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The Advantages of Association: Know-How Sharing and Innovation Adoption in Four Brazilian Cities

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 dataset 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 different types of innovation more often than entrepreneurs who are not members. This is tested against two rival hypotheses. The first 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 TA membership may be endogenous, an instrumental variable is introduced.

KEY-WORDS

INNOVATION ADOPTION; KNOW-HOW SHARING; TRADE ASSOCIATIONS; SMALL FIRMS; DEVELOPING COUNTRY

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1. Introduction

If innovation is fundamental to economic development it is natural for policy makers in developing countries to ask under what conditions the innovation process may be enhanced. Research on social capital and on social networks suggests that interactions between entrepreneurs have a significant effect on their innovation adoption decisions. The argument is that social learning, supported by social capital or social networks, helps the diffusion of innovations by enabling agents to access new ideas. The contribution of the present paper is to identify and quantify in a variety of economic sectors the effect of social learning among small scale entrepreneurs on the adoption of innovations in four urban settings located in Brazil. The empirical analysis uses a unique dataset with comprehensive information on characteristics of firms and their owners that I helped to construct with work in the field[1].

There is already a mature literature that comprises quantitative studies on social learning and innovation in urban settings of *developed* countries. 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 a diversity of industries (Jacobs, 1969) or in areas with specialized industries (Marshall, 1920; Glaeser et al., 1992; Audretsch and Feldman 1996; Ellison, Glaeser and Kerr 2010; Chatterji, Glaeser and Kerr, 2013)[2]. Not surprisingly, the consensus is that social learning has a significant influence on decisions over innovation adoption.

However, the results of studies for urban settings of developed countries cannot be extrapolated to urban settings of developing countries because a number of constraints imposed by the developing country environment are omitted from these studies. Some of these constraints include: limited enforcement of property rights; lack of access to credit; limited access to external sources of information and insufficient human capital. Given the constraints that entrepreneurs in developing countries 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 and theft. A second would be that entrepreneurs might compensate for the constraints that they face through networking. In other words, these constraints might alternatively drive entrepreneurs 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.

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[1] The present paper is related to the literature on *economic* effects of a given endowment of social capital (Putnam, 1993; Knack and Keefer, 1997; Guiso, Sapienza and Zingales, 2009). This is different from the literature on social capital accumulation, which investigates sources of variation in social capital. See for example, Alesina and La Ferrara (2000); Campante, Durante and Sobbrio (2013); Sabatini, Modena and Tortia (2014).

[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).

I use individual-level data 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[3]. 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 different 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.

I test the influence of a weak form of cooperation between entrepreneurs on the innovation adoption decision. A higher propensity to cooperate is measured by membership of trade associations (TAs)[4]. The focus is on TAs because they constitute the main form of cooperation among firms in the sectors surveyed. A TA is a formal organization that represents entrepreneurs' interests where specialized information is provided. For example, we observed that one of the TAs had an employee whose main task was to track funding opportunities and during the time of the survey he managed to secure government resources for a group of entrepreneurs to explore prospective markets in Europe. Some other examples of roles that TAs 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.

At first sight it is intriguing that in the sectors surveyed TAs are the prevalent form of cooperation instead of more cohesive forms such as cooperatives. My conjecture is that a TA solves two problems: the absence of complementarities between firms and the low enforcement of property rights that characterizes the Brazilian business environment. Complementarities between firms are absent in the sense that these firms compete aggressively in the same segment of the production chain with minimal differentiation in their products and production methods. For example, in the city of Campos the clay pottery producers are responsible for all stages of the production process, starting from the clay collection in the quarries to the sale of the finished pottery to the consumers. The low enforcement of property rights means that the court system cannot be relied on to resolve

[3] In the sample of firms included in the survey, 83 per cent have less than 50 workers and 89.2 per cent have annual turnover of less than three million EUR, which under the European convention is considered either micro or small sized.

[4] 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 per cent of firms in the sample never had a formal contract with any other firm.

commercial disputes, making it potentially costly for entrepreneurs to develop relationships based on formal contracts. A TA solves these two problems because it provides a weak form of cooperation that does not require firms either to coordinate production (complementarities) or to commit to each other formally, which averts commercial disputes. At the same time, many of the benefits of deeper forms of cooperation are preserved, including speeding product development, expanding markets, obtaining technology, or otherwise gaining competitive advantages.

For the empirical analysis, the interpretation of TAs follows the framework by Granovetter (1973). He proposes two types of social relationships: weak and strong ties. Weak ties mean that an individual's acquaintances are less likely to be socially involved with one another than her close friends (strong ties). These acquaintances are likely to have strong ties to distinct groups of close friends. Through a weak tie the individual in one group may obtain and learn information about the other group and gain an advantage over another individual of the same group. As the TA offers entrepreneurs the opportunity to establish weak ties with a diversity of individuals and institutions external to their close circle of friends, TAs are used to proxy a greater propensity of the entrepreneurs who join them to cooperate and to access new information. Given the new information provided by a TA, higher professional interaction leads to more sharing of know-how and to the adoption of more types of innovation. One example of this process was observed in Nova Friburgo. A policymaker from Rio de Janeiro, the city capital of the state, who was connected to the local TA proposed an innovation related to the standardization of the size of the products. Before introducing this innovation, the entrepreneurs had the opportunity to discuss the advantages and costs of doing so and later they were able to report their experiences to each other.

There are two main issues related to the use of TA membership as a variable that explains a higher propensity for professional interactions between entrepreneurs. First, entrepreneurs can become members of TAs without participating actively in them[5]. Second, and more important, TA membership might be endogenous because entrepreneurs self-select into membership. Hence, TA membership is instrumented by a variable that contains information on engagement of entrepreneurs in random social activities. The assumption is that an entrepreneur presents a higher propensity to socialize if she is engaged in at least one of these social activities, which in turn makes her more likely to be a TA member.

The main concern about the use of this instrument is orthogonality. The instrument is valid only if it does not influence the dependent variable, adoption of innovation. To substantiate this approach I follow Granovetter (1973) by arguing that the strong ties between an entrepreneur and her friends through social activities make the introduction of new ideas for innovation unlikely because strong ties tend preclude the introduction of new information from outside sources. This means that "individuals with few weak ties will be deprived of information from distant parts of

[5] Some of the respondents in the survey for example reported informally that they were satisfied by no greater involvement than receiving the monthly TA newsletter because this was enough to keep them sufficiently well informed for their needs.

the social system and will be confined to the provincial news and views of their close friends. This deprivation will not only insulate them from the latest ideas and fashions but may put them in a disadvantaged position […]" (Granovetter, 1983: 202). The insularity of individuals participating in social activities and sports clubs is reinforced by the relative small size of the cities where the sectors included in the study are located, where, in general, these individuals were born in the locality or have been living there for many years. Although individuals engaged in social activities exchange information intensively, the stock of ideas and knowledge in these groups is fixed and therefore innovation through these channels is unlikely. For the remaining concerns about self-selection I attempt to minimize this source of bias by controlling for as many personal characteristics of the entrepreneur as possible, such as the education level and her experience.

TA membership 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. This is consistent with the general low levels of human capital and the severe credit restrictions observed in the municipalities surveyed. Of greater significance are the location effects and some of the internal characteristics of the firms. Finally, the presence of a larger exporter in the locality also brings about positive spillovers for innovation. From a policy perspective the main result suggests that a focal point for professional interactions within the vicinity of the firms, in this case a TA, may help entrepreneurs to introduce innovations more effectively than targeted policies for specific types of innovations.

The paper proceeds as follows. Section 2 gives the background and discusses how firms were selected. Section 3.1 describes the data and variables used in the regressions while section 3.2 sets out the methodology. Section 4.1 presents the basic results. Section 4.2 discusses briefly possible sources of spurious regressions. Section 5 presents robustness checks and section 6 relates the findings of this paper to the prior literature and 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, 13 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 per cent of entrepreneurs refused to be interviewed. The number of firms interviewed in the final sample is 500[6]. 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 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 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 per cent) are small sized.

The interviews with the entrepreneurs were conducted in 2002 and essentially involved a broad questionnaire[7]. 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.

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

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

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 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*	

3. 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 is adopted and zero otherwise. Table 1 in the previous section, shows that 325 firms in the sample (65 per cent) 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 gives the proportions of different types of innovation adopted for all firms surveyed[8].

During an interview, each respondent indicated types of innovation that her firm adopted

[8] The proportions are obtained by giving each type of innovation a weight of one for each firm in the sample. Non-adoption is given a weight of one as well. Then, the sum of the weights on all types of innovations and non-adoptions (9x480) corresponds to 100 per cent. The total for each type of innovation is then made proportional to 100 per cent.

based on the list of types of innovations presented above[9]. 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 zero and eight 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.

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

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.

[9] 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 non-members.

3.1.2 Membership of trade associations and sharing of know-how

The fundamental variable for the econometric analysis is TA membership. In Brazil, a TA is defined as a non-profit organization seeking to promote collaboration between firms and to further the interests of entrepreneurs in a business sector. 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. In the sample used for the analysis, 59.20 per cent of firms are members of at least one TA.

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 χ^2	38.732		

All sectors included in the survey have one corresponding TA in the municipality where they are located. In addition, 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 BRL[10] (11.50 EUR) per month and 100.00 BRL (29.00 EUR) per month. 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 an entrepreneur becomes a member of a TA located outside the municipality because, even though the fees remain in the same range as the local TA, transport costs are higher.

In each municipality, the number of firms that are members of a TA is usually a small percentage of the population of firms. For example, in Nova Friburgo, while there are approximately 800 small scale firms producing textiles and garments, only 165 of them 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 that 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

[10] Brazilian Real.

sectors. Besides, the empirical analysis focuses primarily on the correlation between membership and innovation rather than the probability of a firm in a given sector being member of a TA.

3.1.3 Sociability as an instrument

In order to address the potential bias from the endogeneity of TA membership, 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 and non-governmental organizations (NGOs). 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[11].

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 instrument is that the primary objective of SOCs is not economic and membership is motivated by non-market interactions, while TAs have a clear objective of representing the interests of businesses and the supply of new commercially relevant information to entrepreneurs.

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

[11] 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.

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. In relation to the relevance of the instrument, both TA and SOCs membership are ways of connecting socially with the local community and involve a spontaneous association of agents participating in reciprocal interactions. Moreover, because both TA and SOCs membership are correlated with a higher propensity for social engagement, an entrepreneur who is a member of an organization or a club is more likely to be a member of a TA.

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. The complete list of controls can be found on Table A1 of the Appendix. The quantitative analysis uses the following categories of controls: 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, 2009). 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.

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 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). 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 fifth category includes controls related to international trade. Empirical literature on trade shows that firms that export 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. Finally, at the firm level, there are controls related to: use of computers, specialized functions and management tools.

3.2 Methodology

The main hypothesis tested in the empirical analysis is that entrepreneurs who are members of a TA are more likely to adopt more types of innovation than the entrepreneurs who are non-members. The empirical specification is the following. Denote innovation adoption by a_i^* where i identifies the entrepreneur. Membership of the TA is 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:

$$m_i^* = \alpha_2 + \beta_2 z_i + \boldsymbol{\gamma_2} \mathbf{x}_i + \omega_i, \text{ where}$$

It is assumed that (ε, ω) are 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 6. 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 per cent level.

Table 6. 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[12]. Table 7 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 per cent 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 the empirical analysis appear on equation (3), IV Tobit, where the dependent variable takes into account the number of the

[12] In this part controls for sectors are not being used. The robustness checks in the next section show that with controls for sectors the results would remain qualitatively the same.

variety of innovations that are adopted. Both specifications used maximum likelihood[13] 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 per cent level in both specifications. Next to 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.

The location control for Macaé presents coefficients significant at 1 per cent 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 7 and insignificant and for Tobit lower and significant at 5 per cent (see coefficients without the instrument in Table A4 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 7 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 ρ. In the IV Tobit specification, this parameter represents the correlation between ε and ω. In other words, ρ 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 ρ equal to atanhrho = $1/2*\ln[(1+\rho)]/(1-\rho)]$, which is the inverse hyperbolic tangent of ρ. The test rejects the null hypothesis ρ=0 at 1 per cent level, which again shows that the instrument is necessary for the correct estimation of the TA membership coefficient. For the IV Probit specification ρ is defined analogously to IV Tobit (see Wooldridge, 2002 for details). The likelihood test of ρ=0 for the IV Probit in (2) rejects the null hypothesis at the 10 per cent level (with correspondent chi-squared statistic=3.54), which shows once again that the instrument is necessary.

[13] For the maximum likelihood estimation the "cmp" command in Stata was used. (See Roodman, 2008 for details)

Table 7. 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) Betahat/ Sigmahat
							Partial Effects		
	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 ρ=0 in IV Probit: chi2(1) = 3.54324 Prob > chi2 = 0.0598.

Table 7. 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 r=0 in IV Probit: chi2(1) = 3.54324 Prob > chi2 = 0.0598.

Table 7 also reports the coefficients on other individual controls even though they are not the main focus of the analysis. These coefficients should be interpreted with caution because the structure of the qualitative data narrows the supports of the distributions of the regressors. A few controls are significant at 10 per cent and 5 per cent level and the level of significance is often not consistent between IV probit and IV Tobit[14]. 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 7 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 zero per cent level in IV Tobit. Its partial effect is only lower than the ones obtained for Macaé and the TA variable. 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 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. Section 5 discusses alternative estimations that do not rely on these assumptions.

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 7) and compare the results to the IV

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

Probit coefficients, these results are not statistically different. For example, in Table 7 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 7, 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.

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[15]. 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 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

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

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[16]. Therefore, 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 7), the value of the log likelihood for the linear part is -721.127 and, therefore the joint log likelihood is -1,079.685. 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 8 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[17].

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 seven available answers: (1) improved equipment 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 8.

[16] See Wooldridge (2002) for details.

[17] Lewbel (2000) and Dong and Lewbel (2015) propose estimators for discrete choice models with heteroskedastic errors that can be used with discrete endogenous regressors. The trade-off is that these estimators require large support and are therefore inappropriate for the data used in the empirical analysis.

Table 8. Robustness checks: Alternative specifications and controls

	(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 8. Robustness Checks: Alternative specifications and controls (cont.)

	(1)		*(2)*		*(3)*		*(4)*		*(5)*	
	IV Tobit		*IV Poisson*		*IV Poisson*		*IV Tobit*		*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.

6. Conclusions

The present paper uses primary individual level data to evaluate the effect of a weak form of cooperation, facilitated by information provided by 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 access to new information and 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 industrial settings of developed countries, discussed in the introductory section.

In all sectors surveyed, direct cooperation among firms was low or absent. When cooperation was identified it was sporadic and superficial. For example, if an entrepreneur ran out of a raw material, an entrepreneur in the neighborhood would be happy to lend them some, but collaboration would not develop further. The low level of cooperation may be related to the absence of complementarities between firms and the weak enforcement of property rights. An illustration of this is the failure of the "consortia program" in Nova Friburgo. The program, conducted by the Brazilian government, gave incentives in the form of subsidies to groups of firms in order to increase the exports to the large American and European markets. Working in a group was one of the requirements for the program because each firm was constrained by its small scale and would not be able to fulfil product requests alone. Firms were encouraged to exploit scale gains through coordinated production. Soon after the program started to run, opportunistic behaviour led some entrepreneurs to approach consumers and close deals without consulting the other firms in the group, which undermined trust. As a result, the firms in the group broke away from each other and eventually the consortia program was shut down. If firms had been able to write contracts backed by the legal system, so that opportunistic behavior could have been punished, the program might have succeeded (Aguiar, Cândido and Araújo, 2008).

In this difficult environment the TAs are the only form of cooperation that endures over time because the TA setting supports only indirect cooperation, keeping the costs imposed by free-riding low. Before deeper cooperation can develop, two types of policy would help to create the necessary conditions for stable direct cooperation among the entrepreneurs. First, on the macro level, property rights protection should be improved. Second, on the micro level, policies that encourage the emergence of complementarities between firms should be implemented to give them an incentive to specialize in different parts of the productive process. In fact, more specialization may lead to more innovation. Although there is little debate about the relevance of property rights protection for business development, the latter policy recommendation 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 would be desirable to conduct studies that identify the network members and the asymmetries in the diffusion of innovation across individuals.

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; and limited access to sources of information outside the firm. 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 7).

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 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 were the case, we would probably observe larger magnitudes in the spillover effects in the presence of a large exporter. Future research could focus on these mechanisms and identify and evaluate their effects.

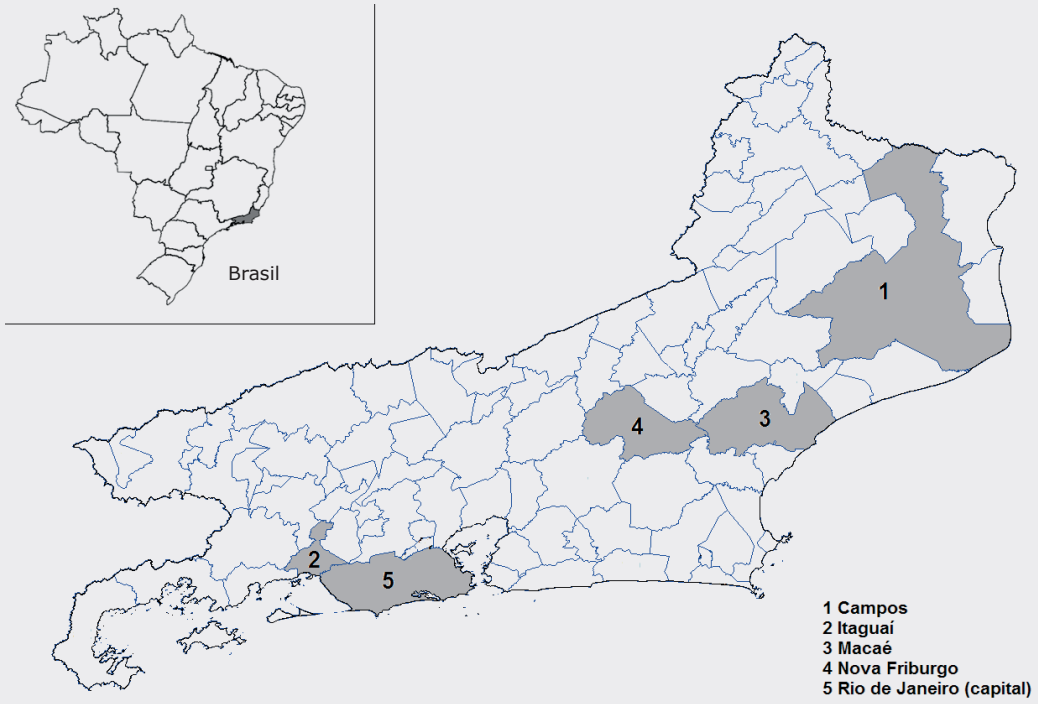
The findings in this paper are inconsistent with the literature on the performance of exporting plants, which tends to emphasize that exporters are larger, more technology-intensive, and pay higher wages than the firms that produce only for the domestic market (see, for example, Bernard and Jensen, 1999; Bustos, 2007; 2008; Verhoogen, 2008). Although the relatively small number of exporters surveyed does not allow us to draw 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 infrastructure, for example, could create the conditions for firms to export without investments in productivity. However, this question 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 A1, we observe that entrepreneurs typically rely more on their own resources and/or borrow from family and friends. The difficulty with these sources of credit is clearly the uncertainty about their availability, which can contribute to the entrepreneurs' 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. Although recent studies present empirical evidence of the correlation between microcredit and firm creation and growth (see, for example, Honohan, 2004; World Bank, 2008), there is still little systematic evidence on the impact of microcredit on economic activity. It would be useful to evaluate the impact of microcredit on the firms in the sample and observe whether there were actual productivity gains caused by it.

Appendix

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



A. 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[18] share is about 50 per cent 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 the state with approximately 430,000 inhabitants[19]. 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 per cent 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 per cent). The third is construction, which also has a high percentage of local GDP (approximately 9.2 per cent). 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 medium firms to

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

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

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 is considered by the local authorities as important for local development. Firms in each sector were selected randomly.

A. Description of control variables

Table A1 presents descriptive statistics for the various control variables used in the quantitative analysis.

Human capital

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 A1 contain information about the respondent, who is also the owner of the business.

Table A1. Descriptive statistics of control variables (cont.)

	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)

Table A1. Descriptive statistics of control variables (cont.)

	Non-adopters		Adopters		Total	
Variable	Mean	SE	Mean	SE	Mean	SE
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						
Age of the firm	12.940	(13.9)	14.131	(15.1)	13.58	(14.6)
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 system focused on teacher's training. (2) The sum of dummy variables (yes=1) for use of local infrastructure, 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.

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 per cent 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[20]. The raw data (outside the table) show that while 44.9 per cent of respondents who are adopters of innovation completed college/university, only 29.7 per cent of the non-adopters have the same education level. Most of the respondents have been working in the firm for over ten years.

In relation to 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 A1 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

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

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 (fifth 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 infrastructure 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 per cent).

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 infrastructure for training better than non-adopters.

Secondary sources of information

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 fifth column, second row under secondary sources of information on Table A1). 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.

Sources of credit/financing

Different sources of credit are used as controls. Data on sources of credit and financing characterize the high interest rates inherited from the debt crises of the 1980s and 1990s[21]. As regards 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), and Caixa Econômica Federal. The first combines private and public ownership while the other two are both federal banks. Government banks did not offer microcredit 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.

Government programs

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. Data on Table A1 show that most of the participants in programs are also adopters.

International trade

One control on Table A1 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. Data in Table A1 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.

[21] During the 1980s Brazil (and Latin America in general) went through a 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 per cent.

Internal characteristics of the firm

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). As regards other types of computer use, 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 eight 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 zero and eight, and the one for managerial methods between zero and 14. Table A1 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.

Table A2: 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

Table A2: Geography of main transactions of firms in the sample (1). (Cont.)

	Campos			Itaguaí			Macaé			Nova Friburgo		
	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N
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 A3: 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

Table A3: Types of Innovations adopted by sector. (Cont.)

Location/Economic Sectors	Design	%	Style of Product	%	Technical Charact	%	New Product	%	New Equipment	%	Automati-zation	%	Managerial Techniques	%	New Inputs	%
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 A4: 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)

Table A4: Basic results without instrumental variable (Cont.)

Dependent Variable: Innovation Adoption	Linear		Probit		Tobit	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
% 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)

Table A4: Basic results without instrumental variable (Cont.)

Dependent Variable: Innovation Adoption	Linear		Probit		Tobit	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
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.

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