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Determinants of Technology Adoption in Mexico

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Abstract

López-Acevedo tries to identify the impact of firm-, region-, and industry-specific characteristics on technology adoption by Mexican firms. Cross-sectional and panel data from 1992–99 show that the firms most likely to adopt new technology are large, train workers, have highly skilled workers, are near the U.S. border, and are owned by foreign entities. Also, bigger firms, firms with a large share of highly skilled workers, and firms that train workers, use intensively more complex technologies in their production process.

This paper—a product of the Latin America and the Caribbean Region, Poverty Reduction and Economic Management Sector Unit—is part of a larger effort in the region to reduce poverty and inequality through human capital investment. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Michael Geller, room I4-046, telephone 202-458-5155, fax 202-522-2112, email address mgeller@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at gacevedo@worldbank.org. February 2002. (40 pages)

Mexico – Technology, Wages, and Employment

DETERMINANTS OF TECHNOLOGY ADOPTION IN MEXICO

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JEL Codes: L60 ; L20 ; J31 and J38.

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1. Introduction

The creation of new knowledge will not necessarily be at the core of Mexico's technological evolution, but rather the adoption and application of existing technological knowledge developed abroad (Bell and Pavitt 1992). In turn, the country's ability to adopt and apply technological knowledge will be crucially shaped by its absorptive capacity, defined as its capability to learn and adopt knowledge developed abroad (Audretsch 1995; Cohen and Levinthal 1989). Moreover, a threshold level of knowledge and technological achievement are prerequisites to developing significant absorptive capacity (Dosi, Pavitt, and Soete 1990; OECD 1997).

Technology diffuses through many channels. Most technology research in Mexico takes place on university campuses and receives government guidance (OECD 2000). Therefore, it is important to measure the impact of government initiatives on new technology adoption (TA) by firms. This paper seeks to identify the impact that TA policies, firm- and industry-specific factors have on TA by Mexican firms.

In this effort, we offer two innovations. First, we present detailed analysis of the heterogeneity involved in TA. Most work uses limited measures of technology, such as research and development (R&D). Our rich data not only allows us to examine the effect of R&D spending, but also to look at different *types* of technology. Second, we measure the effect of policy measures designed to promote TA. By combining location-specific data of firm characteristics with data on government policies and regional structure, we understand better how exogenously determined factors affect TA.

We present this paper in six parts, beginning with the Introduction. Section 2 reviews literature on determinants of TA; Section 3 describes TA patterns in Mexico; Section 4 presents cross-sectional results; Section 5 presents panel data results, and Section 6 offers conclusions.

2 Determinants of Technology Adoption

Technology diffusion occurs when a user adopts technology that the user did not invent. Whenever a firm uses a technology developed by another company, the firm experiences the benefits of technology diffusion. In Mexico, where private R&D investment is very low compared to other countries and new technologies are costly, effective technology diffusion is crucial. In essence, technology diffusion is just a special case of TA.

In an analysis of Mexico, Blomstrom, Kokko, and Zejan (1992) investigate what policy measures encourage multinational corporations (MNCs) to bring technologies into countries outside their headquarters. Since much technology used in Mexico is developed outside of Mexico, such encouragement can be crucial. They find that local competition most encourages imports of technology by MNC subsidiaries. Thus, a way to maximize the inflow of modern technology is to create a competitive environment in which firms must operate.

Foreign direct investment (FDI) is the major technology diffusion channel in developing countries like Mexico (OECD 2000). Since MNCs undertake much of international R&D, they also determine international technology flows. Most developing countries have limited R&D budgets and heavily depend on foreign-developed technology. It may be that MNC subsidiaries use advanced technologies in international markets and provide technical training to local firms through FDI and worker training, thereby adding to the country's human capital base and increasing technology through FDI.

Others doubt that the technology of MNCs benefits local producers (Blomstrom and Kokko 1998). Some authors argue that MNCs keep technology within their own control, so geographic technology transfer occurs but technology diffusion to other companies does not (Cantwell 1989; Haddad and Harrison 1993; Aitken and Harrison 1992). Blomstrom (1989) suggests that technology transfers to domestic firms come from spillovers rather than from formal transactions (Caves 1974; Globerman 1979; Blomstrom and Persson 1983; Blomstrom and Wolff 1994).

Besides investigating what kind of environment encourages TA, research also examines what firm-type is most likely to adopt technology. Firm size is a widely-recognized determinant of TA. Larger firms tend to support the high costs of new technology, and may find a broader range of technologies that meet their needs. The larger a firm's size, the more technology it adopts. Several studies have confirmed this finding (Mansfield 1961; Davies 1979; Romeo 1975; Globerman 1975), and it may be the most robust determinant of TA.

Trade liberalization is a major tool of increasing competition, and in support of Blomstrom and others (1992), several studies correlate liberalization with technology diffusion (Grossman and Helpman 1991, Romer 1994, and Young 1991, find that trade liberalization contributes to economic growth through productivity growth). Liberalization increases the variety of intermediate inputs to manufacturing, facilitates knowledge-transfers, amplifies learning-by-doing effects, and increases the size of consumer markets. These changes encourage diversification within a firm and, correspondingly, TA. Romer (1994) argues that trade distortions may effect productive efficiency by preventing the implementation of new technology, and by limiting the incentive to develop new products. Iscan (1998) finds that after liberalization, total factor productivity (TFP) in Mexican manufacturing increased in conjunction with firm exports.

Firms that export might face more competition abroad and so feel pressure to adopt technology. A recent World Bank and INEGI study (2000) tested the direction of causality between exporting and enterprise performance. The study attempted to relate exports and inter-firm linkages to TA and technical training, but found that the relationship was statistically insignificant.

Another determinant of TA is the availability of appropriately complex technology. Like other variables, its effect is unclear from a theoretical perspective. Some authors argue that the advanced technology used by many MNCs is too complex to improve basic manufacturing in developing countries (Lapan and Bardhan 1973; Cantwell 1989; Haddad and Harrison 1993). Others argue that some technical gap between the host country and the MNC is necessary for the host country to receive any benefit, so spillovers grow proportionally with the technology gap (Blomstrom and Wang 1992; Blomstrom and Wolff 1994).

Torres (2000) provides an interesting result using state-level basic factor analysis. The author finds that science ability, represented by variables like public expenditure on R&D, number of universities, number of published articles, and number of researchers, significantly influences technology diffusion.

In sum, the literature finds that variables such as FDI, local competition, complexity of available technology, trade liberalization, foreign capital in a firm, and regional science ability influence a firm's use of technology. To paint a full picture of technology diffusion, we include a broad array of variables representing all of these factors.

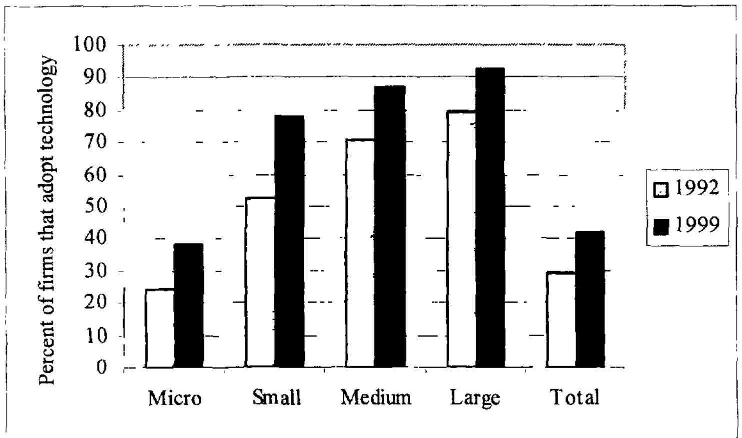
3. Patterns of Technology Adoption: Descriptive Statistics

In this section we discuss what kinds of firms most frequently adopt new technology. We use data from the National Survey of Employment, Salaries, Technology, and Training (ENESTYC) for 1992 and 1999.

Since this section uses simple statistical averages rather than regressions controlling for relevant variables, the reader should not interpret cause (size encourages adoption) from correlation (larger firms adopt more). Studies on technology diffusion in North America and Europe identify firm size as a significant determinant of TA; Figure 1 shows similar results for Mexico. In 1999, while more than 40 percent of all Mexican manufacturing firms adopted some type of new technology, the exact share increases in conjunction with firm size. While only 38 percent of microenterprises adopted new technology, 78 percent of small enterprises, 87 percent of medium-size enterprises, and 93 percent of large enterprises adopted new technology in 1999.

The relationship between TA and firm size did not change between 1992 and 1999. But TA was considerably lower in 1992 for all firm sizes than it was in 1999. Prior to trade liberalization, less than 30 percent of firms had engaged in TA—microenterprises had a TA rate of just under 25 percent, small enterprises had a TA rate of 53 percent, medium-size enterprises had a TA rate of 71 percent, and large enterprises had a TA rate of 80 percent.

Figure 1. TA by Firm Size, 1992 versus 1999



Source: Author's calculations based on ENESTYC 92 and 99.

Table 1 shows that TA in 1999 varies considerably between different types of technology, decreasing with the complexity of the technology adopted.[2] The TA rate varies from 20 percent for manual equipment to 0.8 percent for computerized numeric controlled machinery (CNCM). Large firms are the most likely to adopt robots. However, adoption rates for numeric controlled machinery (NCM) and CNCM vary considerably across firm size. Only 0.6 percent of microenterprises had adopted numeric controlled or computerized technology. However, 10.4 percent of small enterprises, 16.6 percent of medium-size enterprises, and 21 percent of large enterprises adopted this kind of technology. Thus, larger firms seem to adopt more complex technology than their smaller counterparts.

Table 1. TA by Technology Type and Firm Size, 1999

Type of technology	Percent of firms that adopt technology				
	Micro	Small	Medium	Large	All
Manual equipment	20.0	18.2	12.8	6.5	19.7
Automatic equipment	10.6	22.4	18.7	16.4	11.5
Machinery tools	7.2	26.7	38.6	47.3	9.3
NCM	0.5	4.4	4.9	5.5	0.9
CNCM	0.1	6.0	11.7	15.5	0.8
Robots	0.0	0.0	0.7	1.5	0.0

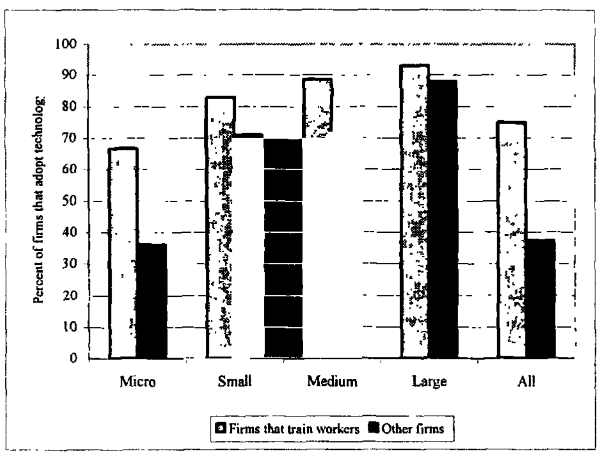
Source: Author's calculations based on ENESTYC 99.

[2] Annex 1 shows descriptive statistics for 1992.

The propensity of TA for firms engaged in training their workers also increases in conjunction with firm size. While TA rates and reliance on worker training positively correlate, the links between them vary considerably across firm size. Figure 2 shows that only 36 percent of microenterprises without training adopted technology, but 67 percent of the microenterprises that did provide training adopted technology. This difference in TA by training condition is less noticeable for large firms, where 88 percent of the firms without training adopted technology versus 93 percent of the firms that train workers.

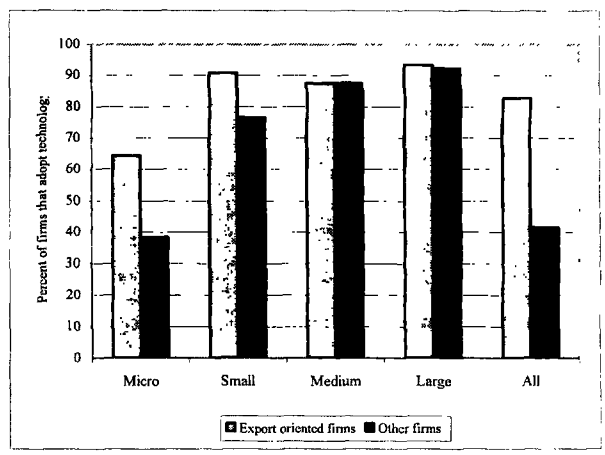
Figure 3 shows that export-oriented firms have higher TA rates (83 percent) than non-export oriented firms (41 percent). This rate varies by firm size, but as in the training case, the difference in TA between export-oriented firms and other firms is much higher for microenterprises than for other firm sizes.

Figure 2. TA by Training and Firm Size, 1999



Source: Author's calculations based on ENESTYC 99.

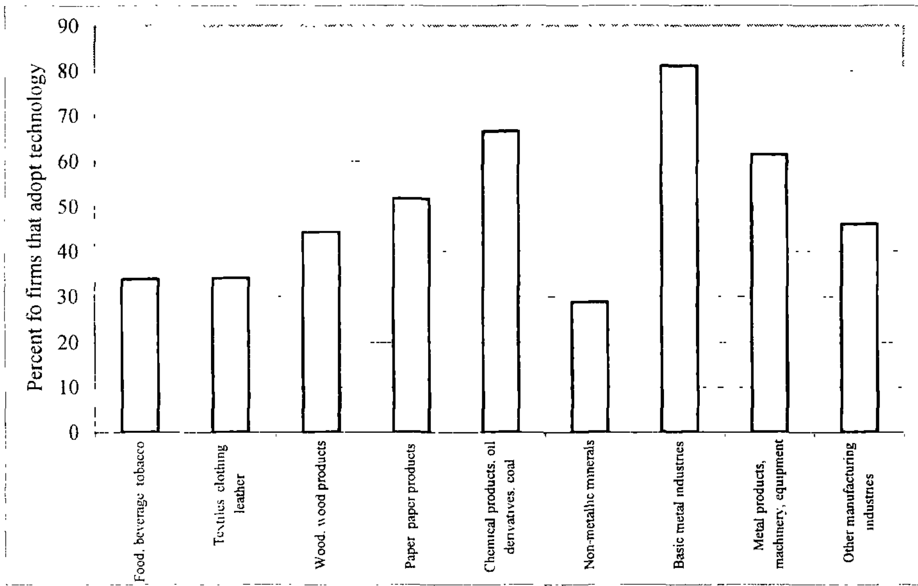
Figure 3. TA by Export Status and Firm Size, 1999



Source: Author's calculations based on ENESTYC 99.

Figure 4 shows that TA rates vary between different manufacturing industries. TA is relatively high in basic metal industries (81 percent), chemical products, oil derivatives, and coal (67 percent), and metal products, machinery and equipment (61 percent). Just as TA varies across industries, it also varies for each firm size within an industry (Table 2).

Figure 4. TA by Industry, 1999



Source: Author's calculations based on ENESTYC 99.

Table 2. TA by Industry and Firm Size, 1999

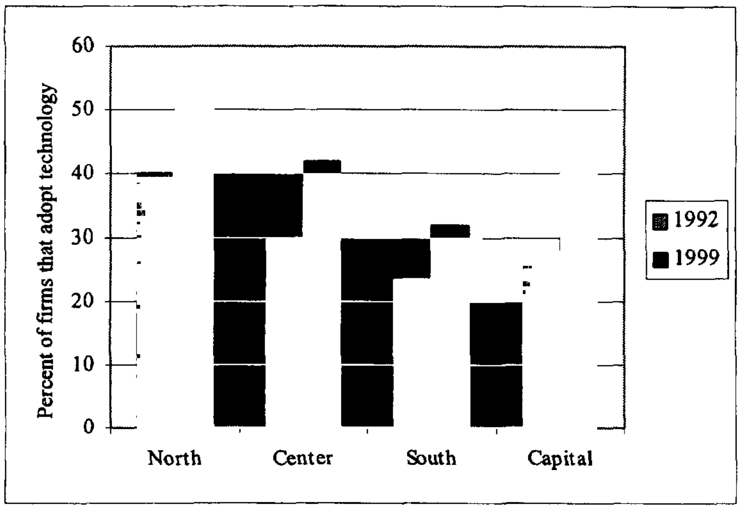
Division	Percent of firms that adopt technology				
	Micro	Small	Medium	Large	All
Food, beverage, tobacco	32.1	66.2	86.3	91.6	33.9
Textiles, clothing, leather	26.2	84.6	86.1	92.4	34.2
Wood, wood products	42.5	78.5	77.4	85.9	44.3
Paper, paper products	47.6	81.9	79.1	89.7	51.8
Chemical products, oil derivatives, coal	55.6	77.6	91.8	94.6	66.6
Non-metallic minerals	27.0	65.5	86.3	88.0	28.8
Basic metal industries	61.2	89.8	87.6	98.0	81.1
Metal products, machinery, equipment	58.4	83.7	91.4	94.0	61.5
Other manufacturing industries	43.6	62.4	89.1	97.1	46.2

Source: Author's calculations based on ENESTYC 99.

TA also varies within regions, with firms located in the North having the highest adoption rates. As Figure 5 shows, in 1999, 53 percent of Northern firms adopted technology, 43 percent of firms in the Capital adopted technology, 41 percent of firms in the Center region adopted technology, and only 32 percent of Southern firms adopted technology. We also observe that TA increased within each region between 1992 and 1999.

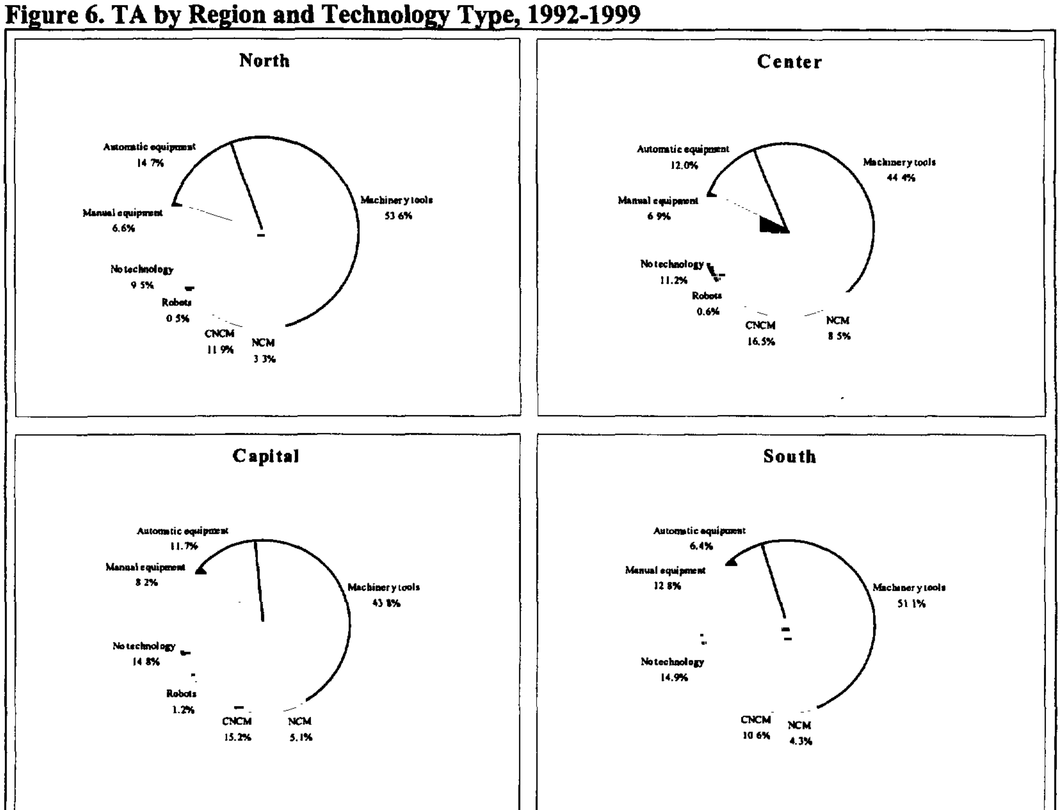
Figure 6 shows the adoption of different technology types by region. We observe that more than 25 percent of firms in the Central region adopt more complex technology (NCM, CNCM, and robots). In the South only 15 percent of firms adopt more complex technology. The most prevalent technology in all regions is machinery tools.

Figure 5. TA by Region, 1992 versus 1999



Source: Author's calculations based on ENESTYC 92 and 99.

Figure 6. TA by Region and Technology Type, 1992-1999



Source: Author's calculations based on the ENESTYC 1992-99 panel.

4. Technological Adoption: The Cross-Sectional Approach

4.1. Methodology

As Kokko (1994) notes, empirical approaches to technology transfer generally model labor productivity of local firms as a function of the market share of multinational subsidiaries and of the other variables described in section 2 (Caves 1974; Globerman 1979; Blomstrom and Persson 1983). If evidence shows that the presence of multinational corporations (MNCs) increased the labor productivity of local firms, a study concludes that spillovers took place.

Grether (1999) uses a different production function to examine Mexico.[3] The author first estimates a firm's multifactor productivity. She uses this measure rather than labor productivity because multifactor productivity is not biased by changes in the input mix. In her view, an increase in multifactor productivity may reflect the acquisition of an additional input, so smaller efficiency dispersion suggests superior technology diffusion. She then computes a multivariate regression using plant-specific, sector-specific, and location-specific variables as possible determinants of technology diffusion.

Since the ENESTYC has information on the different *types* of technology that firms adopt, we need not assume (as we would have to in a production function approach) that a new technology input increases productivity.

This section estimates TA likelihood using cross-sectional logits for 1992 and 1999. The advantage of the cross-sectional models is that they enable comparison between TA changed in the early 1990s to TA later in the decade. Since Mexico experienced exogenous shocks during our sample period from the North American Free Trade Agreement (NAFTA) and the 1994 crisis, a sudden structural change took place during our survey. Therefore we expect that patterns from the first part of the 1990s might not continue through the rest of the decade.

In order to understand this change thoroughly, we use three categories of absorptive capacity – firm-, industry-, and region-specific factors. We measure firm-specific factors by including dummy variables for firm sizes, firm age, labor skill level, R&D spending, foreign ownership of the firm, subsidiary firm, export tendency, formal training, maquila status, and union status. We measure firm age in years after startup. Literature provides strong evidence that TA likelihood positively relates to firm age. We know considerably less about the impact of foreign ownership on the likelihood of TA. The absorptive capacity may be greater and the cost of adopting technology lower if a firm has strong links to foreign enterprises. This would suggest a positive relationship, thus the share of capital in the firm held by foreign owners positively correlates with TA.

A skilled and educated workforce also enhances the absorptive capacity of a firm (Cohen and Levinthal 1989). We measure the shares of the firm employment accounted for by highly skilled, semi-skilled, and less-skilled workers. Since highly skilled workers enhance a firm's absorptive capacity, we expect that TA likelihood increases with a firm's skill base. We also expect that worker training to increase human capital increases absorptive capacity. We include a dummy variable reflecting if the trainer that the firm hires comes from the public sector.

Another dimension of absorptive capacity is R&D. Investment in R&D, measured as the share of firm expenditures accounted for by R&D spending, should increase TA likelihood. But this measure does not include investment destined for technological transfer or equipment acquisition. To account for this exclusion, we include a variable that exclusively measures firm's expenditures on technology transfer or equipment acquisition. We expect this variable to positively correlate with TA.

Since R&D from different sources may have different impacts on absorptive capacity, we include dummy variables to reflect five different R&D sources: consulting firms, public research institutions, private research institutions, the non-R&D department of the firm, and the R&D

[3] Alternative methodologies, such as the framework that Fare, Grosskopf, and Lovell (1994) use, allow us to estimate productive efficiency

department of the firm. Clearly, R&D more closely linked to the firm's production will have greater influence on the firm's absorptive capacity.

Since maquilas are foreign assembly plants with distinct industry groups and policy regulation, we measure whether maquilas are more likely to adopt technology.

We measure industry-specific factors by including dummy variables for each of the nine major manufacturing sectors: (1) food, beverages, and tobacco; (2) textiles, clothing, and leather; (3) wood and wood products; (4) paper and paper products; (5) chemicals, oil derivatives, and coal; (6) non-metallic mineral products; (7) basic metal industries; (8) metal products, machinery, and equipment; and (9) other manufacturing industries.

To determine the effect of location, we include three measures of regional science capacity, which we hypothesize to correlate with absorptive capacity: individuals with a science degree, government expenditure on R&D, and researchers registered in the federal or state systems. We measure these as percentages of the population by state.

To develop a fuller understanding of technology, we distinguish between five types of technology that a manufacturing firm may adopt: (1) any type of technology; (2) automatic equipment; (3) machinery tools; (4) CNCM, and (5) robots.

4.2. Empirical evidence

Although we have results of varying significance for all firm, industry, and region specific factors, we only discuss statistically significant results. A tabular presentation of the results from the best logit model appears in Tables A2.1 and A2.2.

A. Any type of technology

Firm factors. Firm size strongly correlates with TA likelihood, as microenterprises are less likely to adopt technology than their larger counterparts. On the whole, TA likelihood positively relates to firm size, even after controlling for factors that could cause bias. In 1999, a firm's age negatively relates to TA likelihood, while there is no significant relationship in 1992. A strong positive relationship between the shares of different skills labor and TA likelihood appears in both years. Firms providing formal training are also more likely to adopt technology. In 1999, public training is positively correlated with the likelihood of TA. TA likelihood correlates both with R&D intensity and with transferred technology. Firm R&D investment promoted TA in both years. In 1999, it appears that R&D from public research institutions, from a firm's own research department or from another department encouraged TA, while in 1992 only R&D from public research institutions encouraged TA. A firm's status as a maquila related negatively to TA likelihood in 1992, but related positively in 1999; the same results appear in subsidiary firms. Union presence positively relates to TA likelihood.

Industry factors. Controlling for firm-specific characteristics, TA likelihood is significantly lower in textiles, clothing, leather, wood, wood products, and in non-metallic mineral product industries than in other industries. Understandably, these are three industries where technology plays little role in production. In contrast, firms in basic metal industries, and firms producing goods that do not fit in one of the eight standard categories exhibit a markedly higher likelihood of TA.

Regional Factors. Science graduates and researchers per capita are positively correlated with the likelihood of TA. But, surprisingly, there is a negative relation with public expenditure in R&D and TA likelihood.

B. Automatic equipment

Firm factors. Small firms have a higher likelihood of adopting automatic equipment than other firms in 1999. The effect of firm age in the likelihood of TA shifted from positive in 1992 to negative in 1999. Foreign ownership firms are less likely to adopt automatic equipment than other firms. Subsidiary firms increase the likelihood of adopting automatic equipment in 1999, but in 1992 subsidiary firms are less likely to adopt automatic equipment. The shares of semi-skilled and low skilled workers positively relate to the adoption of automatic equipment. In 1999, formal training correlates positively and strongly with the likelihood of adopting automatic equipment, but hiring a public trainer correlates negatively with the adoption of this technology. A firm's R&D investment is only significant in 1992. In this year, a firm's investment in technology transfer increases its likelihood of adopting automatic equipment, while the firm's investment in R&D has the opposite effect. Also in 1992, R&D from public institutions increased the likelihood of adopting automatic equipment. Export-oriented firms are more likely to adopt automatic equipment than other firms in 1999, while in 1992 the presence of a union increased a firm's likelihood of adopting automatic equipment.

Industry factors. Adoption of automatic equipment is quite likely in all industries in 1999, but most likely in basic metal industries.

Regional factors. The frequency of science graduates seems to lower the likelihood of adopting automatic equipment in 1999, but it increased the likelihood in 1992. The effect of location changed markedly from 1992 to 1999. In 1992, firms in the Central region were the most likely to adopt automatic equipment and firms in the Capital region were the least likely to adopt automatic equipment. However, in 1999, firms in the Capital region were the most likely to adopt automatic equipment, and firms in the South were the least likely to adopt automatic equipment.

C. Machinery tools

Firm factors. The adoption of machinery tools strongly correlates with firm size, as large firms are more likely to adopt machinery tools than medium firms, which in turn are more likely to adopt machinery tools than small firms. Firms age reduces the likelihood of adopting machinery tools. High shares of semi-skilled and low skilled workers encourage adoption of machinery tools. Formal training strongly and positively correlates with the likelihood of adopting machinery tools, and public training also increases the likelihood of adopting machinery tools. A firm's investment in R&D and technology transfer increases the likelihood of adopting machinery tools. In 1999, R&D from public institutions and a firm's department other than R&D represented a higher likelihood of adopting machinery tools. Maquila firms are less likely to adopt machinery tools than other firms. In 1992, export-oriented firms were less likely to adopt machinery tools than other firms, while in 1999 firms with a union were more likely to adopt machinery tools.

Industry factors. In 1992, the food, beverages, and tobacco industry was the least likely to adopt machinery tools. In 1999, paper and paper products firms were the most likely to adopt machinery tools.

Regional factors. In 1992, prevalence science graduates and researchers decreased the likelihood of adopting machinery tools, but in 1999 their prevalence had no significant effect on the adoption of machinery tools. Firms located in the Capital region were the most likely to adopt machinery tools in 1992. In 1999, a firm's location in the Capital region did not affect its TA likelihood, but firms in the Central and South regions were still less likely to adopt machinery tools than firms in the North.

D. Computerized numeric controlled machinery

Firm factors. The adoption of CNCM also strongly correlates with firm size. Formal training strongly increases the likelihood of adopting CNCM. A firm's investment in R&D positively correlates with the adoption of CNCM in 1999; the same is true of R&D from a firm's department other than R&D.

Industry factors. In 1992, the paper, paper products, and chemical products industries were the most likely to adopt CNCM. In 1999, the metal products, machinery, equipment, paper and paper product industries were the most likely to adopt CNCM.

Regional factors. In 1992, the nearby presence of science graduates and researchers increased a firm's likelihood of adopting CNCM, while public expenditure in R&D reduced the likelihood of adopting this technology type. Firms located in the Capital region were the least likely to adopt CNCM in 1992.

E. Robots

Results for robots are insignificant due to insufficient observations. The proportion of firms that reported adopting robots is very small. Nevertheless, there is a strong correlation between firm size and robot adoption appears despite the small sample.

To relate a variable to technologies of different complexity, we estimated multinomial logit models for 1992 and 1999. These estimations included six types of technology: manual equipment, automatic equipment, machinery tools, NCM, CNCM, and robots. We can order these technology types from simple manual technology to highly complex CNCM and robots. The results appear in Tables A2.3 and A2.4. An increasing importance of firm size and skilled workers with the likelihood of adopting more complex technology can be appreciated.

5. Determinants of Technology Adoption: Panel Estimation

5.1. Methodology

The cross-sectional approach gives us a photo album of single-year snapshots that show TA patterns at different times. Panel data gives us real time video showing how patterns change. To put it in another way, cross-sectional data gives us points on a curve. Panel estimation shows curve slope at different points, but we need both levels and rates of change to fully understand TA. Another benefit of using both types of analysis is that, while results for a particular category may be insignificant for cross-sectional estimation, the results may become significant in panel estimation. In order to understand TA determinants better, we use the following probit model (following Tan (2000)):[4]

$$\Pr(Adopt)_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 Share_t + \beta_3 Region_t + \varepsilon_{it} \qquad (1)$$

where:

$Adopt_{it}$ = a dummy variable denoting technology adoption in period t for firm i;

X_{it},	= a vector of firm attributes; [5]
$Share_t$	= the rate of technology adoption at time period t, differentiated by technology type;
$Region_t$	= the geographical region where the firm is located at time period t;
ε_{it}	= normal regression error.

5.2. Empirical Evidence

Results from the best probit random effects model are shown in Tables A3.1-A3.3. These tables summarize estimations for the 1992-95, 1995-99 and 1992-99 periods. The results distinguish five types of technology: (1) any technology type; (2) automatic equipment; (3) machinery tools; (4) CNCM, and (5) robots.

A. Firm Factors

Size. For the 1992-99 period, medium and large firms, 57 percent and 66 percent respectively, are more likely than micro and small firms (the omitted category) to adopt some type of technology. Large firms are 43 percent more likely to adopt machinery tools and 93 percent more likely to adopt CNCM. Medium-size firms are also more likely than micro and small firms to adopt machinery tools and CNCM. For the 1992-95 period, firm size negatively correlates with TA, while in the 1995-99 period the correlation is positive. This result may come about because NAFTA and the economic crisis of 1994 encouraged medium and large manufacturing firms to acquire technology to compete globally.

Age. Adoption of machinery tools positively relates to firm age, while adoption of automatic equipment negatively relates to firm age. One reason for this is that our sample only includes firms that survived through the entire period. Surviving small firms may be more flexible than surviving large firms.

[4] To control for persistent technology adoption, equation (1) was also estimated following Wooldridge's (2001) methodology. The parameter estimates remain robust to those shown in Annex 3.

Foreign ownership. For the 1992-99 period, foreign ownership increased the probability of adopting automatic equipment and TA overall by 23 percent. For the 1995-99 period, foreign ownership increased the probability of acquiring robots by 42 percent. For the 1992-95 period, foreign ownership had an important influence on the adoption of CNCM.

Skill. Skilled workers and human capital tend to enhance the absorptive capacity of firms (Cohen and Levinthal 1989). We expect that the presence of skilled labor will encourage TA, but that unskilled labor will negatively relate to TA. Results show that, for the 1992-95 period, the number of highly skilled employees positively correlates with TA, and for the 1992-99 period, it positively correlates with the adoption of automatic equipment. The number of professionals, technical employees, managerial employees, and semi-skilled workers shapes a firm's TA patterns.

Training. Intuitively, training workers should enhance a firm's absorptive capacity. The positive and significant coefficient of the training variable in our regression suggests that training does indeed enhance absorptive capacity. For the 1995-99 and 1992-99 periods, training positively correlates with TA. For the 1992-99 period, a firm that trains workers is 20 percent more likely to adopt some type of technology, and 41 percent more likely to adopt CNCM than a firm that does not provide training. For the 1992-95 and 1995-99 periods, training positively correlates with the adoption of more complex technology, like CNCM.

R&D. Firm investment in R&D is also positively related to the adoption of complex technology. Moreover, a firm's investment in technology transfer increases the probability of adopting CNCM in the 1992-95 and 1992-99 periods, and increases the probability of adopting robots in the 1995-99 period.

Maquila. The technology performance of maquila firms differed between 1992-95 and 1995-99. We find that the probability of TA for maquila firms in the earlier period is 10 percent

[5] We lag skill shares by one period (to the previous period's levels) to preclude bias from skill changes that occur during the period of technology adoption. The use of lagged skill shares measures restricts the sample of firms.

higher than for non-maquila firms. However, in the later period, it is 32 percent lower than for other firms.

Exports. For the 1992-95 period, a firm's status as an export-oriented firm positively correlated with TA, and specifically with automatic equipment. However, we observe a negative relationship between exports and the adoption of machinery tools for the 1995-99 period. The 1992-99 period had no significant relations between export-oriented firms and the adoption of different types of technology.

B. Regional Factors

For the 1992-99 period, firms in Mexico City seemed less likely than firms in the North (the omitted category) to adopt some type of technology. There was a similarly strong relationship for the adoption of machinery tools. Surprisingly, for the 1995-99 period, firms in the Central and South regions were more likely to adopt CNCM than firms in the North. For the 1992-95 period, firms in the South and Capital regions were less likely to adopt technology than firms in the North. We can conclude that, in general, firms located in the North are more likely to adopt technology than firms located in other regions.

C. Technology Diffusion Rate

Significant limitations only allow us to estimate technology diffusion for the 1992-99 period. The effect of the technology diffusion rate is positive for the adoption of any type of technology, automatic equipment, and machinery tools, suggesting that a firm is more likely to adopt a technology if other firms are using the technology.

5.3 Technological Intensity

Another measure of TA involves not just whether a firm adopts technology, but the degree to which it uses this technology. We refer to this degree as the *intensity* in the use of new technology. We measure technological intensity as the share of production equipment that the technology accounts for. Tables A3.4-A3.6 compare technological intensity for six types of technology: manual equipment, automatic equipment, machinery tools, NCM, CNCM, and robots.

From the panel tobit estimations for the 1995-99, and 1992-99 periods, we find that intensity in the use of more complex technologies is positively correlated with firm size. However, for the 1992-95 period, we find that the opposite relation: larger firms are negatively correlated with the intensity in the use of more complex technologies. We also find that the share of semi-skilled and unskilled workers, for the 1992-99 period, reduces the intensity in the use of NCM, for the 1995-99 period, reduces the intensity in the use of manual equipment, and for the 1992-95 period increases the intensity in the use of machinery tools.

For the 1992-99 period, training increases the intensity in the use of automatic equipment and CNCM, for the 1995-99 period. For the 1992-95 and 1995-99 periods, training is positively correlated with the use of more complex technologies, while it reduces the use of more simple technologies. We find the same patterns with investments in R&D, for all the three periods, R&D increases the intensity in the use of more complex technologies, while it reduces the intensity in the use of more simple technologies such as manual equipment and machinery tools.

For the three periods, export oriented firms are positively correlated with the intensity in the use of robots, while the presence of a union reduces the intensity in the use of machinery tools. The fact that a firm has joint activities has no effect in the technological intensity. Finally, firms located in the North are related with more intensively use of automatic equipment, and less intensively use of machinery tools, than the other regions.

6. Prolonged Activity

We want to be able to predict the likelihood of a firm's activity at time t+1 by knowing its actions at time t. To summarize this analysis, Table A4.1 shows conditional means for certain types of activity in 1999, given the activities in 1992.

We find consistency in export, training, and technology activities over time. In other words, a firm that receives over half its sales from exports, trains its workers, or adopts technology in 1992 is quite likely to do so again in 1999. In addition worker training precedes and strongly correlates with TA. A firm that did not adopt technology but did train its workers in 1992 has an 89 percent likelihood of adopting technology in 1999. The same phenomenon appears with exports: a firm that exported but did not adopt technology in 1992 has a 79 percent chance of adopting technology in 1999. Although part of this increase in technology adoption between periods is exogenous—TA rates for all firms increased by five to twenty-five percent between 1992 and 1999 (Figure 2)—the exogenous effect cannot explain all of the increase for non-adopting export and training firms.

7. Conclusions

Two main conclusions appear from this paper. First, we can generally predict a firm's TA likelihood by knowing a few of its characteristics. TA likelihood increases with firm size. Firms that train workers, have a high share of skilled labor, have a high proportion of foreign capital, have large R&D budgets, and are located in the North are most likely to adopt new technologies. Moreover, subsidiary firms and firms with a union strongly increase the likelihood of TA in 1999. Firms adopting the most complex technologies are large, train workers, and have large R&D budgets. There is an increasing amount of skilled workers with the likelihood of adopting more complex technology. Also, larger firms, firms with a large share of highly skilled workers, and firms that train workers use intensively more complex technologies in their production process.

Second, public policy can influence TA patterns in two main ways. The first is direct—by sponsoring formal training, funding R&D, or facilitating the formation of clusters or backward linkages, for example. The second mechanism is broader and develops through changes in the external environment. NAFTA, for example, appears to have significantly increased TA likelihood. Overall, TA rates increased considerably between 1992 and 1999.

The OECD (2000) emphasizes that governments can improve the effectiveness of R&D expenditure by supporting proliferation of venture capital and credit institutions. Public/private partnerships with selective participation also maximize the value of government R&D expenditure. These partnerships could take the form of shared seminars, working groups, or regular discussion meetings. Inviting private sector representatives to policy planning meetings offers a good way of integrating public priorities with private needs. Additionally, public research expenditure should focus on basic knowledge and broad findings that can aid a wide variety of industries.

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Annex 1: Technology Adoption Descriptive Statistics for 1992

Table A1.1. TA by Technology Type and Firm Size, 1992

Type of technology	Percent of firms that adopt technology				
	Micro	Small	Medium	Large	All
Manual equipment	6.4	6.6	7.7	4.1	6.4
Automatic equipment	10.4	22.9	23.0	19.2	11.9
Machinery tools	6.6	14.5	25.3	35.6	8.1
NCM	0.2	3.1	6.2	5.0	0.7
CNCM	1.0	5.6	8.1	15.1	1.8
Robots	0.0	0.0	0.3	0.7	0.0

Source: Author's calculations based on ENESTYC 92.

Table A1.2. TA by Training and Export Status by Firm Size, 1992

	Provides formal training		Export oriented	
Firm size	Yes	No	Yes	No
Micro	64.4	21.9	32.2	24.6
Small	63.8	40.8	45.1	53.0
Medium	72.3	65.4	78.7	70.1
Large	81.3	65.1	77.3	79.8
All	66.7	23.2	47.8	28.8

Note: Figures refer to the percent of firms that adopt technology.
Source: Author's calculations based on ENESTYC 92.

Table A1.3. TA by Industry and Firm Size, 1992

Division	Percent of firms that adopt technology				
	Micro	Small	Medium	Large	All
Food, beverage, tobacco	26.9	56.0	69.1	77.7	29.0
Textiles, clothing, leather	10.5	39.7	70.6	78.9	19.1
Wood, wood products	13.1	52.3	67.6	64.4	16.8
Paper, paper products	40.8	71.4	67.6	83.8	45.4
Chemical products, oil derivatives, coal	40.7	58.4	73.4	80.2	52.3
Non-metallic minerals	9.7	38.7	61.7	72.0	12.1
Basic metal industries	70.0	51.3	49.2	74.6	64.3
Metal products, machinery, equipment	34.2	56.9	73.7	82.8	39.1
Other manufacturing industries	68.0	56.3	72.2	86.7	66.8

Source: Author's calculations based on ENESTYC 92.

Annex 2: Cross-Section Estimations

Table A2.1. Likelihood of TA for Manufacturing Firms, 1992

Explanatory Variables	Any type of technology			Automatic equipment			Machinery tools			CNCM			Robots		
	Coeff.		Marg. Ef.	Coeff.		Marg. Ef.	Coeff.		Marg. Ef.	Coeff.		Marg. Ef.	Coeff.		Marg. Ef.
Firm-specific															
Size: Small	0.452	**	0.0851	0.131		0.0101	0.369	*	0.0163	1.565	**	0.0033	22.061		0.0000
Medium	1.068	**	0.2383	-0.058		-0.0045	0.936	**	0.0589	2.089	**	0.0071	24.745		0.0000
Large	1.585	**	0.3651	-0.295		-0.0210	1.495	**	0.1228	2.982	**	0.0187	25.076		0.0000
Age	0.000		0.0000	0.011	**	0.0009	-0.020	**	-0.0008	-0.013		0.0000	0.014		0.0000
Foreign ownership	-0.166		-0.0298	-0.361		-0.0251	0.099		0.0043	0.135		0.0002	0.475		0.0000
Subsidiary	-1.031	**	-0.1412	-1.020	**	-0.0535	-0.097		-0.0037	-0.306		-0.0003	0.771		0 0000
Share of labor: Semi-skilled	0.007	**	0.0013	0.008	**	0.0007	0.013	**	0.0006	-0.002		0.0000	-0.128		0.0000
Low skilled	0.005	**	0.0010	0.007	**	0.0006	0.009	**	0.0004	-0.009		0.0000	-0.124		0.0000
Training	1.334	**	0.2658	0.531	**	0.0452	1.048	**	0.0581	1.431	**	0.0026			
Public training	0.058		0.0103	-0.238		-0.0163	0.111		0.0045	-0.428		-0.0003	0.737		0.0000
R&D	0.065	**	0.0126	-0.031	**	-0.0025	0.045	**	0.0019	0.096	**	0.0001	0.080		0.0000
Technology transfer	0.018	**	0.0034	0.016	**	0.0013	0.005	*	0.0002	0.007		0.0000	0.012		0.0000
Source of R&D.															
Public Institutions	1.025	**	0.2297	1.240	**	0.1606	0.389		0.0191	-1.014		-0.0007			
Private Institutions	0.856		0.1908	0.213		0.0189	0.938		0.0607	-0.547		-0.0004			
Other firm's department	-0.238		-0.0422	0.062		0.0051	-0.808		-0.0236	1.670	**	0.0045	2.454		0.0000
Own firm's R&D dept.	-0.446		-0.0747	0.503		0.0498	-0.562		-0.0182	0.532		0.0007	0.868		0.0000
Maquila	-0.692	**	-0.0957	0.034		0.0024	-1.142	**	-0.0268	0.349		0.0004	-0.624		0.0000
Export oriented	-0.266		-0.0468	0.203		0.0178	-1.353	**	-0.0319	-0.501		-0.0004	0.707		0.0000
Union	0.409	**	0.0712	0.558	**	0.0467	0.300		0.0120	0.244		0.0002	0.140		0.0000
Industry-specific															
Textiles, clothing, leather	-0.853	**	-0.1158	-0.308	*	-0.0197	-0.786	**	-0.0214	1.055	*	0.0016			
Wood, wood products	-0.814	**	-0.1122	-0.168		-0.0114	-2.313	**	-0.0379	0.082		0.0001			
Paper, paper products	0.466	**	0.0920	0.364	*	0.0322	-0.839	**	-0.0235	3.241	**	0.0212			
Chemical products	0.003		0.0006	-0.699	**	-0 0417	0.216		0.0096	1.776	**	0.0048	17.097		0.0000
Non-metallic minerals	-1.380	**	-0.1646	-0.694	**	-0.0393	-1.878	**	-0.0353	-0.635		-0.0005			
Basic metal industries	1.443	**	0.3336	0.015		0.0012	-0.508		-0.0169	0.370		0.0005			
Metal products, machinery	0.296	**	0.0483	0.915	**	0.0818	-1.187	**	-0.0266	0.423		0.0004	17.540		0.0000
Other manufacturing ind.	1.843	**	0.4244	2.246	**	0.3859	-1.237	*	-0.0305	1.000		0.0018			
Region-specific															
Science grad/cap	0.017		0.0032	0.452	**	0.0443	-1.495	**	-0.0336	3.300	**	0.0270	-1.795		0.0000
Researchers/cap	1.846	**	0.4293	0.341		0.0319	-1.184	*	-0.0299	7.324	**	0.6167	-2.964		0.0000
Public exp. in R&D	-0.053	**	-0.0099	0.013		0.0011	0.014		0.0006	-0.272	**	-0.0003	0.130		0.0000
Region:															
Central	-0.304	**	-0.0341	0.606	**	0.0356	-1.444	**	-0.0254	0.567		0.0004	-0.986		0.0000
South	-0.285	*	-0.0365	0.188		0.0115	-1.710	**	-0.0303	-0.738		-0.0004			
Capital	-3.640	**	-0.2393	-3.540	**	-0.0845	3.885	**	0.5049	-9.318	**	-0.0011	2.173		0.0000
Constant	-1.452	**		-4.276	**		0.519			-11.260	**		-33.957		
Number of obs.	5,071			5,071			5,071			5,071			2,022		
Log likelihood	-2414.8016			-1598.7678			-1136.7526			-225.359			-27.2859		
Pseudo R2	0.2095			0.1379			0.2065			0.5118			0.3280		

* Significant at 10% level; **Significant at 5% level.

Note: Dependent variable = 1 if firm adopted any type of technology, 0 otherwise.

Table A2.2. Likelihood of TA for Manufacturing Firms, 1999

Explanatory Variables	Any type of technology		Automatic equipment		Machinery tools		CNCM		Robots	
	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.
Firm-specific										
Size: Small	1.100 **	0.0002	0.570 **	0.0491	0.941 **	0.0691	2.894 **	0.0126	14.937 **	0.0000
Medium	1.311 **	0.0002	0.290	0.0239	1.319 **	0.1233	3.575 **	0.0294	16.861	0.0003
Large	1.760 **	0.0002	-0.029	-0.0021	1.717 **	0.1893	3.789 **	0.0365	17.058 **	0.0004
Age	-0.040 **	0.0000	-0.015 **	-0.0011	-0.015 **	-0.0008	-0.008	0.0000	0.000	0.0000
Foreign ownership	-0.694	-0.0003	-1.346 **	-0.0578	0.426	0.0270	-0.199	-0.0002	0.657	0.0000
Subsidiary	0.541 **	0.0001	0.525 **	0.0445	-0.220	-0.0099	0.459	0.0005	0.608	0.0000
Share of labor: Semi-skilled	0.005 **	0.0000	0.013 **	0.0010	0.008 **	0.0004	0.008	0.0000	0.082	0.0000
Low skilled	0.008 **	0.0000	0.007 **	0.0005	0.007 **	0.0004	0.001	0.0000	0.086	0.0000
Training	0.469 **	0.0001	0.457 **	0.0347	0.405 **	0.0219	1.236 **	0.0018	0.558	0.0000
Public training	0.402 **	0.0001	-0.555 **	-0.0308	0.463 **	0.0277	0.378	0.0004	0.303	0.0000
R&D	2.854 **	0.0003	0.029 **	0.0021	0.043 **	0.0023	0.015	0.0000	0.029	0.0000
Technology transfer	0.371 **	0.0001	-0.056	-0.0040	0.179 **	0.0103	-0.021	0.0000	0.167	0.0000
Source of R&D:										
Public Institutions	2.602 **	0.0003	-0.474	-0.0286	1.439 **	0.1430	-0.830	-0.0005	-0.083	0.0000
Private Institutions	-0.252	-0.0001			-1.507	-0.0431	-0.424	-0.0003		
Other firm's department	3.989 **	0.0003	1.038	0.1170	1.238 **	0.1135	-1.230	-0.0006		
Own firm's R&D dept.	3.197 **	0.0003	0.710 *	0.0701	-0.155	-0.0076	0.396	0.0004	0.860	0.0000
Maquila	0.356 **	0.0001	0.178	0.0129	-0.417 **	-0.0171	-0.020	0.0000	0.026	0.0000
Export oriented	0.527	0.0001	0.654 **	0.0620	0.180	0.0101	-0.283	-0.0002	0.115	0.0000
Union	0.568 **	0.0001	-0.018	-0.0012	0.487 **	0.0288	-0.505	-0.0003	0.788	0.0000
Industry-specific										
Textiles, clothing, leather	0.204 *	0.0000	0.744 **	0.0623	-0.558 **	-0.0207	0.016	0.0000	-0.418	0.0000
Wood, wood products	0.355 **	0.0001	1.615 **	0.1811	-1.664 **	-0.0423	-1.651	-0.0007	-0.300	0.0000
Paper, paper products	0.915 **	0.0002	0.465 **	0.0389	0.602 **	0.0388	1.016 *	0.0015	-0.032	0.0000
Chemical products	0.675 **	0.0001	0.940 **	0.0982	0.257	0.0147	0.393	0.0004	-0.831	0.0000
Non-metallic minerals	0.099	0.0000	0.102	0.0071	-1.487 **	-0.0409	-0.882	-0.0005	0.434	0.0000
Basic metal industries	1.452 *	0.0002	2.139 **	0.3442	-0.405	-0.0179	-0.535	-0.0004	0.038	0.0000
Metal products, machinery	0.776 **	0.0001	1.852 **	0.2034	-1.195 **	-0.0342	1.196 **	0.0015	0.804	0.0000
Other manufacturing ind.	0.960 **	0.0002	1.381 **	0.1730	-0.646	-0.0256	-1.056	-0.0006	0.404	0.0000
Region-specific										
Science grad/cap	0.304 **	0.0001	-0.244	-0.0163	-0.074	-0.0038	0.117	0.0001	0.069	0.0000
Researchers/cap	1.071 **	0.0002	-0.314	-0.0203	0.518	0.0347	-0.586	-0.0004	-0.640	0.0000
Public exp. in R&D	-0.046 **	0.0000	-0.009	-0.0006	-0.026	-0.0014	0.006	0.0000	0.009	0.0000
Region:										
Central	0.068	0.0000	0.117	0.0039	-0.391 **	-0.0084	0.199	0.0002	0.589	0.0000
South	0.164	0.0000	-0.439 **	-0.0233	-0.325	-0.0128	-0.234	-0.0002	2.082	0.0000
Capital	-0.732	-0.0003	2.291 **	0.3249	0.214	0.0111	2.959	0.0119	2.392	0.0000
Constant	-2.192 **		-3.337 **		-2.382 **		-7.898 **		-32.705	
Number of obs.	7,220		7,207		7,220		7,220		7,165	
Log likelihood	-2629.3164		-2216.7957		-1786.7886		-205.736		-9.8271	
Pseudo R2	0.4654		0.1424		0.1998		0.4059		0.4412	

* Significant at 10% level; **Significant at 5% level.

Note: Dependent variable = 1 if firm adopted any type of technology, 0 otherwise.

Table A2.3. Multinomial Logit Results for Technology Adoption in Manufacturing Firms, 1992

Explanatory Variables	Manual equipment		Automatic equipment		Machinery tools		NCM		CNCM		Robots	
	Coeff.	Z-St.	Coeff.	Z-St.	Coeff	Z-St.	Coeff.	Z-St.	Coeff.	Z-St.	Coeff.	Z-St.
Firm-specific												
Size: Small	0.089	0.35	0.317 *	1.90	0.378 *	1 86	1.452 **	2.56	1.128 **	3.14	25.556	0.00
Medium	0.577	1.22	0.520	1.61	1.213 **	3 54	2.168 **	2.97	1 965 **	3.59	28.803	0.00
Large	0.116	0.16	0.742 *	1.69	1.893 **	4.46	2.175 **	2.43	3.052 **	5.00	29.690	0.00
Age	0.005	1.10	0.010 **	2.90	-0.010 **	-2.00	0 015	1.14	-0.012	-1.06	-0.003	-0 04
Foreign ownership	0.376	0.63	-0.140	-0.32	-0.079	-0.18	0.511	0.71	-0.613	-1.00	0.967	0.37
Subsidiary	-1.061 **	-2 42	-1 088 **	-4.39	-0.599 **	-2.19	-1.369 **	-2.03	-1.113 **	-2 27	0.108	0.04
Semi-skilled workers	-0.003	-1.09	0 008 **	4.11	0.012 **	4.67	0.017	1.00	0.004	0 61	-0.132	-0 36
Less skilled workers	0.003	1.46	0.005 **	2.59	0.010 **	4.19	0.009	0.55	-0.003	-0.46	-0 136	-0.38
Training	0.989 **	3.29	0.782 **	4.27	1.388 **	6.28	2.705 **	5.05	2.575 **	7.56	19 443	0.00
Public training	1.008 **	3.10	0.101	0.46	0.559 **	2.34	-0.475	-1.09	-0.306	-0.92	0.939	0 34
Technology transfer	0.026 **	6 35	0.029 **	8.96	0.029 **	8.40	0.019 *	1.75	0.032 **	5.72	0 046	1 17
Maquila	-1.077 **	-4.46	-0.114	-0.84	-1.097 **	-5.37	0.123	0.30	0.866 **	3.28	-0.714	-0.27
Export oriented	0.776	1.54	0.163	0.39	-1.384 **	-2.34	-0.122	-0.12	-0.577	-0.66	0.678	0.23
Union	-0 363	-1.61	0.614 **	4 22	0.398 **	2.17	0.424	0.86	-0.054	-0.17	0.453	0.15
Region-specific												
Science grad/cap	0 861 **	2.87	0.737 **	3.13	-0.976 **	-3.82	0.678	0.61	2.756 **	4.10	-1.244	-0.22
Researchers/cap	0.768	0.71	1.201 **	2.25	0.009	0.01	0.707	0.33	7.100 **	7.35	-2.313	-0.16
Public exp. in R&D	-0.060 *	-1.74	-0.021	-1.08	-0.021	-0.82	0.020	0 25	-0.233 **	-5.89	0.112	0.22
Region:												
Central	0.227	0.92	0.385 **	2.26	-1.471 **	-8.31	0.050	0.07	-0.017	-0.04	-1.254	-0 36
South	0.989 **	3.44	0.038	0.17	-1.443 **	-6.78	-1.027	-0.72	-1.771	-1.54	-32.089	0.00
Capital	1.595	0.89	-4.416 **	-6.19	1.449	1.10	-5.427 *	-1.87	-11.706 **	-9.07	0.138	0.01
Constant	-3.893 **	-7.90	-4.053 **	-10.26	-0.679 *	-1 75	-9.238 **	-4 03	-8.983 **	-7.26	-38 897	

Number of obs. = [illegible] Log likelihood = [illegible] Pseudo R2 = [illegible]

* Significant at 10% level; **Significant at 5% level.

Note: Dependent variable = 1 if firm adopted manual equipment, 2 if firm adopted automatic equipment, 3 if firm adopted machinery tools, 4 if firm adopted NCM, 5 if firma adopted CNCM, 6 if firm adopted robots, and 0 otherwise. The comparison group is no adoption of new technology.

Table A2.4. Multinomial Logit Results for Technology Adoption in Manufacturing Firms, 1999

Explanatory Variables	Manual equipment		Automatic equipment		Machinery tools		NCM		CNCM		Robots	
	Coeff.	Z-St.	Coeff	Z-St.	Coeff	Z-St.	Coeff	Z-St.	Coeff	Z-St.	Coeff	Z-St.
Firm-specific												
Size: Small	0.468 **	2.74	1.281 **	7.61	1.509 **	8.87	1.869 **	4.81	3.607 **	7.64	39.461	1.16
Medium	0.396	0.84	1.392 **	3.15	1.968 **	4.83	1.686 **	2.23	4.439 **	6.40	41.490	1.20
Large	0.142	0.20	1.678 **	2.72	2.556 **	4.56	2.334 **	2.64	5.089 **	6.18	42.186	1.20
Age	-0.056 **	-12.87	-0.042 **	-8.72	-0.040 **	-7.92	-0.049 **	-3.47	-0.043 **	-3.72	-0.036	-0.74
Foreign ownership	-0.793	-1.22	-1.016 *	-1.64	-0.308	-0.56	-0.880	-0.95	-0.265	-0 37	0 450	0 23
Subsidiary	0.189	1.37	0.239	1.55	0.128	0.75	0.500	1.28	0.580	1.53	1.055	0.55
Semi-skilled workers	0.000	0.31	0.013 **	9.97	0.012 **	7.61	0.001	0 24	0.012	1.17	0.074	0.21
Less skilled workers	0.006 **	6.23	0.008 **	5.42	0.009 **	4.93	0.003	0.58	0.003	0.29	0.075	0.22
Training	0.632 **	4.26	0.971 **	6.31	0.900 **	5.32	2.334 **	5.82	1.941 **	4.16	1.334	0.35
Public training	0.422 **	2.06	0.075	0.35	0.831 **	3.99	0.882 **	2.32	0.903 **	2.33	0.950	0.46
Technology transfer	0.740 **	5.20	0.706 **	4.89	0.740 **	5.19	0.564	1.55	0.727 **	3 92	0.959 *	1 75
Maquila	0.065	0 54	0.079	0.54	-0.328 *	-1.84	-0.399	-0.88	-0.222	-0.53	-0.365	-0.19
Export oriented	0.871 **	2.53	1.194 **	3.38	0.575	1.51	0.597	0.91	0.498	0.78	1 029	0.48
Union	0.680 **	4.78	0.281 *	1.70	0.650 **	3.94	0.531	1.37	-0.046	-0.13	1.276	0 52
Region-specific												
Science grad/cap	0.206	1.62	-0.170	-1.10	-0.248	-1.39	-1.165 **	-2.08	0.174	0.25	-0.046	-0.01
Researchers/cap	-0.186	-0.46	-1.033 *	-1.89	-0.556	-0.98	-5.451 **	-3.00	-2.081	-1.02	-1.936	-0.19
Public exp. in R&D	0 014	0.98	0.019	1.02	0 013	0 68	0.190 **	3 18	0.055	0.81	0.044	0.13
Region:												
Central	-0 111	-1.11	-0.083	-0.70	-0.582 **	-4.53	-1.023 **	-2.53	-0.045	-0.09	0.178	0 07
South	-0.182	-1.24	-0.456 **	-2.50	-0.545 **	-2.76	-0 152	-0.27	-0.548	-0.55	1 459	0.41
Capital	-1.399 **	-2.35	2.430 **	2.76	1.093	1.24	5.211 *	1.76	4.415	1.30	4.441	0.25
Constant	-1.190 **	-5.21	-1.716 **	-6.14	-1.844 **	-5.77	-2.998 **	-3.01	-6 945 **	-4.69	-54.322	

Number of obs. = 7,220 Log likelihood = [illegible] Pseudo R2 = [illegible]

* Significant at 10% level; **Significant at 5% level.

Note: Dependent variable = 1 if firm adopted manual equipment, 2 if firm adopted automatic equipment, 3 if firm adopted machinery tools, 4 if firm adopted NCM, 5 if firma adopted CNCM, 6 if firm adopted robots, and 0 otherwise. The comparison group is no adoption of new technology.

Annex 3: Panel and Intensity Estimations

Table A3.1. Probit Results for TA in Manufacturing Firms, 1992-1995

Explanatory Variables	Any type of technology		Automatic equipment		Machinery tools		CNCM		Robots	
	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.
Firm-specific										
Size: Medium	-0.4654 **	-0.0948	-0.1252	-0.0192	-0.3380 **	-0.0504	-0.5987 **	-0.0639	-0.4280	-0.0049
Large	-0.9472 **	-0.1994	-0.4574 **	-0.0701	-0.8626 **	-0.1211	-1.1654 **	-0.1118	-7.8429	-0.0166
Age	-0.0008	-0.0002	-0.0036 *	-0.0007	0.0051 **	0.0010	-0.0031	-0.0005	-0.0198	-0.0003
Foreign ownership	0.3595 **	0.0750	0.1187	0.0195	0.0139	0.0023	0.2407 **	0.0327	0.6557	0.0118
Labor: Highly skilled	0.0076 **	0.0019	0.0037	0.0007	0.0041	0.0008	-0.0056	-0.0008	0.0115	0.0002
Semi-skilled	0.0001	0.0000	-0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000
Low skilled	0.0002 **	0.0001	-0.0001	0.0000	0.0002 *	0.0000	0.0001	0.0000	0.0000	0.0000
Training	0.0800	0.0065	-0.0704	-0.0043	0.0934	0.0059	0.1244 *	0.0062	0.2719	0.4876
R&D	0.0045 **	0.0011	0.0009	0.0002	0.0032 **	0.0006	0.0044 **	0.0007	0.0026	0.0000
Technology transfer	0.4148 **	0.1023	-0.0251	-0.0048	0.0855 *	0.0169	0.2501 **	0.0410	-0.4019	-0.0054
Maquila	0.0977 *	0.0183	0.0469	0.0068	0.0672	0.0099	0.1196	0.0140	-0.2756	0.4876
Export oriented	0.2516 **	0.0601	0.3583 **	0.0709	0.0809	0.0153	0.0300	0.0044	0.1758	0.0030
Union	0.0452	0.0028	-0.0565	-0.0027	0.0265	0.0013	0.1183	0.0046	0.0440	0.0002
Region:										
Central	-0.0828	-0.0115	-0.0187	-0.0020	-0.0782	-0.0083	0.0217	0.0018	0.5478	0.0058
South	-0.1736 *	-0.0403	-0.2052	-0.0348	0.0157	0.0028	-0.1653	-0.0223	-7.6690	-0.0166
Capital	-0.1532 **	-0.0299	-0.0082	-0.0012	-0.2397 **	-0.0347	0.1317	0.0161	0.1930	0.0026
Constant	-0.0658		-0.8221 **		-1.1248 **		-1.4916 **		-2.7130	
Log likelihood	-2033.2656		-1361.4194		-1442.3422		-965.6919		-116.916	

* Significant at 10% level; **Significant at 5% level.

Notes: 1. Dependent variable = 1 if the firm adopted any type of new technology, 0 otherwise.
2. Technology diffusion rate was dropped due to collinearity.
3. Skill shares are lagged one period.
4. Number of observations = 3,293; number of groups = 3,293.

Table A3.2. Probit Results for TA in Manufacturing Firms, 1995-1999

Explanatory Variables	Any type of technology		Automatic equipment		Machinery tools		CNCM		Robots	
	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.
Firm-specific										
Size: Medium	0.4670 **	0.0427	0.0234	0.0024	0.3846 **	0.0531	0.3166 *	0.0338	0.0047	0.0001
Large	0.6922 **	0.0599	-0.0830	-0.0082	0.5115 **	0.0691	0.4888 **	0.0522	0.0429	0.0007
Age	-0.0031	-0.0005	-0.0045 *	-0.0008	0.0025	0.0006	-0.0004	-0.0001	-0.0032	-0.0001
Foreign ownership	0.1491	0.0222	-0.0827	-0.0130	-0.0010	-0.0002	0.1257	0.0208	0.4161 *	0.0137
Labor: Highly skilled	0.0078	0.0014	0.0028	0.0005	0.0041	0.0010	0.0020	0.0004	-0.0305	-0.0010
Semi-skilled	0.0003	0.0000	-0.0006 **	-0.0001	0.0002	0.0000	0.0002	0.0000	0.0000	0.0000
Low skilled	-0.0001	0.0000	0.0000	0.0000	-0.0001	0.0000	-0.0001	0.0000	0.0003	0.0000
Training	0.3956 **	0.0084	-0.1443	-0.0032	0.0416	0.0013	0.7484 **	0.0172	4.4212	0.0221
Technology transfer	-0.0585	-0.0106	-0.1000	-0.0179	-0.0972	-0.0240	0.1147	0.0218	0.1836 **	0.0064
Maquila	-0.3195 **	-0.0491	-0.1085	-0.0158	-0.0492	-0.0099	0.0517	0.0078	-0.4858	-0.0105
Export oriented	0.0349	0.0056	0.0480	0.0081	-0.1747 *	-0.0392	0.0374	0.0064	0.2439	0.0079
Union	-0.1668	-0.0034	-0.1807	-0.0037	-0.0505	-0.0014	-0.0543	-0.0011	4.4508	0.0205
Region:										
Central	-0.0087	-0.0009	-0.0751	-0.0076	-0.1640 **	-0.0226	0.2613 **	0.0278	0.1181	0.0022
South	0.0580	0.0095	-0.3375 *	-0.0533	-0.0439	-0.0102	0.2899 *	0.0535	0.1829	0.0059
Capital	-0.1519	-0.0207	-0.0628	-0.0085	-0.0847	-0.0156	0.1895	0.0270	0.3241	0.0086
Constant	0.2471		-0.5688 **		-0.5561 **		-2.4005 **		-11.0014	
Log likelihood	-598.6809		-654.0883		-1146.5922		-679.9884		-95.0515	

* Significant at 10% level; **Significant at 5% level.

Notes: 1. Dependent variable = 1 if the firm adopted any type of new technology, 0 otherwise.
2. Technology diffusion rate was dropped due to collinearity.
3. Skill shares are lagged one period.
4. Number of observations = 1,702; number of groups = 1,702.

Table A3.3. Probit Results for TA in Manufacturing Firms, 1992-1999

Explanatory Variables	Any type of technology		Automatic equipment		Machinery tools		CNCM		Robots	
	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.	Coeff.	Marg. Ef.
Firm-specific										
Size: Medium	0.5677 **	0.0626	0.2373	0.0351	0.2987 **	0.0610	0.6368 **	0.0712	-0.1330	-0.0017
Large	0.6572 **	0.0583	0.0310	0.0037	0.4350 **	0.0682	0.9297 **	0.0843	-0.2672	-0 0026
Age	-0.0009	-0.0001	-0.0037 *	-0.0009	0.0041 **	0.0010	-0.0017	-0.0003	-0.0081	-0.0002
Foreign ownership	0.2797 **	0.0387	0.2369 **	0.0502	-0.0750	0.0000	0.0566	0.0076	0.2455	0.0055
Labor: Highly skilled	0.0109 *	0.0019	0.0063 *	0.0015	0.0022	0.0191	-0.0045	-0.0008	0.0112	0.0003
Semi-skilled	0.0003	0.0001	-0.0004 **	-0.0001	0.0001	0.0187	0.0001	0.0000	0.0003 *	0.0000
Low skilled	0.0004 *	0.0001	0.0002	0.0000	0.0001	0.0186	0.0001	0.0000	0.0000	0.0000
Training	0.2106 **	0.0058	-0.0678	-0.0025	0.1057	0.0221	0.4147 **	0.0103	4.3972	0.0197
R&D	0.0029	0.0006	0.0013	0.0003	0.0014	0.0190	0.0021	0.0004	0.0035	0.0001
Technology transfer	0.0774	0.0139	-0.1456	-0.0366	0.0138	0.0209	0.1262 *	0.0221	0.0289	0.0007
Maquila	-0.0944	-0.0114	-0.0803	-0.0160	0.0280	0.0257	0.0957	0.0142	-0.3871	-0.0061
Export oriented	0.0631	0.0106	-0.0993	-0.0234	-0.1565	-0.0159	0.2328	0.0396	-0.0895	-0.0017
Union	-0.1130	-0.0019	-0.1685	-0.0038	-0.1420	0.0155	-0.0275	-0.0005	4.9396	0.0123
Region:										
Central	-0.1264	-0.0112	-0.0158	-0.0018	-0.2335 **	-0.0077	0.1500	0.0129	0.1647	0 0018
South	-0.2131	-0.0387	-0.1804	-0.0421	-0.1246	-0.0077	0.0351	0.0063	-5.6082	-0.0226
Capital	-0.2012 *	-0.0310	0.0218	0.0042	-0.3380 **	-0.0403	0.2027	0.0277	0.3089	0.0057
Technology diffusion rate	0.0407 **	0.0087	0.5701 **	0.1411	0.0476 **	0.0300	0.0194	0.0034	-0.4093	-0.0081
Constant	-2.3784 **		-9.2729 **		-1.9412 **		-2.6713 **		-11.3325	
Log likelihood	-1016.1305		-837.4122		-1253.5804		-833.0133		-84.3751	

* Significant at 10% level; **Significant at 5% level.

Notes: 1. Dependent variable = 1 if the firm adopted any type of new technology, 0 otherwise.
2. Skill shares are lagged one period.
3. Number of observations = 2,089; number of groups = 1,066.

Table A3.4. Tobit Results for TI in Manufacturing Firms, 1992-1995

Explanatory Variables	Manual equipment		Automatic equipment		Machinery tools		NCM		CNCM		Robots	
	Coeff.	Z-St.	Coeff	Z-St.	Coeff	Z-St.	Coeff	Z-St.	Coeff	Z-St.	Coeff	Z-St.
Firm-specific												
Size: Medium	5.101 **	5.02	-5.891 **	-5.15	7.446 **	5.45	-1.774 **	-2.88	-2.867 **	-5.03	-0.478 **	-2.30
Large	14.941 **	9.69	-10.576 **	-6.14	3.093	1.51	-5.231 **	-5.61	-5.928 **	-6.92	-0.719 **	-2.29
Age	-0.019	-0.79	0.018	0.66	0.009	0.28	0.015	1.04	-0.028 **	-2.06	-0.004	-0.89
Foreign ownership	1.714	1.53	2.825 **	2.23	-8.055 **	-5.32	-0.350	-0.51	1.269 **	2.01	0.314	1.37
Semi-skilled workers	-0.015	-0.50	-0.002	-0.06	0.118 **	3.18	-0.017	-0.98	0.024	1.53	0.003	0.59
Less skilled workers	-0.019	-0.64	0.004	0.11	0.150 **	4.07	-0.023	-1.35	-0.003	-0.17	0.003	0.49
Training	0.885	1.08	1.902 **	2.20	-2.342 **	-2.30	0.653	1.36	-0.439	-1.03	-0.037	-0.23
R&D	-0.066 **	-2.89	0.125 **	5.26	-0.067 **	-2.37	0.002	0.15	0.077 **	6.53	-0.007	-1.51
Technology transfer	-2.166 **	-2.11	1.368	1.24	-1.947	-1.49	0.768	1.26	1.885 **	3.45	-0.129	-0.63
Maquila	1.139	1.23	-2.126 **	-2.05	-0.649	-0.53	-0.024	-0.04	0.447	0.87	0.114	0.60
Export oriented	-0.325	-0.17	-2.542	-1.24	1.650	0.67	0.268	0.24	0.634	0.62	0.692 *	1.84
Union	-0.568	-0.56	2.771 **	2.50	-2.537 *	-1.92	0.432	0.71	-0.588	-1.07	-0.209	-1.03
Joint activities	0.036	0.62	-0.003	-0.05	-0.026	-0.36	0.048	1.41	-0.025	-0.81	0.001	0.07
Industry specific												
Food, beverages, tobacco	-1.225	-0.95	4.310 **	2.96	-0.983	-0.57	-2.216 **	-2.83	0.075	0.10	-0.368	-1.39
Textiles, clothing, leather	-0.466	-0.35	-6.890 **	-4.63	8.701 **	4.89	-0.449	-0.56	0.297	0.40	-0.246	-0.91
Wood, wood products	0.010	0.01	-11.397 **	-5.08	18.706 **	6.98	-2.379 **	-1.97	-1.255	-1.12	-0.350	-0.86
Paper, paper products	-8.078 **	-4.76	-3.102	-1.62	1.027	0.45	4.778 **	4.64	4.727 **	4.96	-0.092	-0.27
Non-metallic minerals	2.137	1.11	-0.784	-0.36	-4.324 *	-1.67	-2.937 **	-2.52	0.632	0.58	0.045	0.11
Basic metal industries	1.513	0.67	-3.788	-1.49	6.047 **	1.99	-2.544 *	-1.86	1.410	1.11	-0.147	-0.32
Metal prod., machinery	1.648	1.30	-10.233 **	-7.24	10.021 **	5.94	-0.643	-0.84	2.324 **	3.31	0.546 **	2.12
Other manufacturing ind.	-2.131	-0.70	-1.974	-0.58	5.967	1.46	0.222	0.12	-0.491	-0.29	0.260	0.42
Exports	-0.071 **	-3.05	-0.047 **	-2.02	0.076 **	2.77	-0.015	-1.09	-0.052 **	-4.52	-0.009 **	-2.10
Region:												
Central	-0.973	-1.02	-1.797 *	-1.67	1.048	0.81	0.122	0.21	0.890 *	1.66	0.047	0.24
South	5.522 **	3.42	-3.939 **	-2.16	-2.741	-1.26	-0.396	-0.40	-1.101	-1.21	-0.245	-0.74
Capital	-1.934 *	-1.71	-3.935 **	-3.08	5.012 **	3.28	0.287	0.42	0.312	0.49	-0.378	-1.63
Constant	22.391 **	6.87	26.997 **	7.65	20.481 **	4.90	8.831 **	4.55	5.541 **	3.17	1.042	1.61
Log likelihood	-31526.285		-31924.904		-33021.772		-28043.063		-27286.233		-20792.54	

* Significant at 10% level; **Significant at 5% level.

Notes: 1. Dependent variable = share of technology use in the production process.

2. Number of observations = 6,586; number of groups = 3,293.

Table A3.5. Tobit Results for TI in Manufacturing Firms, 1995-1999

Explanatory Variables	Manual equipment		Automatic equipment		Machinery tools		NCM		CNCM		Robots	
	Coeff.	Z-St.	Coeff	Z-St.	Coeff	Z-St.	Coeff	Z-St.	Coeff	Z-St.	Coeff	Z-St.
Firm-specific												
Size: Medium	-2.779	-1.62	4.157 *	1.92	-2.804	-1.28	-0.737	-0.76	1.044	0.88	0.098	0.25
Large	-5.122 **	-2.91	8.350 **	3.75	-8.558 **	-3.83	0.634	0.64	3.433 **	2.81	0.578	1.44
Age	-0.006	-0.23	0.008	0.23	0.009	0.25	0.012	0.81	-0.016	-0.82	-0.008	-1.35
Foreign ownership	-0.332	-0.22	-0.906	-0.47	-1.561	-0.80	-1.732 **	-2.03	0.816	0.76	1.779 **	5.10
Semi-skilled workers	-0.118 **	-2.24	0.100	1.51	0.017	0.26	-0.038	-1.26	0.037	1.01	-0.006	-0.46
Less skilled workers	-0.112 **	-2.16	0.066	1.02	0.087	1.30	-0.042	-1.41	-0.010	-0.27	-0.003	-0.27
Training	-3.171 **	-2.14	3.844 **	2.05	-4.337 **	-2.28	0.281	0.33	2.743 **	2.66	0.193	0.56
R&D	-0.073 **	-3.03	-0.012	-0.40	-0.031	-1.00	0.044 **	3.15	0.068 **	4.08	-0.001	-0.19
Technology transfer	-0.492	-0.61	-0.787	-0.77	0.089	0.09	0.723	1.56	-0.331	-0.59	0.208	1.10
Maquila	0.085	0.07	0.064	0.04	-0.805	-0.51	0.139	0.20	0.809	0.94	-0.257	-0.91
Export oriented	3.297 *	1.86	-0.842	-0.38	-2.160	-0.96	-0.541	-0.55	0.424	0.34	0.825 **	2.03
Union	-0.084	-0.05	4.099 **	2.02	-4.772 **	-2.35	2.863 **	3.21	-0.930	-0.83	-0.204	-0.56
Joint activities	-0.009	-0.15	0.063	0.80	-0.085	-1.06	-0.012	-0.33	0.023	0.52	0.041 **	2.83
Industry specific												
Food, beverages, tobacco	-0.586	-0.31	5.664 **	2.34	-3.795	-1.59	-1.732 *	-1.66	-0.310	-0.23	0.178	0.42
Textiles, clothing, leather	0.500	0.29	-0.537	-0.25	0.866	0.40	-2.021 **	-2.13	0.524	0.44	0.163	0.42
Wood, wood products	6.598 **	2.23	-7.672 **	-2.05	5.367	1.45	-2.670 *	-1.65	-1.430	-0.70	-0.399	-0.61
Paper, paper products	-10.169 **	-4.38	1.704	0.58	-1.135	-0.39	0.507	0.40	6.311 **	3.91	0.569	1.10
Non-metallic minerals	-0.884	-0.33	-3.956	-1.16	1.162	0.35	-2.964 **	-2.02	3.329 *	1.78	1.473 **	2.46
Basic metal industries	-0.583	-0.18	-2.155	-0.51	3.983	0.96	-1.341	-0.74	-0.384	-0.17	-0.546	-0.73
Other manufacturing ind	-0.268	-0.07	-1.971	-0.38	2.846	0.55	4.078 *	1.81	-3.637	-1.27	-0.489	-0.53
Exports	-0.031	-0.79	-0.202 **	-4.14	0.179 **	3.72	0.016	0.77	0.015	0.54	0.020 **	2.36
Region:												
Central	-0.908	-0.69	-2.188	-1.32	1.963	1.20	0.497	0.70	-0.365	-0.40	0.519 *	1.78
South	3.120	1.40	-7.987 **	-2.82	6.432 **	2.31	-0.804	-0.66	-4.269 **	-2.75	0.050	0.10
Capital	-2.612 *	-1.74	-2.198	-1.16	3.226 *	1.72	0.711	0.87	0.006	0.01	-0.073	-0.22
Constant	40.224 **	7.50	17.318 **	2.56	35.211 **	5.15	6.380 **	2.11	2.260	0.61	0.107	0.09
Log likelihood	-16135.422		-16935.163		-16993.677		-14227.418		-14895.218		-11167.327	

* Significant at 10% level; **Significant at 5% level.

Notes: 1. Dependent variable = share of technology use in the production process.

2. Metal products, machinery, and equipment industry was dropped due to collinearity.

3. Number of observations = 3,419; number of groups = 1,717.

Table A3.6. Tobit Results for TI in Manufacturing Firms, 1992-1999

Explanatory Variables	Manual equipment			Automatic equipment			Machinery tools			NCM			CNCM			Robots		
	Coeff.		Z-St.	Coeff		Z-St.	Coeff		Z-St.	Coeff		Z-St.	Coeff		Z-St.	Coeff		Z-St.
Firm-specific																		
Size: Medium	-5.623	**	-2.88	4.068		1.56	-1.832		-0.69	0.964		0.77	2.580	**	1.97	-0.270		-0.61
Large	-6.505	**	-3.27	7.775	**	2.92	-6.624	**	-2.45	2.100	*	1.65	3.603	**	2.69	0.176		0.39
Age	0.001		0.05	0.024		0.62	0.011		0.28	0.015		0.84	-0.032	*	-1.65	0.002		0.24
Foreign ownership	2.421		1.63	-1.552		-0.78	-0.958		-0.47	-1.227		-1.30	-0.275		-0.27	0.541		1.61
Semi-skilled workers	-0.041		-0.57	0.092		0.96	-0.038		-0.39	-0.106	**	-2.23	0.026		0.53	0.014		0.84
Less skilled workers	-0.045		-0.63	0.081		0.85	0.009		0.09	-0.102	**	-2.16	-0.008		-0.17	0.009		0.56
Training	-0.037		-0.03	4.470	**	2.50	-2.116		-1.16	-0.992		-1.13	1.602	*	1.78	-0.253		-0.81
R&D	-0.033		-1.27	0.055		1.62	-0.066	*	-1.88	0.014		0.80	0.100	**	5.86	-0.005		-0.85
Technology transfer	-1.549		-1.43	-1.222		-0.85	-0.201		-0.14	0.115		0.16	2.074	**	2.88	-0.136		-0.54
Maquila	-0.032		-0.03	-1.687		-1.02	2.581		1.53	-0.164		-0.21	-0.048		-0.06	-0.075		-0.27
Export oriented	-1.536		-0.76	0.171		0.06	-0.856		-0.31	-0.844		-0.65	1.858		1.37	1.784	**	3.86
Union	4.854	**	2.82	-1.898		-0.82	-5.930	**	-2.53	3.051	**	2.77	0.063		0.05	-0.373		-0.95
Joint activities	-0.009		-0.14	0.082		0.97	-0.088		-1.02	-0.010		-0.24	0.048		1.14	0.045	**	3.06
Industry specific																		
Food, beverages, tobacco	1.139		0.61	6.082	**	2.41	-3.699		-1.46	-2.707	**	-2.32	-0.111		-0.09	-0.109		-0.26
Textiles, clothing, leather	-0.047		-0.03	-1.249		-0.55	4.730	**	2.06	-0.372		-0.35	-0.474		-0.42	-0.414		-1.10
Wood, wood products	7.418	**	2.62	-6.518	*	-1.69	6.420	*	1.65	-1.783		-1.00	-1.786		-0.93	-0.542		-0.85
Paper, paper products	-7.701	**	-3.45	-1.888		-0.62	-0.067		-0.02	0.564		0.40	7.818	**	5.16	0.253		0.50
Non-metallic minerals	-0.213		-0.08	4.105		1.12	-3.277		-0.89	-4.801	**	-2.84	2.057		1.12	0.158		0.26
Basic metal industries	2.517		0.86	-4.407		-1.11	6.577		1.64	-2.287		-1.23	-0.966		-0.49	-0.430		-0.65
Other manufacturing ind.	-4.275		-1.19	12.622	**	2.59	-2.560		-0.52	-1.618		-0.71	-3.892		-1.60	-0.887		-1.09
Exports	0.016		0.44	-0.217	**	-4.33	0.199	**	3.95	0.002		0.07	0.024		0.98	0.008		0.94
Region:																		
Central	-2.607	**	-1.98	-2.408		-1.35	4.232	**	2.35	-0.051		-0.06	0.261		0.29	0.205		0.69
South	0.937		0.38	-9.704	**	-2.90	7.343	**	2.18	-0.257		-0.17	-1.273		-0.76	0.050		0.09
Capital	-1.174		-0.77	-4.237	**	-2.04	4.606	**	2.21	-0.062		-0.06	0.436		0.42	-0.196		-0.57
Constant	25.029	**	3.49	20.594	**	2.18	37.265	**	3.85	14.040	**	3.01	0.639		0.13	-0.028		-0.02
Log likelihood	-14657.138			-15518.031			-15599.636			-13326.971			-13362.579			-10037.887		

* Significant at 10% level; **Significant at 5% level.

Notes: 1. Dependent variable = share of technology use in the production process.

2. Metal products, machinery, and equipment industry was dropped due to collinearity.

3. Number of observations = 3,155; number of groups = 1,066.

Annex 4: Transition Matrix

Table A4.1. Transition Matrix for Firms in Year t and t+n, 1992-1999

1992	1999						
Activity	% of firms from the total	Technology Adoption %		Training %		Exports %	
		Continue	Stop	Continue	Stop	Continue	Stop
No Technology Adoption	27.00	70.28	29.72				
Technology Adoption	73.17	78.27	21.73				
No Training	18.00			60.78	39.22		
Training	82.00			93.07	6.93		
No Exports	95.40					3.64	96.36
Exports	4.60					71.43	28.57
Technology Adoption							
Given no training	6.80	65.52	34.48				
Given training	41.20	67.80	32.20				
Given no training and no exports	6.47	65.94	34.00				
Given training and no exports	34.00	67.66	32.34				
Given exports but no training	0.42	57.14	42.86				
Given training and exports	1.30	71.43	28.57				
No Technology Adoption							
Given no training	2.00	28.00	72.00				
Given training	6.70	51.41	48.59				
Given no training and no exports	1.90	26.83	73.17				
Given training and no exports	6.30	49.63	50.37				
Given exports but no training	0.09	50.00	50.00				
Given training and exports	0.32	85.71	14.29				
Training							
Given no adoption and no exports	1.90	88.89	11.11				
Given adoption and no exports	0.00						
Given exports but no adoption	0.32	0.00	100.00				
Given training and exports	1.30	92.86	7.14				
Exports							
Given no adoption and no training	0.00						
Given no adoption and training	0.32	78.57	21.43				
Given adoption and training	1.31	50.00	50.00				
Given adoption	1.60	77.14	22.86				

Source: Author's calculations based on ENESTYC 92 and 99.

APPENDIX A

INEGI has compiled the National Survey of Employment, Salaries, Technology, and Training (ENESTYC). The Ministry of Labor co-designed the questionnaire, which gathered rich information on training, technology, wages, employment, forms of labor contracting, and internal plant organization of Mexican manufacturing firms. The government conducted the survey in 1992, 1995, and 1999, but its questions on technology ask whether the firm adopted technology in the periods 1989-1992, 1994-1995, or 1997-1999, respectively. Our references to the time of technology adoption mention only the final year of the period (e.g. 1992 rather than 1989-1992). Data from the 1992 survey includes 5,071 firms, from the 1995 survey includes 5,242 firms, and from the 1999 survey includes 7,429 firms.

A valuable feature of ENESTYC is that it allows us to identify the same firm in 1992, 1995, and 1999. Nonetheless, we should qualify our estimations with survivor bias. Only firms that exist in all three years can be included in the panel database. As Audretsch (1995) shows, survival likelihood is strikingly low for small and new enterprises and increases with firm size and age. Thus, the panel includes an unrepresentatively high number of large and mature firms. While random observation selection should not cause bias in our resulting estimations, surviving firms are not randomly selected. Darwinian selection of extant firms means that the firms in our sample tend to be more efficient and have better performance than an average Mexican firm.

Another advantage of this database is the broad spectrum of firm sizes included by industry, shown in tables B.1-B.3. The rich information available in ENESTYC allows us to distinguish technology diffusion policies for firms of different size and character.

INEGI also conducts the Annual Industrial Survey (EIA). The survey covers 6,500 manufacturing plants throughout Mexico that account for 80 percent of production in each industry group. Since the survey attempts to cover the majority of manufacturing production but not a majority of plants in all categories, our sample includes all large plants and most medium-sized scale plants, but few small-scale plants and very few microenterpise plants.

We link the ENESTYC panels to firms in the EIA. This allows us to combine EIA data on productivity, labor, value-added, and capital with ENESTYC variables for the plants common to both surveys. The panels also include some regional variables using the Indicators of Scientific and Technology Activity in Mexico from the National Council of Science and Technology (CONACYT). A description of the variables in the panels appears in the Appendix. The 1992-95 panel has 3,293 firms, the 1995-99 panel has 1,717 firms, and the 1992-99 panel has 1,066 firms.

The information on individual establishments that INEGI gathers through its questionnaires (which law requires firms to answer) is legally confidential, and INEGI is unable to give the raw data to outside agencies. Therefore, we followed an established procedure in which most data analysis was done in INEGI's Aguascalientes headquarters with the support of INEGI personnel. Nevertheless, the reader should bear in mind the limitations on data analysis imposed by this institutional arrangement.

APPENDIX B

Table B.1. Manufacturing Firms in the 1992-1995 Panel by Industry and Size

Division	All	Size			
		Large	Medium	Small	Micro
Total	**3,293**	**352**	**576**	**1,099**	**1,266**
Food, beverage and tobacco	669	105	114	163	287
Textiles, clothing, leather	551	36	93	231	191
Wood and wood products	149	28	42	61	18
Paper and paper products	219	16	31	103	69
Chemical products	494	40	94	185	175
Non-metallic minerals	161	45	31	25	60
Basic metal industries	102	13	13	39	37
Metal products, machinery	897	65	147	272	413
Other manufacturing industries	51	4	11	20	16

Source: 1992-95 ENESTYC Panel.

Table B.2. Manufacturing Firms in the 1995-1999 Panel by Industry and Size

Division	All	Size			
		Large	Medium	Small	Micro
Total	**1,717**	**829**	**737**	**145**	**6**
Food, beverage and tobacco	372	232	114	26	
Textiles, clothing, leather	273	133	113	23	4
Wood and wood products	57	19	32	6	
Paper and paper products	146	54	83	9	
Chemical products	306	126	153	26	1
Non-metallic minerals	75	32	33	10	
Basic metal industries	41	21	15	5	
Metal products, machinery	419	198	183	37	1
Other manufacturing industries	28	14	11	3	

Source: 1995-99 ENESTYC Panel.

Table B.3. Manufacturing Firms in the 1992-1999 Panel by Industry and Size

Division	All	Size			
		Large	Medium	Small	Micro
Total	1,066	554	439	72	1
Food, beverage and tobacco	227	154	63	10	
Textiles, clothing, leather	162	70	80	12	
Wood and wood products	36	9	19	8	
Paper and paper products	95	36	52	7	
Chemical products	190	86	87	16	1
Non-metallic minerals	46	34	10	2	
Basic metal industries	36	18	18		
Metal products, machinery	257	138	102	17	
Other manufacturing industries	17	9	8		

Source: 1992-99 ENESTYC Panel.

APPENDIX C

1992-99 Panel Variables Description

Variable	Description	Value
From the ENESTYC		
Firm size	Firm size according to the number of workers: Micro 1 - 15 Small 16 - 100 Medium 101 -250 Large 250 - more	Dummy for each size 1= if the firm belongs to a certain size 0= otherwise.
Division	Manufacturing industries: 1) Food, beverages, and tobacco 2) Textiles, clothing, and leather 3) Wood and wood products 4) Paper, paper products, printing, and publishing 5) Chemicals, oil derivatives, and coal 6) Non-metallic mineral products 7) Basic metallic industries 8) Metallic products, machinery, and equipment 9) Other manufacturing industries	Dummy for each industry 1= if the firm belongs to a certain industry 0= otherwise.
Total workers	Number of workers in the firm.	Continuous
Regions:		Dummies
North	Includes the states of Baja California, Baja California Sur, Coahuila, Chihuahua, Durango, Nuevo León, Sinaloa, Sonora, Tamaulipas, and Zacatecas.	1= if the firm is located in the North, 0= otherwise.
Center	Includes the states of: Aguascalientes, Colima, Guanajuato, Hidalgo, Jalisco, México, Michoacán, Morelos, Nayarit, Puebla, Querétaro, San Luis Potosí, and Tlaxcala.	1= if the firm is located in the Center, 0= otherwise.
South	Includes the states of Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz, and Yucatán.	1= if the firm is located in the South, 0= otherwise.
Capital	Distrito Federal	1= if the firm is located in the Capital, 0= otherwise.
Years	Firm's age.	Continuous
Foreign capital	Percentage of foreign capital in the firm.	Dummy 1= if foreign capital in the firm > 50%, 0= otherwise.
Subsidiary	Subsidiary firm.	Dummy 1= if the firm is a subsidiary, 0= otherwise.
Joint activities	Number of firms with joint activities.	Continuous
R&D	Firm's investment in R&D (it does not include technology transfer or equipment acquisition).	Continuous
Technology transfer	Firm's investment in technological transfer.	Continuous
Technology type	Type of technology that the firm adopts: 1) Manual equipment 2) Automatic equipment 3) Machinery tools 4) Numeric controlled machinery 5) Computerized numeric controlled machinery 6) Robots	Categorical 0= No technology 1= Manual equipment 2= Automatic equipment 3= Machinery tools 4= Numeric controlled machinery 5= Computerized numeric controlled machinery 6= Robots Dummies 1= if the firm adopts a certain type of technology,

		0= otherwise.
Technological intensity	Intensity in the use of a certain type of technology.	Dummy 1= if the use in production of a certain type of technology > 40%, 0= otherwise.
Highly skilled workers	Number of executives and managers in the firm.	Continuous
Semi-skilled workers	Number of production workers in the firm.	Continuous
Unskilled workers	Number of general workers in the firm.	Continuous
Share of highly skilled workers	Share of highly skilled workers from the total of workers in the firm.	Ranks between 0-100
Share of semi-skilled workers	Share of semi-skilled workers from the total of workers in the firm.	Ranks between 0-100
Share of unskilled workers	Share of unskilled workers from the total of workers in the firm.	Ranks between 0-100
Training	Training for workers.	Dummy 1= if firm provides training, 0= otherwise.
Source of training	Source of the training that the firm provides.	Dummy 1= if the training comes from the public sector, 0= otherwise.
Union	Existence of a union in the firm.	Dummy 1= if a union exists, 0= otherwise.
Source of R&D	Source of R&D: 1) Consulting firms 2) Public institutions 3) Private institutions 4) A firm's department other than R&D 5) Own firm's R&D department	Dummy for each source 1= if the firm's R&D is from a certain source, 0= otherwise.
Exports	Firm's market orientation	Dummy 1= if foreign sales > 50%, 0= otherwise.
Maquila	Firms dedicated to maquila activities.	Dummy 1= if maquila 0= otherwise.
Technology diffusion rate	Proportion of firms that adopted technology in a given year.	Ranks between 0-100
From the EIA		
Industry exports	Percentage of exports from total sales, by industry.	Ranks between 0-100
Regional variables from CONACYT		
Science graduates	Percentage of individuals with a degree in Science from the total population, by state.	Continuous
Graduates	Percentage of individuals that got a degree from the total population, by state.	Continuous
Researchers	Percentage of researchers registered in both federal and state systems from the total population, by state.	Continuous
Public R&D per capita	Federal expenditure in R&D per capita, by state.	Continuous
Public R&D	Percentage of the federal expenditure in R&D from the total federal expenditure, by state.	Continuous

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