.004]	[0.003]	[0.011]	[0.003]**	[0.010]**	[0.005]	[0.003]***	[0.003]*	[0.002]	[0.001]
Industry Dummies Included?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log Past per Capita GDP Included?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7329	7329	7329	7329	7329	7329	7329	7329	7177	7177	6785	6366

Source: Authors' calculations using data from the Investment Climate Surveys.

Notes: Each column shows the marginal effects (at mean values) from a probit regression of the source of technological innovation shown in the column heading on international activities. Robust standard errors are in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%. All variables are defined in Table A.1.

Table A4. Determinants of Product and Technological Innovations

	Full Sample	Full Sample	Full Sample	Full Sample	Sample Excluding Firms in Country's Capital City	Sample of High-Tech Industries	Sample of Low-Tech Industries	Sample of Exporters for More than 10 Years and Non-Exporters	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Majority Foreign-Owned	-0.049	-0.039	-0.05	-0.038	-0.050	-0.055	-0.048	-0.051	-0.047
	[0.016]***	[0.018]**	[0.015]***	[0.018]**	[0.017]***	[0.029]*	[0.017]***	[0.017]***	[0.015]***
Minority Foreign-Owned	0.031	0.039	0.035	0.048	0.037	0.023	0.037	0.036	0.029
	[0.017]*	[0.016]**	[0.016]**	[0.020]**	[0.018]**	[0.031]	[0.018]**	[0.016]**	[0.017]*
Exporter	0.042	0.034	0.038	0.056	0.036	0.062	0.034	0.043	0.040
	[0.008]***	[0.009]***	[0.008]***	[0.009]***	[0.009]***	[0.014]***	[0.010]***	[0.008]***	[0.008]***
Importer	0.089	0.081	0.085	0.098	0.091	0.075	0.094	0.097	0.085
	[0.008]***	[0.009]***	[0.008]***	[0.009]***	[0.009]***	[0.014]***	[0.009]***	[0.009]***	[0.008]***
Manager College Educat. or More		0.042							
		[0.009]***							
Access to External Finance			0.030						
			[0.007]***						
R&D									0.072
									[0.013]***
Observations	16,719	14,618	16,719	14,644	12,042	5,971	10,748	14,602	16,719
Industry Dummies Included?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies Included?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Log Past per Capita GDP Includec	No	No	No	No	No	Yes	No	No	No

Source: Authors' calculations using data from the Investment Climate Surveys.

Notes: The dependent variable is a dummy variable equal to 1 if the firm introduced either a technological or a product innovation. The table reports the marginal effects on the firm's propensity to innovate from probit regressions. Clustered standard errors by industry and country are in brackets. * significant at 10%, ** significant at 5%, *** significant at 1%. All regressions include also firm age, size dummies, a public-owned dummy, a training dummy, and the percentage of the workforce with more than secondary education. In column (8), the sample includes all non-exporters but only the exporters that began exporting more than 10 years prior to the survey year. All variables are defined in Table A.1.