# THE ADVANTAGES OF ASSOCIATION: KNOW-HOW SHARING AND INNOVATION ADOPTION IN FOUR BRAZILIAN CITIES

by

Isleide R. Zissimos


**Working Paper No. 11-W03**

January 2011

DEPARTMENT OF ECONOMICS
VANDERBILT UNIVERSITY
NASHVILLE, TN 37235

www.vanderbilt.edu/econ

**The Advantages of Association:**
**Know-How Sharing and Innovation Adoption in Four Brazilian Cities.**[1]

Isleide Zissimos
Vanderbilt University
January 2011

**Abstract**

This paper investigates the role of social learning in the diffusion of different types of innovation in four urban areas of Brazil. A unique database of small sized firms in 19 economic sectors is used to show evidence that entrepreneurs who are members of trade associations (TAs) tend to adopt and diversify types of innovation more often than entrepreneurs who are not members. This is tested against two rival hypotheses. The first involves controls for human capital. The second controls for policy and institutional factors, and for internal characteristics of the firms. In both cases membership to TAs is significant. This set of results is robust across different specifications and in different subsamples. In addition, the urban areas where firms are located are also significant predictors of innovation adoption, which is consistent with the literature on geographic clusters of firms. Because membership of a TA can be endogenous, an instrumental variable is introduced.

KEYWORDS: Innovation adoption, know-how sharing, trade associations, small firms, developing country.
JEL CLASSIFICATION NUMBERS: O33, O14, O54, R11

[1] This paper develops work from my Ph.D. thesis. I would like to thank Rick Bond, Bill Collins, Yves Fauré, Lia Hasenclever, Tong Li, Andrea Moro, Adriana Perez, Shabana Singh, Caleb Stroup and Ben Zissimos for useful conversations about this paper. I would also like to thank seminar participants from the Center for Latin American Studies and Department of Economics at Vanderbilt University, the Social Network Conference at Queen Mary University, Fundação Getúlio Vargas and Universidade de São Paulo for comments. I gratefully acknowledge financial support from National Counsel of Technological and Scientific Development (CNPq, Brazil) and Institut de Recherche pour le Développement (IRD, France).

## 1. Introduction

Innovation is fundamental to the process of economic development. Social learning contributes to the diffusion of innovations by helping agents to access new ideas. In the context of developing countries, an emerging branch of the literature on agricultural settings uses theoretical models and quantitative empirical studies to evaluate the effects of social learning on the adoption of new technologies (Foster and Rosenweig 1995; Besley and Case 1994; Bandiera and Rasul 2006; Conley and Udry 2009; Young 2009). In these studies, the basic framework is the introduction of a new seed, fertilizer or other agricultural chemical by a farmer or group of farmers through experimentation or with the support of formal institutions. Other farmers observe, communicate with their neighbors, family or friends and decide whether or not to adopt the new technology. The quantitative analyses then focus on the degree in which these social interactions influence the decision on innovation adoption.

The first contribution of the present paper is to use the same basic framework applied to the context of *urban* settings of a developing country. The second is to identify and quantify in a variety of economic sectors the effect of social learning among small scale entrepreneurs on adoption of innovations in four such settings located in Brazil. In doing so, I use a unique dataset with comprehensive information on characteristics of firms and their owners that I helped to construct with work in the field.

There is already a well developed literature that includes quantitative studies on social learning and innovation in urban settings of *developed* countries.[2] In these studies, the emphasis is on spillovers of knowledge across firms and how they correlate with innovation activity and growth, either in geographic areas with diversity of industries (Jacobs 1969) or in areas with specialized industries (Marshall 1920; Glaeser, Kallal, Sheinkman, and Shleifer 1992, Audretsch and Feldman 1996; Ellison, Glaeser and Kerr 2010). When we compare the results of these studies with the results from agricultural settings in developing countries, not surprisingly the consensus is that social learning has a significant influence on the decision over innovation adoption.

[2] As far as I am aware studies on social learning and innovation adoption for urban settings of developing countries are only qualitative. Examples of such contributions are Schmitz (1982), Von Hippel (1988) and Schmitz and Nadvi (1999).

In the context of urban settings of developing countries there is a lack of rigorous empirical understanding of the extent in which social learning affects innovation. Indeed, the outcome of an analysis for this context arguably cannot be inferred from prior studies set in alternative contexts for two reasons: First, if the results of studies for agricultural settings of developing countries are extrapolated to urban settings of developing countries, various confounding factors that influence the decision on adoption of innovation are omitted. These confounding factors are related to the relatively higher complexity of manufacturing production and can include for example the presence of different types of governmental and non-governmental organizations, more interactions with suppliers and customers or more demands on the skills of the workers. Second, if the results of studies for urban settings of developed countries are extrapolated to urban settings of developing countries, the various constraints imposed by the developing country environment are omitted. These constraints can include the following: Limited enforcement of property rights; lack of access to credit; limited access to external sources of information; and insufficient human capital.

Given the extra factors influencing the innovation adoption decision and the constraints that entrepreneurs face, it would seem reasonable to observe two different types of response by entrepreneurs to such an environment. One would be that they adopt more aggressive competitive practices towards one another, prompting a deterioration of social relations, possibly leading to more extreme actions such as sabotage. A second would be that entrepreneurs might compensate for the constraints that they face through networking. In other words, the same constraints might alternatively drive both entrepreneurs and farmers to rely more on their social connections in order to access basic services such as know-how, and in doing so to improve their economic performance. The present paper attempts to identify and quantify this second type of response among entrepreneurs.

Individual-level data are used to evaluate the innovative behavior of owner-entrepreneurs of micro, small and medium sized firms from 13 sectors located in four municipalities of Rio de Janeiro state. Given the small scale of the businesses in the sample, each entrepreneur has

personal control over all stages of production and sales in the firm that she owns. This allows the use of the behavior of the entrepreneur to proxy the behavior of the firm.

The focus of the empirical analysis is on whether or not firms innovate and the diversification of types of innovation in the sectors referred to above. The term "innovation" refers to the development, adaptation, imitation and/or adoption of a practice or object that is perceived as new to a firm (Dosi 1988: 222). Under this definition, the practice or object may be new to the entrepreneur, and does not exclude the possibility that the innovation already exists elsewhere. Although the definition is general, it is particularly appropriate for the environment of developing countries where the innovation activities are often less sophisticated than the ones observed in developed countries. These types of innovation are: (1) changes in product design; (2) changes in the technical characteristics of a product; (3) introduction of a new product; (4) acquisition of new equipment; (5) automatization; (6) introduction of new management techniques; and (7) adoption of new inputs.

I test the influence of professional interactions between entrepreneurs on the adoption of innovation decision. Higher propensity to establish professional interactions[3] is measured by membership of trade associations (TAs). A TA is a formal organization that represents entrepreneurs' interests where specialized information is provided, such as educational or government programs, and concerns about business can be discussed. Given the ability of TAs to contribute to the establishment of social ties (Granovetter 1973) I assume that members of a TA interact and exchange know-how more often than non-members.

While it is appropriate for research in agricultural settings to give greater prominence to the role of friends and neighbors in the adoption and diffusion of technology, arguably this is not true for urban settings. The reason is that the complexity of the industrial process, which requires technical training and specialized knowledge, excludes friends and relatives from know-how exchange, unless they are engaged in similar businesses. And due to the density and variety of sectors, differently from agricultural settings, neighbors are unlikely to be exclusively engaged in

[3] In the context of this present paper "professional interaction" does not necessarily imply a formal contract between entrepreneurs since it can comprise informal relationships developed through the business practice. In fact, the empirical analysis found that 75% of firms in the sample never had a formal contract with any other firm.

the same sector or chain of production. Therefore, the natural candidates for exchange of know-how are suppliers of inputs and services, customers, or other firms that occupy the same position in the chain of production (through "horizontal relationships"). Although the empirical analysis considers the role of suppliers and customers, this paper concentrates more on the latter.

There are two main issues related to the use of membership of a TA as a variable that explains higher propensity for professional interactions between entrepreneurs. First, it might be endogenous because entrepreneurs self-select to be members. Second, entrepreneurs can become members of TAs without participating actively in them[4]. Hence, TA membership is instrumented by a variable that contains information on engagement of entrepreneurs in random social activities. These social activities include participation in cultural associations, sports clubs, religious groups, neighborhood associations, charity organizations, citizenship groups, environmental groups, and other social associations. The assumption is that if an entrepreneur presents a higher propensity of socializing and in that she is engaged in at least one of these social activities, she is more likely to become a member of TA. This instrument is attractive because it picks out the propensity to socialize driven by a variety of organizations motivated by distinct purposes.

The membership of TA is tested against six categories of controls that were selected based on rival theories of innovation: human capital; sources of information outside the firm; sources of credit and financing; participation in government programs; international trade; and internal characteristics of the firm. The membership of TAs emerges as a significant predictor of innovation diversification and this pattern is robust across a series of specifications. The results show that human capital and access to credit are not predictors of innovation, which is consistent with the general low levels of human capital and the severe credit restrictions observed in the municipalities surveyed. The location effects and some of the internal characteristics of the firm are more significant than these variables. Finally, the presence of a larger exporter also brings about positive spillovers for innovation.

[4] Some of the respondents in the survey for example reported informally that they were satisfied by not greater involvement than receiving the newsletter of the TA monthly because this is enough to keep them well informed.

The paper proceeds as follows. Section 2 gives the background and discusses how firms were selected. Section 3.1 describes the data and different variables used in the regressions while Section 3.2 shows the methodology. Section 4.1 presents the basic results. Section 4.2 discusses briefly sources of spurious regressions. Section 5 presents the robustness checks and section 6 concludes. Complementary figures and tables referred to in the text can be found in the Appendix.

## 2. Selection of Firms and Background

This paper analyzes evidence of the sharing of know-how and the adoption of innovation among entrepreneurs in 13 sectors located in the municipalities of Campos dos Goytacazes, Itaguaí, Macaé, and Nova Friburgo in Rio de Janeiro state, in the southeast of Brazil. The geographic locations of these municipalities are shown on the map in Figure 1 in the Appendix. As in many areas of Brazil, these urban settings present social and economic problems related to poverty, inequality and low levels of human capital. A more detailed description of each municipality can be found also in the Appendix. The purpose of this section is to explain briefly how firms in the database I use were selected and to give an overview of their basic characteristics.

It is important to clarify that the sample design is not intended to represent the economies of the municipalities but rather to capture patterns of the behavior of small scale firms in a variety of sectors. The selection of firms followed two steps. The first mapped all sectors in each municipality and organized them according to the highest GDP shares and/or employment shares. Then, thirteen sectors with a high concentration of micro, small and medium sized firms were chosen ad hoc. The Appendix details the procedure undertaken for the selection of these sectors and describes each municipality.

In the second step, within each sector firms that were registered and not registered in TAs were selected randomly and invited to participate in the survey by phone. Only about 5% of entrepreneurs refused to be interviewed. The number of firms interviewed in the final sample is

500[5]. Because firms were randomly selected there is no reason to suspect any selection bias. Table 1 shows the distribution of firms according to the sector that they are engaged to and whether or not they innovate and whether or not they are a member of a TA. Table A2 in the Appendix shows the descriptive statistics for types of innovation adopted per sector. Note that the number of firms in each individual activity is insufficient for the construction of reliable estimates based on specific types of activities. Instead the investigation focuses on general patterns that can be found across the 13 sector in the sample.

**Table 1:** Innovation adoption and membership of trade associations by sector

| Location/Economic Sectors | Do not innovate | % | Adopt at least 1 innovation | % | Members of TA | % |
|---|---|---|---|---|---|---|
| *Campos* | | | | | | |
| Garments (n=20) | 1 | 0.2 | 19 | 3.8 | 18 | 3.6 |
| Furniture (n=20) | 11 | 2.2 | 9 | 1.8 | 1 | 0.2 |
| Construction (n=20) | 12 | 2.4 | 8 | 1.6 | 3 | 0.6 |
| Clay products (n=20) | 2 | 0.4 | 18 | 3.6 | 19 | 3.8 |
| Food products (n=20) | 8 | 1.6 | 12 | 2.4 | 7 | 1.4 |
| Agro-industry (n=45) | 10 | 2 | 35 | 7 | 36 | 7.2 |
| Campos Total | 44 | 8.8 | 101 | 20.2 | 84 | 16.8 |
| *Itaguaí* | | | | | | |
| Transport (n=31) | 8 | 1.6 | 23 | 4.6 | 21 | 4.2 |
| Construction (n=37) | 15 | 2.2 | 22 | 4.4 | 17 | 3.4 |
| Extractive industry, smelting, metallurgy, machines and equipment (n=23) | 0 | 0 | 23 | 4.6 | 14 | 2.8 |
| Services to firms (n=9) | 3 | 0.6 | 6 | 1.2 | 4 | 0.8 |
| Itaguaí Total | 26 | 4.4 | 74 | 14.8 | 56 | 11.2 |
| *Macaé* | | | | | | |
| Commerce for industries (n=38) | 29 | 5.8 | 9 | 1.8 | 15 | 3 |
| Oil industries and related services (n=73) | 35 | 7 | 38 | 7.6 | 51 | 10.2 |
| Industrial services and personal technical services (n=39) | 33 | 6.6 | 6 | 1.2 | 18 | 3.6 |
| Macaé Total | 97 | 19.4 | 53 | 10.6 | 84 | 16.8 |
| *Friburgo* | | | | | | |
| Garments (n=70) | 1 | 0.2 | 69 | 13.8 | 46 | 9.2 |
| Textiles (n=7) | 1 | 0.2 | 6 | 1.2 | 3 | 0.6 |
| Metal products, equipments (n=8) | 0 | 0 | 8 | 1.6 | 8 | 1.6 |
| Construction (n=6) | 1 | 0.2 | 5 | 1 | 6 | 1.2 |
| Tourism (n=5) | 1 | 0.2 | 4 | 0.8 | 4 | 0.8 |
| Commerce of textile products (n=9) | 4 | 0.6 | 5 | 1 | 5 | 1 |
| Friburgo Total | 8 | 1.4 | 97 | 19.4 | 72 | 14.4 |
| Total | 175 | 35 | 325 | 65 | 296 | 59.2 |

Table 1 also shows that the majority of firms in the sample adopt at least one type of innovation and the total number of adopters is slightly smaller than the number of entrepreneurs who are

[5] For the regression analysis some observations are removed because of missing data.

members of trade associations. Table 2 shows the distribution of firms in the sample according to their size in terms of numbers of workers and shows that the majority of firms (83%) are small sized.

**Table 2:** Size of firms according to the number of workers

| Number of workers | Frequency | % | Cumulative % |
|---|---|---|---|
| 0 workers | 32 | 6.4 | 6.4 |
| 1 ≤ workers < 9 | 210 | 42.0 | 48.4 |
| 10 ≤ workers < 49 | 173 | 34.6 | 83.0 |
| 50 ≤ workers < 249 | 62 | 12.4 | 95.4 |
| ≥250 | 21 | 4.2 | 99.6 |
| Missing | 2 | .4 | 100.0 |
| Total | 500 | 100.0 | |

The interviews with the entrepreneurs were conducted in 2002 which essentially involved a broad questionnaire[6]. The interviews and compilation of the data were part of the research project "The transformation of local technology in Rio de Janeiro state: Institutions, interactions and innovations," sponsored by Instituto de Economia da Universidade Federal do Rio de Janeiro, Brazil and Institut de Recherche pour le Développement, France. The questions covered detail aspects of production and management, education and experiences of entrepreneurs and employees, relationship with suppliers, customers and rivals, research, sources of information and learning. The data collected are described in the next section.

## 3. The Data

### *3.1 Data Description*

#### *3.1.1 Innovation*

The term "innovation" refers to the development, adaptation, imitation and/or adoption of a practice or object that is perceived as new to a firm. The objective of the empirical analysis is: (i) to detect whether firms innovate or not when entrepreneurs are members of at least one TA and; (ii) the relationship between membership of a TA and the diversification of types of innovation. For the first part a binary variable is defined as one if at least one type of innovation

[6] The complete description of the database can be found in Hasenclever and Fauré (2004).

is adopted and zero otherwise. Table 1 in the previous section, shows that 325 firms in the sample (65%) adopt at least one type of innovation. The second part considers the combination of eight generic types of innovation that firms in the sample can choose to adopt: (1) changes in the product design, (2) changes in the style of the product; (3) changes in technical characteristics of the product, (4) new product (5) acquisition of new equipment, (6) automatization, (7) new managerial and administrative techniques, and (8) adoption of new raw materials. Table 3 shows the frequencies on the adoption of types of innovation.

**Table 3:** Types of innovation adopted

| | |
|---|---|
| Do not adopt any type of innovation | 32.29% |
| Changes in the product design | 13.54% |
| Changes in the style of the product | 10.42% |
| Changes in technical characteristics of the product | 10.21% |
| New product | 8.75% |
| Adoption of new equipment | 5.83% |
| Automatization | 5.00% |
| Introduction of new management methods | 5.63% |
| Adoption of new raw materials | 8.33% |
| | |
| Innovation variable: mean | 2.65 |
| Innovation variable: standard deviation | 2.68 |
| Number of respondents | 480 |

During an interview each respondent indicated types of innovation that her firm adopted based on the list of types of innovations presented above.[7] Each type of innovation is defined as a binary choice variable equal to one when the innovation was adopted and zero otherwise. Then, for each firm the sum of these discrete variables is used to construct a variable called "sum of innovations adopted". This variable ranges between 0 and 8 and gives us an approximation for the diversification in types of innovations adopted. If one type of innovation leads to another type, for example if the use of new raw material leads to changes in design, that counts as two types of innovation being adopted. Summary statistics for the innovation variable appears in Table 3.

[7] Information on the frequency of use of each type of innovation was not collected. This obviously limits the scope for comparisons of firms' performance and probably overstates innovation adoption because firms that adopt rarely are treated in the same way as firms that adopt frequently. In my view there are no qualitative implications for the empirical results because this increases the proportions of adopters not only among firms that are members of TAs but also among firms that are nonmembers.

The cost of adoption varies according to the type of innovation considered. Changes in the product design, style of the product, technical characteristics of a product, and new managerial and administrative techniques are more labor intensive while acquisition of new equipment; automatization; and new raw materials are more costly in terms of capital. Factors that influence the cost of adoption such as sources of financing or education levels, are controlled for in the regression analysis.

### *3.1.2 Membership of Trade Associations and Sharing of Know-How*

The fundamental variable for the analysis is membership of trade associations (TAs). This is used to proxy a greater propensity of entrepreneurs to interact professionally. I assume that higher professional interaction leads to more sharing of know-how and to the adoption of more types of innovation.

In Brazil, a TA is usually a non-profit organization seeking to promote collaboration between firms, and to further the interests of entrepreneurs in a business sector. Some examples of the roles that they perform are: standardization; advertising; political donation; lobbying; diffusion of information of interest to the business; the updating of skills of employers and employees; and the development and monitoring of professional educational programs. The feature of a TA that is relevant for the analysis in this paper is that entrepreneurs spontaneously join TAs and they can voluntarily choose to exchange information with other entrepreneurs before taking decisions concerning the firms. Use of the TA membership to proxy higher professional engagement is more appropriate for small scale businesses (which are the focus here) than larger ones because typically in small businesses the entrepreneur is the main and/or the only decision maker. In large firms where a board of directors is participating directly in the main decision process the professional interaction trait cannot be separated from the collective internal process in addition to other agency issues.

Although the analysis of this present paper concentrates on the relationship between professional interactions and innovation adoption, professional interactions are not necessarily the only source

of social learning. It can be argued that activities organized in a TA can contribute to the innovation process directly, through educational programs for example, or to the development of more professional interactions that will lead to innovation, for example lobbying. On the other hand the direction of causality may also work in reverse: professional interactions can create demand for the organization of activities by the TA that will lead to innovation. Even though in both cases professional interactions are playing a fundamental role, the implication for the empirical analysis is that the regression coefficient associated to TA membership does not separate the effect of activities organized by a TA from the effect of professional interactions per se. Unfortunately the data required to measure these effects separately were not collected during the field work, but I believe the instrumental variable, which is discussed in the next section, helps to minimize other effects that are not associated to professional interactions.

**Table 4:** Crosstab results for membership of TA and Adoption of Innovation

| | *Adoption of Innovation* | | |
|---|---|---|---|
| *Membership to TA* | *No* | *Yes* | *Total* |
| No | 93 | 98 | 181 |
| Yes | 62 | 227 | 289 |
| *Total* | 155 | 325 | 480 |
| Likelihood-ratio $\chi^2$ | 38.732 | | |

All sectors included in the survey have one correspondent TA in the municipality where they are located. Also there are TAs that operate at regional and national levels. The cost of joining a local TA is almost negligible. It is the entrepreneur's opportunity cost of filling in a form with information about her firm. Because each municipality is small there are no significant transport costs related to visiting the TA. To maintain their membership they pay a small fee that varies according to the size of the firm and sector that they belong to. For the TAs of which the firms in the sample are members the monthly fee ranges between 40.00 Reais (23.00 dollars) and 100.00 Reais (60.00 dollars). The fees are set low in order to attract more members because TAs have an incentive to have as many members as possible, which strengthens their political influence and the ability to bring public resources to the location. The costs necessarily increase if entrepreneur become members of TAs located outside the municipality because, even though the fees remain in the same range as the local TAs, the transport costs become higher.

In each municipality, the number of firms that are members of TAs is usually a small percentage of the population of firms. For example, in Nova Friburgo there are approximately 800 small scale firms producing textiles and garments, only 165 of which are members of the local TA. Table 1 in the previous section shows that the proportion of members of TAs included in the sample is higher than the one observed in the municipalities. This should not influence the results in this paper because the firms that were members and non-members of TAs were selected randomly within the sectors. Besides, the empirical analysis focuses primarily on the correlation between membership and innovation instead of the probability of a firm in a given sector to be member of a TA.

TA membership is defined as a discrete variable equal to one when the firm is a member of the TA inside or outside the municipality and zero otherwise. Members of at least one TA constitute 59.20% of all. There are two main issues related to membership of a TA. First it might be endogenous because entrepreneurs self-select to be members, which can lead to an upward bias in coefficient estimates. On the other hand, entrepreneurs can register to TAs without participating actively in them, which can lead to underestimated coefficients. These issues can be solved with the introduction of an instrument that is discussed in the next section.

### *3.1.3 Sociability as an Instrument*

In order to address biases from both the endogeneity of TA membership and measurement error, an instrument for TA membership is constructed. This is done by using information on eight widespread types of social organizations or clubs (SOCs), of which entrepreneurs reported to be members: (1) cultural, (2) sports, (3) religious, (4) neighborhood association, (5) charity, (6) citizenship, (7) environmental and (8) other associations. The activities included in other associations are for example reading groups or non-governmental organizations (NGOs). The proportions of entrepreneurs who are members of each type of SOC appear in Table 5. Entrepreneurs care about the purpose of SOCs and this conditions whether or not they become members. The cost of joining most types of SOCs is essentially the opportunity cost of the time

spent in them and fees are negligible. The exception is the sports clubs where the individual fee is usually higher than the TA fee. The key difference between membership of TA and the proposed instrument is that the primary objective of SOCs is not economic and membership of them is motivated by nonmarket interactions while TAs have a clear objective of representing the interests of businesses.

**Table 5:** Types of social organizations and clubs

| | |
|---|---|
| Not a member of any SOC | 55.6% |
| Cultural | 10.0% |
| Sports clubs | 15.0% |
| Religious | 19.80% |
| Neighbors | 11.60% |
| Charity | 20.0% |
| Citizenship | 12.0% |
| Environment | 11.0% |
| Others | 11.0% |
| Number of respondents | 500 |

Maximum likelihood estimates of TA membership will be consistent if the instrument is uncorrelated with the error term. In other words, it must be the case that unobserved differences in the membership of SOCs do not vary systematically with human capital or other production characteristics. Also, the instrument must be relevant in the sense that the process through which the instrument affects the TA membership has to be clear. The arguments that support the validity of this instrument are the following. First, the instrument is unlikely to be correlated with the error term because the reasons for an entrepreneur to join a SOC are essentially random provided that the various types of SOCs included in the instrument have quite different purposes (for example, religion and entertainment). And, while I cannot eliminate entirely sources of bias, historical accounts suggest that local governments have never practiced policies to either encourage or discourage participation in the SOCs that were surveyed in this paper. Second, in relation to the relevance of the instrument, both membership of TAs and membership of SOCs are ways of connecting socially with the local community and involve a spontaneous association of agents participating in reciprocal interactions. And, because both membership of TAs and membership of SOCs are correlated with a higher propensity for social engagement, an entrepreneur who is a member of an organization or a club is also more likely to be a member of a TA.

A discrete choice variable is defined as taking a value of one when membership of at least one type of SOC is observed and zero otherwise. Alternatively, an instrument analogous to the innovation variable can be defined where sum of the binary variables for membership to social organization is calculated for each firm. With this form the regression results are qualitatively identical to the ones found with the binary form.

### *3.1.4 Other observable characteristics*

In order to minimize problems of omitted variable bias and other mis-specifications, various controls based on rival theories on innovation are used. These controls appear on Table 6 and can be grouped into the six following categories:

The first category, human capital, contains controls related to models of endogenous growth and diffusion of technology (Nelson and Phelps 1966; Romer 1986; Lucas 1988; Aghion and Howitt 1998; Acemoglu 2007). According to these models, human capital increases production capacity because it contributes to technological creation and invention, as well as facilitating the adoption of new technologies and products. The controls related to human capital appear on Table 6. The data not surprisingly suggest that respondents who are innovation adopters present on average higher levels of education and training. More specifically, the first four rows of table 6 contain information about the respondent, who is also the owner of the business. Respondents who are adopters of innovation are slightly older than non-adopters and firms are managed mainly by men (the mean for the gender of respondent is 1.781, which is equivalent to 78.1% of the total of firms being managed by men). This is consistent with the absence of women in leadership positions, which is a common trait of Latin American firms.[8] The raw data (outside the table) show that while 44.9% of respondents who are adopters of innovation completed college/university, only 29.7% of the non-adopters have the same education level. Most of the respondents have been working in the firm for over ten years.

[8] For a summary of women participation in the leadership of small and medium enterprises see OECD (1998).

**Table 6**: Descriptive Statistics of Control Variables

| | Non-adopters | | Adopters | | Total | |
|---|---|---|---|---|---|---|
| Variable | Mean | SE | Mean | SE | Mean | SE |
| *Human Capital* | | | | | | |
| Gender of respondent (female=1, male=2) | 1.832 | (0.38) | 1.757 | (0.43) | 1.781 | (0.41) |
| Age of respondent ( Less than 21 years old=1; 21-39=2; 40-59=3; More than 59=4) | 2.574 | (0.68) | 2.585 | (0.60) | 2.581 | (0.63) |
| School degree of respondent (up to elementary education=1, "normal" =2, technical secondary education=3, secondary education=4, college/university=5) [1] | 3.252 | (1.47) | 3.628 | (1.50) | 3.506 | (1.50) |
| Number of years working in the firm (up to 10 years=1; more than 10 years=2) | 1.419 | (0.50) | 1.363 | (0.48) | 1.381 | (0.49) |
| Invested in training of workers (yes=1) | 0.226 | (0.42) | 0.591 | (0.49) | 0.473 | (0.50) |
| % of workers with elementary education (0%=0, 1-24%=1, 25-49%=2, 50-74%=3, 75-99%=4, 100%=5) | 2.400 | (1.98) | 2.883 | (1.71) | 2.727 | (1.82) |
| % of workers with high school education (categories as above) | 2.271 | (1.92) | 1.575 | (1.44) | 1.800 | (1.64) |
| % of workers with college/university education (categories as above) | 0.271 | (0.65) | 0.443 | (0.68) | 0.388 | (0.68) |
| % of workers with post-graduate education (categories as above) | 0.013 | (0.11) | 0.080 | (0.32) | 0.058 | (0.28) |
| Evolution of workers skills since 1999 (decreasing=0, stable=1, increasing=2) | 1.271 | (0.60) | 1.418 | (0.58) | 1.371 | (0.59) |
| Research about clients within the firm (yes=1) | 0.329 | (0.47) | 0.542 | (0.50) | 0.473 | (0.50) |
| Research about products within the firm (yes=1) | 0.271 | (0.45) | 0.477 | (0.50) | 0.410 | (0.49) |
| Research about products within the firm's labs (yes=1) | 0.006 | (0.08) | 0.120 | (0.32) | 0.083 | (0.28) |
| Use of workers' experience (never=0, rarely=1, sometimes=2, always=3) | 1.961 | (1.29) | 2.148 | (1.12) | 2.087 | (1.79) |
| Use of local infra-structure for training[2] | 0.761 | (1.40) | 2.148 | (2.16) | 1.700 | (2.05) |
| *Secondary Sources of information* | | | | | | |
| Secondary research about clients (yes=1) | 0.032 | (0.18) | 0.157 | (0.36) | 0.117 | (0.32) |
| Consultancy (never=0, rarely=1, sometimes=2, often=3, always=4) | 0.161 | (0.58) | 0.708 | (0.98) | 0.514 | (0.90) |
| Universities or/and research institutes (categories as above) | 0.148 | (0.54) | 0.572 | (0.93) | 0.435 | (0.85) |
| Specialized publications (categories as above) | 1.168 | (1.29) | 1.452 | (1.19) | 1.36 | (1.23) |
| Patent databases (categories as above) | 0.013 | (0.16) | 0.203 | (0.58) | 0.142 | (0.50) |
| *Sources of Credit/Financing* | | | | | | |
| Own resources (categories as above) | 3.148 | (1.42) | 3.00 | (1.39) | 3.048 | (1.40) |
| Family or/and friends (categories as above) | 0.039 | (0.30) | 0.265 | (0.72) | 0.192 | (0.62) |
| BNDES through private banks (categories as above) | 0.039 | (0.30) | 0.203 | (0.68) | 0.15 | (0.59) |
| Other private banks (categories as above) | 0.09 | (0.46) | 0.397 | (0.87) | 0.298 | (0.77) |
| Banco do Brasil (categories as above) | 0.142 | (0.66) | 0.394 | (0.90) | 0.313 | (0.84) |
| Caixa Econômica Federal (categories as above) | 0.013 | (0.16) | 0.160 | (0.62) | 0.113 | (0.53) |
| Fiscal incentives (categories as above) | 0.000 | (0.00) | 0.132 | (0.54) | 0.09 | (0.45) |
| Suppliers or/and customers financing (categories as above) | 0.019 | (0.24) | 0.317 | (0.87) | 0.221 | (0.74) |
| International resources (categories as above) | 0.013 | (0.16) | 0.062 | (0.41) | 0.046 | (0.35) |
| Government Programs (yes=1) | 0.080 | (0.26) | 0.246 | (0.431) | 0.188 | (0.39) |
| *International Trade* | | | | | | |
| Exporter (yes=1) | 0.019 | (0.14) | 0.095 | (0.29) | 0.071 | (0.26) |
| Presence of local large exporter in the sector (yes=1) | 0.632 | (0.48) | 0.411 | (0.49) | 0.472 | (0.50) |
| *Internal characteristics of firm* | | | | | | |
| Use computers for management (yes=1) | 0.600 | (0.49) | 0.634 | (0.48) | 0.623 | (0.49) |
| Use computers for production (yes=1) | 0.123 | (0.33) | 0.446 | (0.50) | 0.342 | (0.48) |
| Use computers for design (yes=1) | 0.065 | (0.25) | 0.200 | (0.40) | 0.156 | (0.36) |
| Use computers for CAD/MRP (yes=1) | 0.071 | (0.26) | 0.240 | (0.43) | 0.185 | (0.39) |
| Use computers for Internet access (yes=1) | 0.535 | (0.50) | 0.665 | (0.47) | 0.623 | (0.49) |
| Sum of specialized functions[3] | 0.484 | (1.23) | 2.302 | (2.36) | 1.715 | (2.23) |
| Sum of managerial and administrative methods[4] | 1.729 | (2.43) | 4.618 | (4.00) | 3.685 | (3.81) |
| Quality management (yes=1) | 0.206 | (0.41) | 0.465 | (0.50) | 0.381 | (0.49) |
| Formal business (yes=1) | 0.781 | (0.42) | 0.794 | (0.41) | 0.796 | (0.40) |
| Observations | 155 | | 325 | | 480 | |

Notes: (1) "Normal" secondary education is part of an old an system focused on teacher's training. (2) The sum of dummy variables (yes=1) for use of local infra-structure, which includes laboratories, consultancy, Sebrae, Senai, Sesi, Firjan, universities, firm incubator, offices of technology transfer, junior enterprises. (3) Sum of dummy variables (yes=1) for production, marketing, R&D, human resources, sales, purchasing, accounts, and technical control. (4) Sum of dummy variables (yes=1) for control of cash flow; stocks; and costs; investment plan; performance indicators, information systems for management; development of trademarks, association with existing trademarks, human resources management, just-in-time, cells of production, systems of quality/ISO, multi-tasking, partnership with suppliers and customers.

In relation to the workers the differences in the level of human capital between adopters and non-adopters are not very important, although they are still noticeable. The next five rows of Table 6 contain information about training and education of the workers. Adopters of innovation invest on average more in training of workers than non-adopters (0.226 for non-adopters and 0.591 for adopters). Adopters have relatively higher number of workers with college/university and post-graduate education while non-adopters have more workers with elementary education only. The mean for the total of firms ($5^{th}$ column) indicate that the total number of workers with primary education is significantly higher than the number of workers with secondary education or who completed college, suggesting that the aggregate level of human capital is low. This however is consistent to the smaller size of the firms in the sample, their limited access to resources, and the poor infra-structure for education of the municipalities. In relation to the aggregate supply of labor, the censuses of 1990 and 2000 show that while Itaguaí kept its number of workers stable, Nova Friburgo and Campos lost workers to the metropolitan area and to areas with oil activities, which includes Macaé. The next row shows the opinion of the respondents about the evolution of qualifications in the three years prior to the survey. They think that qualification is increasing, even though less than half of them invested in training or programs that involve the workers (about 47%).

The remaining rows on human capital have information about research developed by entrepreneurs and workers, and different sources of information generated within the firm. There are three questions related to whether the firms do research and its focus: research about clients within the firm; research about product within the firms; and research in the firm's labs. In all cases adopters of innovation presented higher averages (first column compared with the third column. Notice however that among the total of firms less than half actually do any kind of research. Adopters on average use more the experience of workers as a source of ideas and information and take advantage of the local infra-structure for training better than non-adopters.

While models of human capital and growth focus on decisions about innovation at the firm level, the second category of controls specifically takes into account information flows originating from the chain of production and in the public domain (Jaffe 1986; Freeman 1987; Lundvall 1992; Cassiman and Veugelers 2002). In this context, the main hypothesis is that the innovation

process can be influenced by interactions between distinct agents, including firms' suppliers and customers, universities and research institutes. The intuition behind this argument is that an individual firm rarely possesses all the knowledge necessary for the whole process of innovation. Therefore, it has to combine information and knowledge from different sources. The controls used to capture information flows outside the firm are the following: use of secondary research about clients; consultancy; universities and research institutes; specialized publications; and patent databases. The use of secondary research consists of commissioning independent research undertaken by a research institute, for example. This is the least used source on average (see 5th column, 2nd row under secondary sources of information on Table 6). The use of publications is the cheapest and the most frequent source used for research information, which can include journals, magazines, and catalogs, and adopters use them more often than non-adopters. Economic theory shows that patents and other forms of intellectual property protection have a positive effect on innovation because they delay imitation. The effects of protection on small scale firms in developing countries are unclear because these firms usually do not have a research and development department responsible for inventions that can be patented and therefore cannot benefit from protection. However they can consult patent databases in order to search for new information and this is the control used in the analysis. The use of patent databases concentrates responses around "never" or "rarely". In general all sources of information from outside the firm present very low frequencies of use.

The third category of controls is credit and finance. Credit depends on macroeconomic policy and is essential in developing economies because it can reduce the entrepreneur's reluctance to adopt new technologies (Ghosh, Mookherjee and Ray, 2000). Different sources of credit are used as controls. The data on sources of credit and financing characterize the high interest rates inherited from the debt crises of the 1980s and 1990s.[9] For the firms surveyed, the main source of funding for investment is the personal resources of the entrepreneurs where the mean found for non-adopters (3.148) is slightly higher than the one found for adopters (3.00). The main government banks in Brazil are Banco do Brasil; The Brazilian Development Bank (BNDES);

[9] In 1980s Brazil and Latin American went through the debt crisis and hyperinflation, which caused sharp fall in growth. The economy finally stabilized with the implementation of the Real Plan, which kept the interest rates higher and credit difficult to obtain. In 1998 the Brazilian currency suffered a speculative attack during the Russian crisis and in order to avert the return of high inflation the government raised interest rates even more. In 2001 the nominal interest rate set by the Central Bank was 17.3%.

and Caixa Econômica Federal. The first combines private and public ownership while the other two are both federal banks. Government banks did not offer micro-credit at the time of the survey and this probably explains why private banks are used more often. The least used type of funding for is that of the international financial markets. Fiscal incentives are not at all used by non-adopters and they were removed from the main regressions in order to prevent issues arising from collinearity of the regressors

The fourth category considers that the government can also apply direct policies in the form of programs intended to increase firms' performance through the support of exports or the development of cooperation between firms. These programs can cause two effects. The first is a potential increase in the professional interaction of the entrepreneurs. The second directly affects adoption of innovation when the objective of the program is to improve technology used in the firms. The data on Table 6 shows that most of the participants in programs are also adopters.

The fifth category includes controls related to international trade. The empirical literature on trade shows that firms that export have better are on average more productive than non-exporters (Bernard and Jensen 1999). The reason is that firms can learn about foreign technology through the exporting experience. They can benefit from interacting with foreign customers, for example because the latter impose higher product quality standards than the domestic customer, while at the same time providing information on how to meet the higher standards. One control found in Table 6 is associated with firms that export part of their production. Another effect of international trade concerns the exposure to multinational firms or large exporters. If firms are supplying to multinationals or large exporters, then these companies can also demand higher standards and show how to meet them. There are other positive spillovers, such as through the employment of workers that are trained by and subsequently leave the large firms. Although the urban areas under investigation do not present multinationals, two of them do have large exporters, the presence of which are controlled for. The data in Table 6 show that most of firms in the sample do not export and many of them have exposure to large exporters. Interestingly the regression results presented in the next section show that presence of large local exporter is correlated to the adoption of innovation to be higher.

At the firm level, there are controls related to: use of computers; specialized functions; and management tools (see description of specialized functions and management tools on footnote of Table 6). There are five variables that capture different types of computer use, which show that there are more firms using them for management and Internet access than other functions, such as production and design. The management done with computers is basically control of cash flow, which can be done simply with a Microsoft Excel spreadsheet. The difference between the mean of non-adopters and adopters is not very significant (0.600 and 0.634 respectively with standard errors 0.49 and 0.48). For the other types of computer use the values of the means for adopters are higher than the ones for non-adopters. The remaining rows show information about specialized functions, managerial methods, and quality control. The firms surveyed were asked about 8 types of specialized functions and 14 types of managerial methods. Analogous to the definitions of the innovation variable and the instrument, for each type of specialized function or managerial method, a discrete choice variable is defined as one when they use it and zero otherwise. The sum of the binary variables for specialized functions or managerial methods is calculated for each firm. Therefore the sum of specialized functions varies between 0 and 8 and the one for managerial methods between 0 and 14. The table shows that firms rarely use specialized functions and a few use managerial and administrative methods. Quality control is used by less than half of the firms.

### *3.2 Methodology*

The main hypothesis tested in the empirical analysis is that entrepreneurs who present a higher propensity for social engagement are more likely to adopt more types of innovation than the entrepreneurs who do not. The empirical specification is the following. Denote innovation adoption by $a_i^*$ where $i$ identifies the entrepreneur. A higher propensity of $i$ to engage in professional interaction is measured through her membership of the TA and denoted by $m_i$. The six categories of controls that can influence the adoption of innovation, described in the previous section, are represented in the vector $\mathbf{x_i}$. The structural equation can be represented as:

$$a_i^* = \alpha_1 + \beta_1 m_i + \boldsymbol{\gamma_1}\mathbf{x}_i + \varepsilon_i,$$

where ε contains unobserved production characteristics that can influence the adoption of innovation.

For each individual firm, $a^*$ takes on the value zero with positive probability, if the decision of the firm is not to adopt an innovation, and $a^*$ is a continuous random variable over strictly positive values if the firm does adopt. The appropriate specification is a Tobit model, where zero values indicate non-adoption and positive values identify the variety of innovations adopted.

The main concerns raised by this empirical strategy are (i) entrepreneurs self-select in to TAs, that is, the *m* variable may be correlated with ε; and (ii) there are unobserved individual characteristics of the entrepreneurs or measurement error that lead to inconsistent estimates. In order to minimize these potential problems two procedures are undertaken. First, various controls described in the previous section are included. Second, an instrumental variable *z* is introduced with the following reduced form specification:

$$m_i = \alpha_2 + \beta_2 z_i + \boldsymbol{\gamma_2 x}_i + \omega_i,$$

where (ε, ω) is assumed to be zero-mean bivariate normal, indepedent of *z*. If ε, ω are correlated, then *m* is endogenous. For each individual firm, *m* takes on the value one if the entrepreneur is a member of the TA, and zero otherwise. For this reduced form equation the appropriate specification is Probit. Maximum likelihood methods are used to compute estimations of the coefficients for the variables described above.

## 4. Results

### *4.1 Basic Results*

First, let's examine the estimated relationship between the instrument and membership of the TA, which is presented in Table 7. The probit equation (1) regresses TA membership on the SOC variable while probit equation (2) uses all controls discussed in section 3. In both cases the instrument is significant at the 1% level.

**Table 7**:Probit results for membership of TA and membership of SOCs

| Dependent Variable: Membership of TA | (1) | | (2) | |
|---|---|---|---|---|
| | Coeff. | St. Err. | Coeff. | St. Err. |
| SOCs (d) | 0.753*** | (0.12) | 0.834*** | (0.17) |
| Constant | -0.057 | (0.08) | | |
| Other controls | No | | Yes | |
| Log-likelihood | -302.770 | | -210.339 | |
| LR Chi-squared | 39.73 | | 223.58 | |
| Observations | 480 | | 479 | |

Note: *** significant at 1%, ** significant at 5%, * significant at 10%. Constant not included in equation (2).

The procedure now is to assess the effect of TA membership and other controls on adoption of innovation, using membership of SOCs as an instrument for TA membership. Table 8 presents the basic results. Equation (1) is a linear benchmark which consists of estimates of a two-step procedure. The first step is a probit specification that regresses the TA variable on the SOCs variable and all other controls. The second step is the usual OLS specification and regresses the innovation adoption variable on the predicted values of the TA variable from the first step and all other controls. Although the estimated coefficients of this procedure are used only for reference, there is a preliminary indication from this that the coefficient for TA membership is relevant for innovation adoption because of its high positive value and significance at the 1% level.

Equations (2) and (3) estimate coefficients respectively for IV Probit and IV Tobit. IV Probit is included because it identifies the direct decision on adoption of innovation. In addition, it is used as an auxiliary equation in other parts of the empirical analysis. The most important results for this paper appear on equation (3), IV Tobit, where the dependent variable takes into account the number of the variety of innovations that are adopted. Both specifications used maximum likelihood[10] estimation and the binary form of the instrument for the reduced form equation of the TA variable. The results show that TA membership is positively related to the innovation adoption variable and significant at 1% level in both specifications. Next the IV Tobit estimates reported in (3) there are also two columns with its partial effects, which give us a better idea of the magnitude of the estimated effects. They show that TA membership has the second highest partial effect in magnitude and it is less only than Macaé's partial effect. This suggests that membership of TA is in fact relevant for the decision of entrepreneurs about adoption of innovations.

[10] For the maximum likelihood estimation the "cmp" command in Stata was used.

**Table 8**:Basic results for innovation adoption, membership of trade associations and controls

| Dependent Variable: Innovation Adoption | (1) Linear/Probit (2 steps) | | (2) IV Probit | | (3) IV Tobit | | | | (4) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Partial Effects | | Betahat/ Sigmahat |
| | Coeff | Std Err | Coeff | Std Err | Coeff | Std Err | E(a\|x,a>0) | E(a\|x) | |
| Trade associations (d) | 1.678*** | (0.55) | 1.175*** | (0.39) | 2.449*** | (0.55) | 1.431 | 1.927 | 1.152 |
| *Human Capital* | | | | | | | | | |
| Gender of respondent | -0.315 | (0.21) | -0.242 | (0.23) | -0.385 | (0.28) | -0.238 | -0.320 | -0.181 |
| Age of respondent | -0.301** | (0.14) | -0.112 | (0.14) | -0.280 | (0.20) | -0.173 | -0.233 | -0.132 |
| School degree of respondent | -0.102 | (0.07) | -0.150** | (0.07) | -0.104 | (0.09) | -0.064 | -0.086 | -0.049 |
| Number of years working in the firm | -0.097 | (0.19) | -0.443** | (0.21) | -0.249 | (0.26) | -0.154 | -0.207 | -0.117 |
| Invested in training of workers (d) | 0.477** | (0.20) | 0.275 | (0.21) | 0.652** | (0.27) | 0.403 | 0.542 | 0.307 |
| Research about clients within firm (d) | 0.371* | (0.19) | 0.148 | (0.21) | 0.484* | (0.25) | 0.299 | 0.403 | 0.228 |
| % workers with elementary education | 0.034 | (0.07) | 0.023 | (0.07) | 0.010 | (0.09) | 0.006 | 0.008 | 0.005 |
| % workers with high school education | 0.034 | (0.08) | 0.085 | (0.08) | -0.016 | (0.11) | -0.010 | -0.013 | -0.008 |
| % workers with university/college | -0.021 | (0.14) | 0.036 | (0.16) | -0.008 | (0.19) | -0.005 | -0.007 | -0.004 |
| Evolution of workers skills since 1999 | 0.211 | (0.15) | 0.274* | (0.16) | 0.405* | (0.21) | 0.250 | 0.337 | 0.191 |
| Research products in firm (d) | 0.263 | (0.19) | -0.258 | (0.22) | 0.419 | (0.26) | 0.260 | 0.349 | 0.197 |
| Research products in labs (d) | 0.602* | (0.33) | 0.769 | (0.60) | 0.465 | (0.43) | 0.299 | 0.396 | 0.219 |
| Use previous workers' experience | 0.076 | (0.08) | -0.004 | (0.09) | 0.115 | (0.12) | 0.071 | 0.095 | 0.054 |
| Use local infra-structure for training | 0.048 | (0.06) | 0.097 | (0.07) | 0.051 | (0.07) | 0.032 | 0.042 | 0.024 |
| *Sources of information* | | | | | | | | | |
| Secondary research on clients (d) | 0.297 | (0.28) | 0.362 | (0.38) | 0.232 | (0.36) | 0.146 | 0.195 | 0.109 |
| Consultancy | 0.151 | (0.11) | 0.210 | (0.14) | 0.164 | (0.14) | 0.101 | 0.137 | 0.077 |
| Universities/research institutes | 0.079 | (0.12) | 0.155 | (0.15) | 0.042 | (0.16) | 0.026 | 0.035 | 0.020 |
| Specialized publications | 0.045 | (0.07) | 0.027 | (0.08) | 0.096 | (0.10) | 0.059 | 0.080 | 0.045 |
| Patent databases | 0.536*** | (0.17) | 0.235 | (0.34) | 0.512** | (0.22) | 0.316 | 0.426 | 0.241 |
| *Credit* | | | | | | | | | |
| Own resources | 0.055 | (0.07) | 0.049 | (0.07) | 0.030 | (0.09) | 0.019 | 0.025 | 0.014 |
| Family/friends | 0.037 | (0.14) | 0.182 | (0.18) | 0.09 | (0.18) | 0.05 | 0.07 | 0.040 |
| BNDES | -0.195 | (0.16) | -0.182 | (0.28) | -0.386* | (0.22) | -0.24 | -0.32 | -0.182 |
| Private banks | 0.151 | (0.11) | 0.320** | (0.16) | 0.219 | (0.15) | 0.135 | 0.182 | 0.103 |
| Banco do Brasil | -0.078 | (0.12) | -0.015 | (0.12) | -0.110 | (0.15) | -0.068 | -0.091 | -0.052 |
| Caixa Econômica Federal | 0.202 | (0.17) | 0.471 | (0.45) | 0.209 | (0.22) | 0.129 | 0.173 | 0.098 |
| Suppliers/customers | 0.087 | (0.12) | 0.282 | (0.21) | 0.071 | (0.16) | 0.044 | 0.059 | 0.033 |
| International sources | -0.169 | (0.25) | -0.216 | (0.68) | -0.201 | (0.33) | -0.124 | -0.167 | -0.095 |

Note: *** significant at 1%, ** significant at 5%, * significant at 10%. Constant not included. (d) partial effect is for discrete change of dummy variable from 0 to 1. Likelihood-ratio test of $\rho=0$ in IV Probit: chi2(1) = 3.54324 Prob > chi2 = 0.0598.

**Table 8**:Basic results for innovation adoption, membership of trade associations and controls (cont.)

| Dependent Variable: Innovation Adoption | (1) Linear/Probit (2 steps) | | (2) IV Probit | | (3) IV Tobit | | | | (4) Betahat/ Sigmahat |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Partial Effects | | |
| | Coeff | Std Err | Coeff | Std Err | Coeff | Std Err | E(a\|x,a>0) | E(a\|x) | |
| *Government programs* | -0.153 | (0.24) | 0.263 | (0.28) | -0.124 | (0.31) | -0.076 | -0.102 | -0.058 |
| *International trade* | | | | | | | | | |
| Exporter (d) | 0.327 | (0.35) | 0.628 | (0.55) | 0.183 | (0.46) | 0.115 | 0.153 | 0.086 |
| Presence of large exporter (d) | 1.446*** | (0.47) | 1.005 | (0.70) | 1.794*** | (0.61) | 1.116 | 1.485 | 0.844 |
| *Internal characteristics of firms* | | | | | | | | | |
| Age of the firm | 0.000 | (0.01) | 0.020** | (0.01) | 0.004 | (0.01) | 0.003 | 0.004 | 0.002 |
| Computers for management (d) | -0.569** | (0.24) | -0.224 | (0.26) | -0.881*** | (0.34) | -0.557 | -0.741 | -0.414 |
| Computers for production (d) | 0.381* | (0.22) | 0.392 | (0.25) | 0.572** | (0.29) | 0.360 | 0.481 | 0.269 |
| Computers for design (d) | 0.598** | (0.30) | -0.351 | (0.35) | 0.479 | (0.39) | 0.307 | 0.407 | 0.225 |
| Computers CAD/MRP (d) | -0.271 | (0.27) | -0.005 | (0.32) | -0.190 | (0.36) | -0.116 | -0.156 | -0.089 |
| Computers for Internet access (d) | 0.036 | (0.26) | -0.004 | (0.27) | -0.032 | (0.36) | -0.020 | -0.026 | -0.015 |
| Specialized functions | 0.196*** | (0.05) | 0.182*** | (0.07) | 0.257*** | (0.07) | 0.158 | 0.213 | 0.121 |
| Quality management (d) | 0.018 | (0.21) | 0.108 | (0.23) | 0.228 | (0.28) | 0.141 | 0.190 | 0.107 |
| Formal business (d) | -0.063 | (0.26) | 0.227 | (0.26) | -0.066 | (0.35) | -0.041 | -0.055 | -0.031 |
| *Location* | | | | | | | | | |
| Campos (d) | -0.833* | (0.47) | 0.076 | (0.68) | -0.634 | (0.62) | 0.468 | 0.621 | -0.298 |
| Itaguaí (d) | -1.060** | (0.50) | 0.243 | (0.69) | -0.953 | (0.65) | 0.262 | 0.349 | -0.448 |
| Macaé (d) | -3.587*** | (0.29) | -2.455*** | (0.44) | -4.769*** | (0.41) | -1.810 | -2.446 | -2.243 |
| Friburgo (d) | 2.469*** | (0.78) | 0.115 | (0.91) | 1.366 | (1.07) | 0.916 | 1.187 | 0.643 |
| Log-likelihood | | | -358.549 | | -978.581 | | | | |
| Wald/LR Chi-squared | | | 306.63 | | 680.69 | | | | |
| Sigma | | | | | 2.126 | | | | |
| ρ | | | -0.592 | | -0.606 | | | | |
| atanhrho_12 | | | | | -0.702*** | (0.19) | | | |
| Observations | 479 | | 479 | | 479 | | | | |

Note: *** significant at 1%, ** significant at 5%, * significant at 10%. Constant not included. (d) partial effect is for discrete change of dummy variable from 0 to 1. Likelihood-ratio test of ρ=0 in IV Probit: chi2(1) = 3.54324 Prob > chi2 = 0.0598.

The location control for Macaé presents coefficients significant at 1% level for IV Probit and IV Tobit and the highest partial effect. This is consistent with the literature on industrial clusters (see, for example, Glaeser et al., 1992). In this literature the location of firms can present sources of positive externalities that increase the propensity of firms to adopt innovations.

Without the instrument the coefficients for membership of TAs for the linear and probit specifications are lower than the ones in Table 8 and insignificant and for Tobit lower and significant at 5% (see coefficients without the instrument in Table A3 in the Appendix). This suggests that without the instrument the effect of entrepreneurs who become members of TAs without participating actively in them, which biases the estimates downwards, dominates the self-selection effect (which biases the estimates upwards). Therefore, the intuition behind the results in Table 8 is that the instrument is able to filter out members of TAs that are less likely to interact professionally with others, bringing the TA membership coefficient up to its correct value.

The endogeneity of the TA variable can be checked with tests on the parameter $\rho$. In the IV Tobit specification, this parameter represents the correlation between $\varepsilon$ and $\omega$. In other words, $\rho$ makes the connection between the reduced form equation of *m* and the structural equation of *a* in the log-likelihood function that is maximized in the estimation. For computational reasons, the IV Tobit in (3) tests a transformation of parameter $\rho$ equal to atanhrho = $1/2*\ln[(1+\rho)]/(1-\rho)]$, which is the inverse hyperbolic tangent of $\rho$. The test rejects the null hypothesis $\rho=0$ at 1% level, which again shows that the instrument is necessary for the correct estimation of the TA membership coefficient. For the IV Probit specification $\rho$ is defined analogously to IV Tobit (see Wooldridge 2002 for details). The likelihood test of $\rho=0$ for the IV Probit in (2) rejects the null hypothesis at the 10% level (with correspondent chi-squared statistic=3.54), which shows once again that the instrument is necessary.

Table 8 also reports the coefficients on other individual controls. A few controls are significant at 10% and 5% level and the level of significance is often not consistent between IV Probit and

IV Tobit.[11] Among the controls for human capital, school degree of the respondent, training of workers, research about clients within the firm, and evolution of workers' skills present significant coefficients. In the second category of controls, the only source of information with a significant coefficient is the patent database. On the third category the sources of credit and financing with significant coefficients are private banks and BNDES. The two columns under (4) on Table 8 report partial effects for $E(a|x,a>0)$ and $E(a|x)$ in the IV Tobit equation. For those three categories of controls, the partial effects are relatively low compared to the ones obtained for other coefficients that are discussed below.

It is interesting to note that even though some coefficients for human capital are not significant, the partial effects in this category are on average higher in magnitude than the partial effects for the sources of information and credit and finance categories. This makes sense if we consider that the innovative process depends more on characteristics that are closer to human capital, such as creativity, than it does on other characteristics, such as specific sources of investment. The importance of training of workers also points in this direction, even though the results do not indicate that the effect of training is stronger than the effect of TA membership. Better trained workers can contribute to the innovation adoption process.

Among the international trade controls, the presence of a large exporter has a coefficient significant at 1% level in IV Tobit. Its partial effect is only lower than the ones obtained for Macaé and the TA variable. Being an exporter is not a significant predictor of innovation adoption. This is an unexpected outcome but it can be explained by the very low number of firms in the sample that actually export.

There are a few internal characteristics of the firm with significant coefficients: the age of the firm; use of computers for management; for production; and specialized functions. In all cases the partial effects are relatively low.

Since IV Tobit is a central specification for this paper, it is necessary to check whether this is a reasonable one. Given the survey format of the dataset, one would suspect that the

[11] Coefficients that are significant only for equation (1) are not discussed.

homoscedasticity and normality hypotheses, on which the Tobit specification relies, may not hold. Unfortunately this is true for both assumptions. The tests of normality and homoscedasticity for IV Tobit in equation (3) give score statistics equal to 311.659 for normality and 371.756 for homoscedasticity with p-values approximately zero, which clearly rejects the two null hypotheses of normality and homoscedasticity.

According to Wooldridge (2002) IV Tobit can still be a reasonable specification under these circumstances. As a rough guide, first notice that all the signs for the coefficients that are significant are the same for all specifications. Then, if we divide the IV Tobit coefficients by sigma (the estimated standard error of equation (3), displayed at the end of Table 8) and compare the results to the IV Probit coefficients, these results are not statistically different from the IV Probit coefficients. For example, in Table 8 the IV Probit coefficient on TA membership is 1.175 and on IV Tobit is 2.449. When we divide the TA coefficient in IV Tobit by sigma = 2.126 we obtain 1.152 displayed in (4) in Table 8, which is not significantly different from 1.175 found for IV Probit. Although the results in (4) differ somewhat from the coefficients in (2), the magnitudes remain similar. This suggests that the IV Tobit model is not misspecified, but other tests should be applied and alternatives to the model should be investigated. These will be discussed on section 5.

### *4.2 Sources of Spurious Regressions*

An important source of concern is that the correlation among innovation adoption decisions of entrepreneurs who are members of the same TA might be spuriously correlated because of unobserved characteristics of each member that causes their behavior to be similar[12]. For example, if entrepreneurs in the same TA have similar ability or risk aversion, their behavior in relation to the adoption of innovation may be correlated, but independent. To think through this concern consider that the empirical analysis includes various sectors that are distinct from each other and the entrepreneurs interviewed were randomly chosen. Also the TAs differ by economic activity. Therefore, even though it is not possible to be absolutely certain, the

[12] The issues raised in this section are the same those Bandiera and Rasul (2006) raised in relation to the adoption of seeds in agriculture.

entrepreneurs should have profiles that are sufficiently different from each other, so that their behavior is not driven by unobserved characteristics that independently coincide.

## 5. Robustness Checks

The purpose of this section is to verify that the regressions specified in Section 4.1 are appropriate for the estimation of the relationship between TA membership and innovation adoption and that there are no other observable characteristics of the firms that are driving the main results. Starting from the IV Tobit regression, we first discuss a test that uses a double hurdle model and then we go through a Poisson specification. The third part of this section will present a robustness check that replaces the innovation variable with other data.

### *5.1 Double Hurdle and Poisson models*

One characteristic of the Tobit model is that a single probability mechanism determines the choice between $a$=0 and $a$>0. In a double hurdle model, the first part consists of whether or not to choose positive $a$. For example, the entrepreneurs' characteristics may differently affect the decision of adopting innovation and the decision of how many innovations to adopt. This can be estimated with the IV Probit model. The second part uses observations for which $a$>0 and consists of a linear regression. [13] So, once the entrepreneur has decided to innovate, the second part describes how many innovations she adopts. Differently from a Tobit model, in a double hurdle model neither normality nor homoscedasticity hypotheses are necessary for the consistency of the estimators. Given the assumption that the two parts are independent, the joint likelihood for the two parts is the sum of the log likelihood of each part. In order to test whether Tobit fits the data better than the double hurdle, its log likelihood is compared to the joint likelihood of the double hurdle model.

The IV Probit part of the double hurdle model yields a log likelihood equal to -358.559 (see Table 8), the value of the log likelihood for the linear part is -721.127 and, therefore the joint log

[13] See Wooldridge (2002) for details.

likelihood is -1079.685. When we compare this result to the one obtained for the IV Tobit model, for which the log likelihood is equal to -978.581, the IV Tobit model fits the data better.

The Poisson specification is another relevant robustness check because it also does not impose assumptions about the distribution of $a$, given $m$ and $\mathbf{x}$. Table 9 shows the results for IV Tobit with controls for sectors and IV Poisson with and without controls for sectors. In particular, the IV Poisson used generalized method of moments (GMM) for the estimation of the coefficients. In all specifications the TA membership is significant.

The last check replaces the innovation variable with information obtained from a verifying question about types of innovation. More specifically the verifying question asked about possible reactions of the firm to the episode of trade liberalization that Brazil went through during the 1990s. There were 7 available answers: (1) improved equipments and productive processes; (2) improved management; (3) innovation of product; (4) innovation of process; (5) improved human resources (6) technological learning; (7) environmental control. This can be defined analogously to the original innovation variable: each type of innovation is defined as a binary choice variable equal to one when the innovation was adopted and zero otherwise. Then, for each the sum of these discrete variables is used to construct another version of the sum of innovations adopted. The regression results for this variable appear in equations (4) and (5) of table 9.

**Table 9**: Robustness Checks

| | (1) IV Tobit | | (2) IV Poisson | | (3) IV Poisson | | (4) IV Tobit | | (5) IV Poisson | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coeff. | Std. Err. | Coeff. | Std. Err. | Coeff. | Std. Err. | Coeff. | Std. Err. | Coeff. | Std. Err. |
| Trade associations (d) | 2.101*** | (0.60) | 0.982* | (0.57) | 1.591** | (0.68) | 2.462** | (1.01) | 0.885** | (0.44) |
| *Human Capital* | | | | | | | | | | |
| Gender of respondent | -0.323 | (0.28) | -0.203 | (0.17) | -0.188 | (0.20) | -0.043 | (0.39) | 0.024 | (0.16) |
| Age of respondent | -0.257 | (0.19) | -0.035 | (0.14) | -0.132 | (0.15) | -0.196 | (0.27) | -0.138 | (0.11) |
| School degree of respondent | 0.018 | (0.09) | -0.035 | (0.05) | -0.035 | (0.07) | -0.119 | (0.12) | 0.040 | (0.05) |
| Number of years working in the firm | -0.362 | (0.25) | -0.104 | (0.16) | -0.066 | (0.17) | 0.822** | (0.35) | 0.485*** | (0.15) |
| Invested in training of workers (d) | 0.480* | (0.26) | 0.422*** | (0.16) | 0.302* | (0.18) | 1.427*** | (0.37) | 0.650*** | (0.16) |
| Research about clients within the firm (d) | 0.524** | (0.24) | 0.308* | (0.18) | 0.493** | (0.19) | 0.440 | (0.35) | 0.078 | (0.14) |
| % of workers with elementary education | -0.033 | (0.09) | -0.042 | (0.05) | -0.072 | (0.06) | -0.018 | (0.13) | 0.031 | (0.05) |
| % workers with high school education | 0.011 | (0.10) | -0.121* | (0.07) | -0.155* | (0.08) | 0.069 | (0.15) | 0.077 | (0.06) |
| % workers with high university/college | -0.034 | (0.19) | -0.072 | (0.12) | -0.108 | (0.13) | -0.201 | (0.26) | -0.057 | (0.10) |
| Evolution of workers skills since 1999 | 0.391* | (0.20) | 0.256* | (0.15) | 0.277* | (0.16) | 0.428 | (0.29) | 0.060 | (0.11) |
| Research products in firm (d) | 0.457* | (0.25) | 0.320** | (0.16) | 0.368** | (0.18) | 0.145 | (0.36) | 0.013 | (0.16) |
| Research products in labs (d) | 0.155 | (0.42) | -0.028 | (0.18) | -0.265 | (0.21) | 0.046 | (0.59) | -0.085 | (0.19) |
| Use previous workers' experience | 0.112 | (0.11) | 0.074 | (0.08) | 0.016 | (0.08) | 0.188 | (0.16) | 0.029 | (0.07) |
| Use local infra-structure for training | 0.055 | (0.07) | -0.027 | (0.04) | -0.046 | (0.05) | 0.018 | (0.11) | 0.022 | (0.04) |
| *Sources of information* | | | | | | | | | | |
| Secondary research on clients (d) | 0.389 | (0.35) | -0.018 | (0.16) | 0.109 | (0.20) | 0.425 | (0.50) | -0.095 | (0.17) |
| Consultancy | 0.248* | (0.14) | 0.012 | (0.07) | 0.172* | (0.09) | -0.276 | (0.20) | (0.13) | (0.09) |
| Universities/research institutes | 0.01 | (0.15) | (0.07) | (0.09) | (0.08) | (0.10) | 0.10 | (0.22) | (0.03) | (0.08) |
| Specialized publications | 0.08 | (0.10) | 0.05 | (0.06) | 0.06 | (0.08) | 0.23 | (0.14) | 0.127* | (0.07) |
| Patent databases | 0.524** | (0.21) | 0.077 | (0.10) | 0.147 | (0.14) | 0.429 | (0.31) | 0.106 | (0.09) |
| *Credit* | | | | | | | | | | |
| Own resources | 0.054 | (0.09) | 0.044 | (0.05) | 0.006 | (0.06) | -0.161 | (0.12) | -0.114** | (0.06) |
| Family/friends | 0.187 | (0.18) | 0.090 | (0.10) | 0.167 | (0.11) | 0.006 | (0.25) | -0.007 | (0.09) |
| BNDES | -0.437** | (0.21) | -0.204* | (0.12) | -0.380*** | (0.14) | 0.290 | (0.30) | 0.148 | (0.14) |
| Private banks | 0.198 | (0.14) | 0.139* | (0.08) | 0.172* | (0.10) | 0.055 | (0.21) | 0.099 | (0.08) |
| Banco do Brasil | -0.059 | (0.14) | -0.034 | (0.09) | -0.118 | (0.13) | 0.345 | (0.21) | 0.123 | (0.08) |
| Caixa Econômica Federal | 0.171 | (0.21) | 0.044 | (0.08) | 0.021 | (0.10) | 0.125 | (0.31) | -0.004 | (0.10) |
| Suppliers/customers | 0.118 | (0.15) | -0.041 | (0.07) | -0.032 | (0.09) | -0.191 | (0.22) | -0.160* | (0.09) |
| International sources | -0.013 | (0.32) | -0.139 | (0.13) | -0.050 | (0.13) | -1.338*** | (0.51) | -0.466 | (0.37) |

**Table 9**: Robustness Checks (cont.)

| | (1) IV Tobit | | (2) IV Poisson | | (3) IV Poisson | | (4) IV Tobit | | (5) IV Poisson | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coeff. | Std. Err. | Coeff. | Std. Err. | Coeff. | Std. Err. | Coeff. | Std. Err. | Coeff. | Std. Err. |
| *Government programs* | -0.078 | (0.30) | 0.126 | (0.18) | 0.231 | (0.24) | 0.246 | (0.43) | 0.186 | (0.17) |
| *International trade* | | | | | | | | | | |
| Exporter (d) | -0.135 | (0.44) | 0.191 | (0.35) | 0.165 | (0.37) | -0.014 | (0.63) | 0.080 | (0.31) |
| Large exporter (d) | 1.765 | (1.32) | 0.643** | (0.26) | 0.723 | (0.74) | 1.481* | (0.88) | 0.441 | (0.37) |
| *Internal characteristics of firms* | | | | | | | | | | |
| Age of the firm | 0.005 | (0.01) | 0.006 | (0.01) | 0.006 | (0.01) | -0.003 | (0.01) | -0.005 | (0.01) |
| Computers for management (d) | -0.714** | (0.33) | -0.592*** | (0.20) | -0.467** | (0.21) | -0.598 | (0.45) | -0.186 | (0.19) |
| Computers for production (d) | 0.309 | (0.28) | 0.398** | (0.16) | 0.309* | (0.18) | -0.679* | (0.40) | -0.306* | (0.16) |
| Computers for design (d) | 0.400 | (0.37) | -0.186 | (0.20) | -0.213 | (0.23) | 0.692 | (0.54) | 0.302* | (0.18) |
| Computers CAD/MRP (d) | -0.333 | (0.35) | 0.157 | (0.21) | -0.236 | (0.23) | -0.483 | (0.51) | -0.314 | (0.22) |
| Computers for Internet access (d) | 0.234 | (0.35) | -0.011 | (0.22) | 0.163 | (0.23) | 0.827* | (0.48) | 0.475** | (0.21) |
| Specialized functions | 0.255*** | (0.07) | 0.153*** | (0.03) | 0.125*** | (0.04) | 0.299*** | (0.09) | 0.087** | (0.04) |
| Quality management (d) | 0.306 | (0.28) | 0.197 | (0.17) | 0.309 | (0.20) | 0.266 | (0.39) | 0.158 | (0.16) |
| Formal business (d) | 0.045 | (0.35) | 0.015 | (0.20) | -0.017 | (0.25) | 0.962* | (0.49) | 0.730*** | (0.22) |
| *Location* | | | | | | | | | | |
| Campos (d) | -0.451 | (0.67) | 0.026 | (0.25) | -0.430 | (0.61) | 3.308*** | (0.88) | 1.527*** | (0.40) |
| Itaguaí (d) | -1.949*** | (0.71) | -0.046 | (0.33) | -0.052 | (0.46) | 2.642*** | (0.93) | 1.268*** | (0.40) |
| Macaé (d) | -5.061*** | (0.43) | -1.856*** | (0.27) | -2.354*** | (0.91) | -1.681*** | (0.57) | -0.629** | (0.29) |
| Friburgo (d) | 2.943** | (1.17) | -0.077 | (0.61) | -0.914 | (1.15) | -4.668*** | (1.51) | -2.361*** | (0.70) |
| Sector controls | Yes | | No | | Yes | | No | | No | |
| Observations | 479 | | 479 | | 479 | | 479 | | 479 | |

Note: *** significant at 1%, ** significant at 5%, * significant at 10%. Constant not included.

## Conclusions

The present paper uses primary individual level data to evaluate the effect of professional interactions, facilitated by membership of trade associations (TAs), on the decisions of small scale entrepreneurs about the adoption of different types of innovation.

The main finding of the empirical analysis is a positive and significant correlation between TA membership and the entrepreneurs' propensity to adopt different types of innovation. The magnitude of the effect of TA membership shows that in an urban setting of a developing country entrepreneurs do rely intensively on networking for innovation purposes. Through TAs, the entrepreneurs have more opportunities for professional interactions that lead to social learning, which in turn can lead to innovation adoption. This result is also consistent with the literature on innovation adoption in agricultural settings of developing countries and industrial settings of developed countries, which were discussed in the Introduction.

Some of the coefficients based on rival hypotheses (human capital, credit, sources of information, and government programs) are unexpectedly insignificant. In the four municipalities researched, these results can be explained by constraints related to: low levels of human capital; strong restrictions to credit and financing; limited access to sources of information outside the firm; and ineffectiveness of government programs. Because these constraints impose nontrivial restrictions on the businesses activities, entrepreneurs are likely to be compensating for them by engaging in networking. This effect is captured by the higher partial effect associated to TA membership (see Table 8).

Another interesting finding is that the presence of a large exporter in the same sector as the small firm has a positive effect on innovation adoption. While the literature on international economics tends to emphasize the role of spillovers brought about by foreign multinational corporations (for example Aitken, Hanson, and Harrison 1997) the spillover mechanisms provided by a (national) large exporter might well differ from the ones of the multinationals. For example, it is possible that multinationals have a higher propensity to use foreign suppliers more often than the large exporters do. If this is the case we would probably observe larger

magnitudes in the spillover effects in the presence of a large exporter. Future research could focus on those mechanisms and identify and evaluate their effects.

The findings in this paper are inconsistent with the literature on the performance of exporting plants, which tends to emphasize that exporters are larger, more technology-intensive, and pay higher wages than the firms that produce only for the domestic market (see, for example, Bernard and Jensen 1999, Bustos 2007, 2008 and Verhoogen 2008). Although the relatively small number of exporters surveyed does not allow us to draw more general conclusions, when this group is analyzed separately they do not present the characteristics mentioned above. This is actually consistent with the "small exporter paradox" presented by Lileeva and Trefler (2010) who show that it is possible for firms to export without making investments in productivity, when the access to foreign markets is improved, through tariff reductions. This result is supported by empirical evidence using Canadian data. In the context of developing countries it is possible that an increase in exports comes from changes that occur outside of the firm: reduction in transport costs through public investments in infra-structure, for example, could create the conditions for firms to export without investments in productivity. This however is a question that needs further investigation.

The credit constraints that firms face are characterized in the findings by the insignificant coefficients related to all sources of credit. But if we go back to the descriptive statistics in Table 6 we observe that entrepreneurs typically rely more on their own resources and/or borrow from family and friends. The difficulty with those sources of credit is clearly the uncertainty about their availability, which can contribute to the entrepreneur's reluctance towards the adoption of new technologies (and therefore the insignificant coefficients). On the other hand Table 6 also indicates, not surprisingly, that more diversified sources of credit are associated with more innovative firms. Many policy makers consider that small scale firms with the profile of the ones researched in this paper would benefit from microcredit programs. In Brazil, only after 2003 the government through the National Bank of Social and Economic Development (BNDES) started to expand microcredit programs for small scale firms. Although recent studies present empirical evidence of the correlation between microcredit and firm creation and growth (see, for example, World Bank, 2008, Honohan, 2004), there is still little systematic evidence on

the causual impact of microcredit on economic activity.[14] It would be useful to evaluate the impact of this policy on the firms in the sample and observe whether or not there were actual productivity gains caused by it.

Finally, the empirical results suggest that maybe policies supportive of voluntary interaction between entrepreneurs can be effective for the adoption and diffusion of new technologies in urban environments with a high density of small firms in manufacturing sectors. These, however, should be considered with extreme caution. Bandiera and Rasul (2006) show that individuals may respond heterogeneously to the choices of different members of their social network. Because these social effects can lead to very different outcomes, for better policy targeting it is still necessary to conduct studies that identify the network members and the asymmetries in the diffusion of innovation across individuals.

[14] Bruhn and Love (2009) and Karlan and Morduch (2009) take this direction.

**References:**


ACEMOGLU, D. (2009) *Introduction to Modern Economic Growth.* Princeton University Press.

AGHION, P. and P. HOWITT (1998) Endogenous Growth Theory. Cambridge, MIT Press.

AITKEN, B., HANSON, H., and HARRISON, A. E. (1997) "Spillovers, Foreign Investment, and Export Behavior." *Journal of International Economics*, 43:103-132.

AUDRETSCH, D. B, and FELDMAN, M. P. (1996) **"**R&D spillovers and the geography of innovation and production". *American Economic Review* 86(3), 630-640.

BANDIERA, O. and RASUL I. (2006) "Social Networks and Technology Adoption in Northern Mozambique." *Economic Journal*, 116: 869-902.

BERNARD A. B. and JENSEN, J. B. (1999) "Exceptional exporter performance: cause, effect, or both?" *Journal of International Economics*, 47: 1-25.

BESLEY, T. and CASE, A. (1994) "Diffusion as a Learning Process: Evidence from HYV Cotton." *Discussion Paper no. 174*, Center of International Studies, Woodrow Wilson School of Public and International Affairs, Princeton University.

BRUHN, M. and LOVE I. (2009) "The economic impact of banking the unbanked: evidence from Mexico." *Policy Research Working Paper Series.*

BUSTOS, P. (2007) "The Impact of Trade on Technology and Skill Upgrading: Evidence from Argentina," *CREI Working Paper*.

——, (2008) "Trade Liberalization, Exports and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinean Firms," *CREI Working Paper*.

CASSIMAN, B. and VEUGELERS, R. (2002) "R&D Cooperation and Spillovers: Some Empirical Evidence from Belgium," *American Economic Review*, 92(4): 1169–1184.

CONLEY, T. G. and UDRY Christopher R. (2010) "Learning about a New Technology: Pineapple in Ghana" *American Economic Review*, 100(1): 35–69.

DOSI G. (1988) "The Nature of the Innovative Process". In: Soete L. *Technical Change and Economic Theory*, Pinter Publishers, London.

ELLISON, G., GLAESER E. L., and KERR W. R. (2010) "What Causes Industry Agglomeration? Evidence from Coagglomeration Patterns." *American Economic Review*, 100(3): 1195–1213.

FOSTER, A. D. and ROSENZWEIG M. R. (1995) "Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture," *Journal of Political Economy* 104: 1176-1209.

FREEMAN, C. (1987) *Technology Policy and Economic Performance: Lessons from Japan.* London: Pinter Publishers.

GLAESER, E., KALLAL H., SCHEINKMAN, J., and SHLEIFER, A. (1992) "Growth in Cities." *Journal of Political Economy*, 100(6): 1126-1152.

GHOSH, P., MOOKHERJEE, D. and RAY D. (2000), "Credit Rationing in Developing Countries: An Overview of the Theory," Chapter 11 in Readings in the Theory of Economic Development, edited by D. Mookherjee and D. Ray, London: Blackwell.

GRANOVETTER, M. (1973) "The Strength of Weak Ties." *American Journal of Sociology* 78(6): 1360- 1380.

HASENCLEVER, L. & FAURÉ, Y. A. (2004) *As Transformações das Configurações Produtivas Locais no Estado do Rio de Janeiro.* Report of research project, sponsered by Conselho Nacional de Pesquisa (Brasil) e o Institut de Recherche pour le Développement (França).Jacobs 1969

HONOHAN, P. (2004) "Financial Development, Growth and Poverty: How Close are the Links?" *World Bank Policy Research Working Paper*, WP3203.

JACOBS, J. (1969). *The Economy of Cities*. New York: Vintage

JAFFE, A. B. (1986) "Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits and Market Value." *The American Economic Review*, 76(5): 984-1001.

KARLAN, D. and MORDUCH J. (2009) "Access to Finance." in: D. Rodrik and M. Rosenzweig (eds.) *Handbook of Development Economics*, 5.

LILEEVA, A. and TROFLER, D. (2010) "Improved Access To Foreign Markets Raises Plant-Level Productivity. . .For Some Plants." *Quarterly Journal of Economics*, 125(3): 1051-1099.

LUCAS, R. E. Jr. (1988) "On the Mechanics of Economic Development." *Journal of Monetary Economics*. 22: 3-42.

LUNDVALL, B-Å. (1992) *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning.* London: Pinter Publishers.

MARSHALL, A. (1920) *Principles of Economics*. London: Macmillan and Co., Ltd. [Online] available from http://www.econlib.org/library/Marshall/marP24.html; accessed 22 October 2006; Internet.

NELSON, R. and PHELPS, E. S. (1966), Investments in Humans, Technological Diffusion and Economic Growth, *American Economic Review: Papers and Proceedings*, 56: 69-75.

Organization for Economic Co-operation and Development (1998) "Women entrepreneurs: synthesis". Centre for Entrepreneurship, SMEs and Local Development. Available at: http://www.oecd.org/documentprint/0,3455,en_2649_34197_1809765_1_1_1_1,00.html

ROMER, P. (1986) "Increasing Returns and Long-Run Growth" *Journal of Political Economy* 94(5): 1002-1037.

ROODMAN, D. (2008) "CMP: Stata Module to Implement Conditional (Recursive) Mixed Process Estimator", available at: http://ideas.repec.org/c/boc/bocode/s456882.html.

SCHMITZ, H. (1982) "Growth Constraints on Small-Scale Manufacturing in Developing Countries: A

Critical Review", *World Development*, 10 (6): 429-450.

SCHMITZ, H. and NADVI, K. (1999) "Clustering and Industrialisation: Introduction". *World Development*, 27(9): 1503-1514.

VERHOOGEN, E. (2008) "Trade, Quality Upgrading and Wage Inequality in the Mexican Manufacturing Sector," *Quarterly Journal of Economics*, 123: 489–530.

VON HIPPEL, E. (1988) *The Sources of Innovation*. Oxford: Oxford University Press.

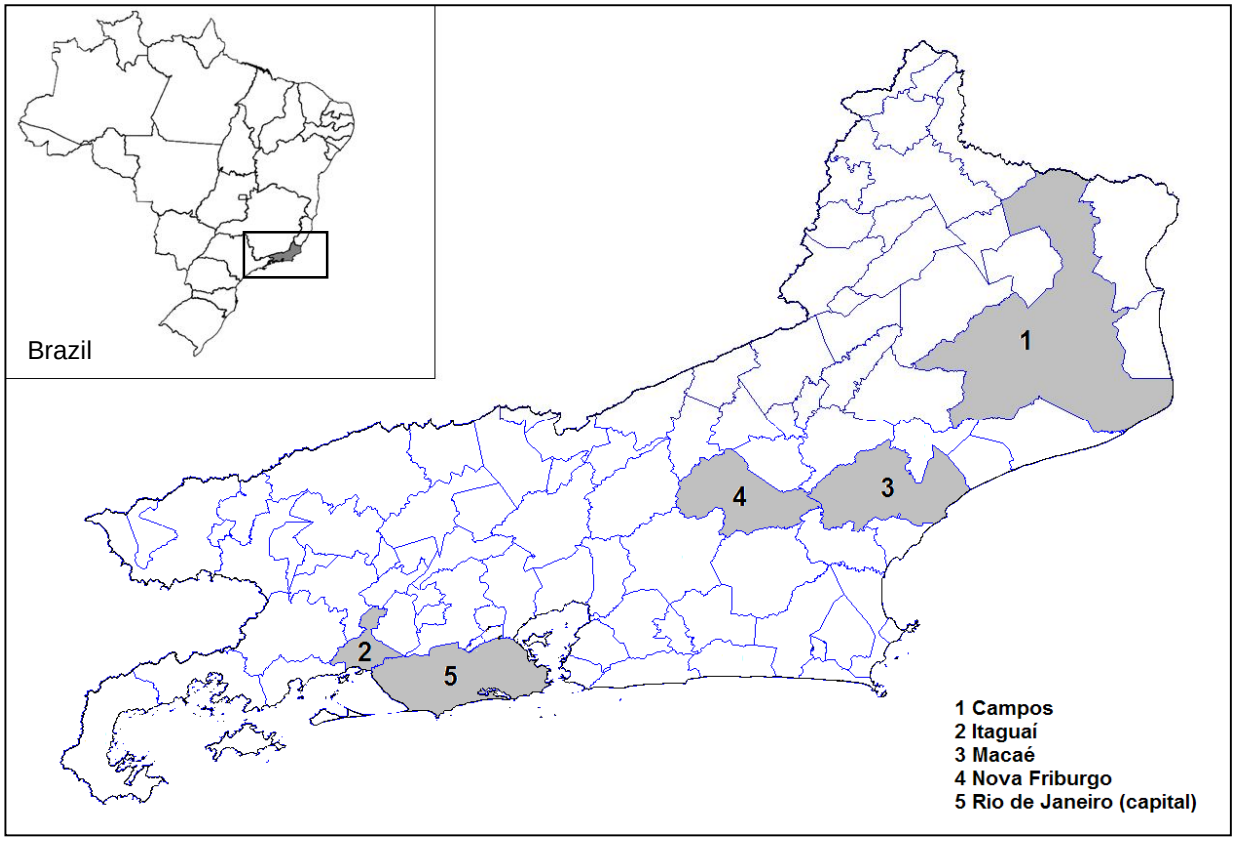
WOOLDRIDGE, J. (2002) *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA, MIT Press.

WORLD BANK (2008) "Finance for All? Policies and Pitfalls in Expanding Access" *Policy Research Report*, The World Bank.

YOUNG, H. P. (2009) "Innovation Diffusion in Heterogeneous Populations: Contagion, Social Influence, and Social Learning." *American Economic Review*, 99(5): 1899–1924.

## Appendix

**Figure 1**: Map of municipalities where firms in the sample are located.




**Description of Municipalities**:

In order to develop an accurate perspective on the economies of the municipalities referred to in this paper, it is useful to know that historically most of the economic activities in the state are concentrated in the capital, Rio de Janeiro, and its GDP[15] share is about 50% of the of the state as a whole. The four municipalities investigated maintain intensive economic relations with the capital.

Campos dos Goytacazes is located on the north-east coast of Rio de Janeiro state, 176 miles away from the capital, on the border with Espírito Santo state and it is the second largest city in

[15] Estimate for 2001 provided by the Center of Data and Information of Rio de Janeiro State (CIDE).

the state with approximately 430,000 inhabitants.[16] Historically, the region has been dependent on sugar-cane production and livestock. Currently the main sector in Campos is agro-industry. Other manufacturing industries tend to be underdeveloped because fiscal incentives attract them to Espírito Santo state and the overall low level of human capital causes growth to be slow.

There are three groups of sectors surveyed in Campos. The first include agricultural products, construction, and ceramic products, which are sectors with the highest number of firms and employment share in the municipality. The second include manufacturing of food and beverages and were chosen because of their high GDP share. The third was based on interviews with local authorities and included sectors that they regarded as having the fastest growth. These comprise garments and furniture. Firms interviewed in each sector were randomly selected.

Itaguaí is located on south-west coast of Rio de Janeiro state, 46 miles away from the capital, and has approximately 94,000 inhabitants. The high rates of unemployment in 1990s forced most of the population to find work in the metropolitan area around the capital, explaining the current status of "dormitory" that is attributed to this municipality. Still, there are four groups of sectors considered relevant for Itaguaí. The first group includes transport and related activities which are sectors organized around the local port, and generate approximately 11.9% of the local GDP. The port is used by producers from various Brazilian states as an alternative route for their exports instead of Rio de Janeiro and São Paulo ports – the most important ports in the country. The second comprises services to firms and takes the highest share of local GPD (around 29%). The third is construction, which also has a high percentage of local GDP (approximately 9.2%). The fourth group represents industry in general and encompasses extractive industry, smelting, metallurgy, machines and equipment. Firms interviewed in each sector were randomly selected.

Macaé is located on the center-west coast of Rio de Janeiro state, 119 miles away from the capital, and has approximately 170,000 inhabitants. The economy was originally based on the agricultural sector and was transformed by the discovery of oil in Campos Basin. The fast growth of the oil sector led various types of businesses linked to the oil activities to emerge in the region. In particular, the relocation of large oil companies to Macaé attracted small and

[16] The largest city in the state is the capital, Rio de Janeiro city, with approximately 6,1 million of inhabitants.

medium firms to the region. They can be divided in three groups. The first is commerce for the industrial sector. The second includes manufacturing and services for industrial sectors. And the third group includes technical services.

Nova Friburgo is located on the mountains of center-west Rio de Janeiro state, 87 miles away from the capital, and has approximately 178,000 inhabitants. It is the most industrialized municipality in the state apart from the capital and its pleasant location is also suitable for tourism. The local manufacturers were traditionally specialized in textiles, metal products and equipment. In the 1990s this structure was forced to change by the competition with foreign firms that trade liberalization posed. These traditional sectors experienced decline while the production of garments, particularly lingerie, expanded. The researchers chose to include in the survey the sectors with the following criteria. First they selected sectors with the highest number of firms and rates of employment. This encompasses garments and complementary activities, such as textiles and commerce. The second criterion was to select sectors with the highest GDP shares. This includes construction and, in spite of the period of decline, metal products and equipment still have a high share of GDP. Finally, tourism was included because it is considered by the local authorities as important for local development. Firms in each sector were randomly selected

**Table A1:** Geography of main transactions of firms in the sample [(1)]

| | Campos | | | Itaguaí | | | Macaé | | | Nova Friburgo | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SE | N | Mean | SE | N | Mean | SE | N | Mean | SE | N |
| *Origin of equipments* | | | | | | | | | | | | |
| Municipality | 2.360 | (2.14) | 136 | 1.300 | (1.83) | 100 | 0.510 | (1.20) | 147 | 0.745 | (1.58) | 98 |
| Region | 0.515 | (1.13) | 136 | 0.310 | (0.73) | 100 | 0.095 | (0.47) | 147 | 0.071 | (0.44) | 98 |
| Capital | 0.676 | (1.34) | 136 | 2.000 | (1.97) | 100 | 0.986 | (1.44) | 147 | 0.235 | (0.81) | 98 |
| RJ state | 0.574 | (1.30) | 136 | 0.240 | (0.73) | 100 | 0.095 | (0.46) | 147 | 0.041 | (0.20) | 98 |
| Other state in Brazil | 0.971 | (1.56) | 136 | 1.230 | (1.68) | 100 | 1.612 | (1.91) | 147 | 2.286 | (2.13) | 98 |
| Abroad | 0.081 | (0.47) | 136 | 0.210 | (0.69) | 100 | 0.279 | (0.84) | 147 | 1.378 | (1.96) | 98 |
| *Origin of inputs* | | | | | | | | | | | | |
| Municipality | 2.514 | (2.03) | 140 | 0.394 | (1.13) | 99 | 0.392 | (1.11) | 148 | 1.170 | (1.40) | 100 |
| Region | 0.596 | (1.23) | 141 | 0.111 | (0.53) | 99 | 0.054 | (0.33) | 148 | 0.120 | (0.50) | 100 |
| Capital | 0.468 | (1.01) | 141 | 0.606 | (1.38) | 99 | 0.581 | (1.25) | 148 | 0.350 | (0.81) | 100 |
| RJ state | 0.539 | (1.28) | 141 | 0.111 | (0.60) | 99 | 0.176 | (0.79) | 148 | 0.120 | (0.56) | 100 |
| Other state in Brazil | 0.908 | (1.58) | 141 | 0.343 | (0.99) | 99 | 0.723 | (1.53) | 148 | 3.030 | (1.77) | 100 |
| Abroad | 0.035 | (0.25) | 141 | 0.061 | (0.35) | 99 | 0.027 | (0.33) | 148 | 0.287 | (0.90) | 101 |
| *Origin of suppliers* | | | | | | | | | | | | |
| Municipality | 2.855 | (2.00) | 138 | 2.020 | (1.98) | 100 | 1.807 | (2.10) | 145 | 2.304 | (1.94) | 92 |
| Region | 0.496 | (1.04) | 139 | 0.400 | (0.97) | 100 | 0.124 | (0.56) | 145 | 0.120 | (0.51) | 92 |
| Capital | 0.511 | (1.04) | 139 | 1.790 | (1.79) | 100 | 0.986 | (1.30) | 145 | 0.380 | (0.81) | 92 |
| RJ state | 0.410 | (1.00) | 139 | 0.170 | (0.51) | 100 | 0.076 | (0.44) | 145 | 0.109 | (0.58) | 92 |
| Other state in Brazil | 0.942 | (1.47) | 139 | 0.670 | (1.30) | 100 | 1.448 | (1.74) | 145 | 2.000 | (1.83) | 92 |
| Abroad | 0.095 | (0.50) | 137 | 0.060 | (0.34) | 100 | 0.069 | (0.35) | 145 | 0.120 | (0.47) | 92 |
| *Destination of sales* | | | | | | | | | | | | |
| Municipality | 3.783 | (1.62) | 143 | 1.859 | (1.94) | 99 | 4.514 | (0.84) | 148 | 1.827 | (1.84) | 104 |
| Region | 0.511 | (0.92) | 141 | 0.758 | (1.05) | 99 | 0.169 | (0.49) | 148 | 0.423 | (0.78) | 104 |
| Capital | 0.550 | (1.15) | 140 | 1.667 | (1.79) | 99 | 0.142 | (0.45) | 148 | 0.856 | (1.01) | 104 |
| RJ state | 0.204 | (0.51) | 142 | 0.475 | (0.91) | 99 | 0.054 | (0.26) | 148 | 0.423 | (0.80) | 104 |
| Other state in Brazil | 0.127 | (0.50) | 142 | 0.515 | (1.12) | 99 | 0.189 | (0.60) | 148 | 2.058 | (1.59) | 104 |
| Abroad | 0.050 | (0.39) | 139 | 0.152 | (0.69) | 99 | 0.020 | (0.25) | 148 | 0.173 | (0.41) | 104 |

Note: (1) Volume of transactions in percent terms, where 0%=0, 1-24%=1, 25-49%=2, 50-74%=3, 75-99%=4, 100%=5

**Table A2:** Types of Innovations adopted by sector

| Location/Economic Sectors | Design | % | Style of Product | % | Technical Charact | % | New Product | % | New Equipment | % | Automati-zation | % | Managerial Techniques | % | New Inputs | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Campos* | | | | | | | | | | | | | | | | |
| Garments (n=20) | 12 | 2.4 | 11 | 2.2 | 8 | 1.6 | 14 | 2.8 | 11 | 2.2 | 13 | 2.6 | 15 | 3 | 10 | 2 |
| Furniture (n=20) | 6 | 1.2 | 6 | 1.2 | 6 | 1.2 | 7 | 1.4 | 4 | 0.8 | 3 | 0.6 | 2 | 0.4 | 3 | 0.6 |
| Construction (n=20) | 2 | 0.4 | 2 | 0.4 | 3 | 0.6 | 6 | 1.2 | 2 | 0.4 | 2 | 0.4 | 4 | 0.8 | 3 | 0.6 |
| Clay products (n=20) | 3 | 0.6 | 11 | 2.2 | 11 | 2.2 | 8 | 1.6 | 18 | 3.6 | 14 | 2.8 | 6 | 1.2 | 4 | 0.8 |
| Food products (n=20) | 4 | 0.8 | 3 | 0.6 | 1 | 0.2 | 10 | 2 | 6 | 1.2 | 3 | 0.6 | 5 | 1 | 5 | 1 |
| Agro-industry (n=45) | 3 | 0.6 | 5 | 1 | 5 | 1 | 22 | 4.4 | 22 | 4.4 | 7 | 1.4 | 18 | 3.6 | 21 | 4.2 |
| Campos Total | 30 | 6 | 38 | 7.6 | 34 | 6.8 | 67 | 13.4 | 63 | 12.6 | 42 | 8.4 | 50 | 10 | 46 | 9.2 |
| *Itaguaí* | | | | | | | | | | | | | | | | |
| Transport (n=31) | 4 | 0.8 | 5 | 1 | 5 | 1 | 8 | 1.6 | 19 | 3.8 | 12 | 2.4 | 17 | 3.4 | 3 | 0.6 |
| Construction (n=37) | 2 | 0.4 | 5 | 1 | 5 | 1 | 12 | 2.4 | 11 | 2.2 | 4 | 0.8 | 10 | 2 | 7 | 1.4 |
| Extractive ind, smelting, metallurgy, machines and equipment (n=23) | 8 | 1.6 | 9 | 1.8 | 9 | 1.8 | 10 | 2 | 16 | 3.2 | 9 | 1.8 | 12 | 2.4 | 12 | 2.4 |
| Services to firms (n=9) | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0.6 | 5 | 1 | 3 | 0.6 | 4 | 0.8 | 0 | 0 |
| Itaguaí Total | 14 | 2.8 | 19 | 3.8 | 19 | 3.8 | 33 | 6.6 | 51 | 10.2 | 28 | 5.6 | 43 | 8.6 | 22 | 4.4 |
| *Macaé* | | | | | | | | | | | | | | | | |
| Commerce for industries (n=38) | 1 | 0.2 | 0 | 0 | 0 | 0 | 4 | 0.8 | 3 | 0.6 | 3 | 0.6 | 4 | 0.8 | 3 | 0.6 |
| Oil industries and related services (n=73) | 3 | 0.6 | 3 | 0.6 | 3 | 0.6 | 14 | 2.8 | 28 | 5.6 | 21 | 4.2 | 24 | 4.8 | 10 | 2 |
| Ind services, personal technical services (n=39) | 1 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 4 | 0.8 | 4 | 0.8 | 3 | 0.6 |
| Macaé Total | 5 | 1 | 3 | 0.6 | 3 | 0.6 | 18 | 3.6 | 36 | 7.2 | 28 | 5.6 | 32 | 6.4 | 16 | 3.2 |
| *Friburgo* | | | | | | | | | | | | | | | | |
| Garments (n=70) | 60 | 12 | 59 | 11.8 | 59 | 11.8 | 59 | 11.8 | 53 | 10.6 | 25 | 5 | 42 | 8.4 | 58 | 11.6 |
| Textiles (n=7) | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 6 | 1.2 | 4 | 0.8 | 4 | 0.8 | 5 | 1 |
| Metal products, equipments (n=8) | 5 | 1 | 7 | 1.4 | 7 | 1.4 | 8 | 1.6 | 7 | 1.4 | 5 | 1 | 5 | 1 | 7 | 1.4 |
| Construction (n=6) | 1 | 0.2 | 3 | 0.6 | 3 | 0.6 | 4 | 0.8 | 5 | 1 | 2 | 0.4 | 3 | 0.6 | 4 | 0.8 |
| Tourism (n=5) | 1 | 0.2 | 1 | 0.2 | 1 | 0.2 | 3 | 0.6 | 3 | 0.6 | 2 | 0.4 | 1 | 0.2 | 4 | 0.8 |
| Commerce of textile products (n=9) | 2 | 0.4 | 3 | 0.6 | 3 | 0.6 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Friburgo Total | 74 | 14.8 | 78 | 15.6 | 78 | 15.6 | 84 | 16.8 | 74 | 14.8 | 38 | 7.6 | 55 | 11 | 78 | 15.6 |
| Total | 123 | 24.6 | 138 | 27.6 | 134 | 26.8 | 202 | 40.4 | 224 | 44.8 | 136 | 27.2 | 180 | 36 | 162 | 32.4 |

**Table A3**: Basic results without instrumental variable

| Dependent Variable: Innovation Adoption | Linear | | Probit | | Tobit | |
|---|---|---|---|---|---|---|
| | Coeff. | Std. Err. | Coeff. | Std. Err. | Coeff. | Std. Err. |
| Trade associations (d) | 0.274 | (0.18) | 0.257 | (0.20) | 0.497** | (0.25) |
| *Human Capital* | | | | | | |
| Gender of respondent | -0.294 | (0.20) | -0.279 | (0.24) | -0.351 | (0.27) |
| Age of respondent | -0.286** | (0.14) | -0.114 | (0.15) | -0.275 | (0.19) |
| School degree of respondent | -0.061 | (0.06) | -0.146* | (0.08) | -0.049 | (0.08) |
| Number of years working in the firm | -0.127 | (0.19) | -0.501** | (0.22) | -0.291 | (0.24) |
| Invested in training of workers (d) | 0.506*** | (0.19) | 0.326 | (0.22) | 0.706*** | (0.26) |
| Research about clients within the firm (d) | 0.201 | (0.18) | 0.036 | (0.21) | 0.257 | (0.23) |
| % of workers with elementary education | 0.068 | (0.06) | 0.054 | (0.07) | 0.058 | (0.08) |
| % workers with high school education | 0.039 | (0.08) | 0.099 | (0.09) | -0.004 | (0.10) |
| % workers with high university/college | 0.044 | (0.13) | 0.095 | (0.17) | 0.083 | (0.18) |
| Evolution of workers skills since 1999 | 0.120 | (0.15) | 0.227 | (0.17) | 0.280 | (0.20) |
| Research products in firm (d) | 0.182 | (0.19) | -0.370* | (0.22) | 0.300 | (0.24) |
| Research products in labs (d) | 0.537* | (0.32) | 0.752 | (0.63) | 0.377 | (0.40) |
| Use previous workers' experience | 0.137* | (0.08) | 0.052 | (0.09) | 0.196* | (0.11) |
| Use local infra-structure for training | 0.114** | (0.05) | 0.156** | (0.07) | 0.143** | (0.07) |
| *Sources of information* | | | | | | |
| Secondary research on clients (d) | 0.429 | (0.27) | 0.553 | (0.40) | 0.408 | (0.34) |
| Consultancy | 0.16 | (0.11) | 0.24 | (0.15) | 0.18 | (0.13) |
| Universities/research institutes | 0.04 | (0.11) | 0.13 | (0.16) | (0.01) | (0.15) |
| Specialized publications | 0.080 | (0.07) | 0.058 | (0.08) | 0.142 | (0.10) |
| Patent databases | 0.516*** | (0.17) | 0.298 | (0.36) | 0.483** | (0.21) |
| *Credit* | | | | | | |
| Own resources | 0.064 | (0.06) | 0.063 | (0.08) | 0.044 | (0.09) |
| Family/friends | 0.064 | (0.13) | 0.219 | (0.19) | 0.118 | (0.17) |
| BNDES | -0.211 | (0.16) | -0.192 | (0.30) | -0.401** | (0.20) |
| Private banks | 0.165 | (0.11) | 0.359** | (0.17) | 0.235* | (0.14) |
| Banco do Brasil | 0.037 | (0.11) | 0.076 | (0.12) | 0.042 | (0.14) |
| Caixa Econômica Federal | 0.308* | (0.16) | 0.678 | (0.49) | 0.351* | (0.20) |
| Suppliers/customers | 0.088 | (0.12) | 0.317 | (0.23) | 0.073 | (0.15) |
| International sources | -0.166 | (0.25) | -0.285 | (0.70) | -0.192 | (0.31) |
| *Government programs* | -0.024 | (0.23) | 0.431 | (0.29) | 0.054 | (0.29) |
| *International trade* | | | | | | |
| Exporter (d) | 0.313 | (0.34) | 0.655 | (0.59) | 0.151 | (0.43) |
| Large exporter (d) | 1.401*** | (0.46) | 0.942 | (0.75) | 1.729*** | (0.57) |
| *Internal characteristics of firms* | | | | | | |
| Age of the firm | -0.001 | (0.01) | 0.022** | (0.01) | 0.004 | (0.01) |
| Computers for management (d) | -0.562** | (0.24) | -0.217 | (0.28) | -0.881*** | (0.32) |
| Computers for production (d) | 0.503** | (0.21) | 0.519** | (0.25) | 0.741*** | (0.27) |
| Computers for design (d) | 0.390 | (0.28) | -0.491 | (0.36) | 0.204 | (0.36) |
| Computers CAD/MRP (d) | -0.070 | (0.26) | 0.137 | (0.34) | 0.084 | (0.33) |
| Computers for Internet access (d) | 0.144 | (0.25) | 0.100 | (0.28) | 0.134 | (0.34) |
| Specialized functions | 0.215*** | (0.05) | 0.213*** | (0.07) | 0.282*** | (0.06) |
| Quality management (d) | 0.131 | (0.20) | 0.194 | (0.24) | 0.369 | (0.26) |
| Formal business (d) | 0.091 | (0.25) | 0.353 | (0.26) | 0.124 | (0.33) |
| *Location* | | | | | | |
| Campos (d) | -0.841* | (0.46) | -0.011 | (0.73) | -0.659 | (0.58) |
| Itaguaí (d) | -1.191** | (0.49) | 0.058 | (0.75) | -1.138* | (0.61) |
| Macaé (d) | -3.725*** | (0.29) | -2.774*** | (0.41) | -4.964*** | (0.38) |
| Friburgo (d) | 2.624*** | (0.77) | 0.352 | (0.97) | 1.639 | (1.00) |
| Observations | 479 | | 479 | | 479 | |

Note: *** significant at 1%, ** significant at 5%, * significant at 10%. Constant not included.