

## **Innovation and Cooperation Between Firms and Universities: Evidence From Brazil**

Luiz Alberto Esteves\*

Gabriel Porcile \*

### **ABSTRACT**

The paper discusses the role of cooperation between universities and firms in the innovative performance of a sample of Brazilian industrial firms. The focus is on both process and product innovation. Using data from the *World Bank Investment Climate* (Brazil, 2003) it is shown that cooperation with universities does positively increase the probability that an industrial firm successfully innovates. It is argued that the evidence is favorable to the idea that in countries where the National System of Innovation is still immature cooperation between firms and universities is an important mechanism for fostering both product and process innovation.

\* Department of Economics, Federal University of Paraná (UFPR)

## **Introduction**

A key concept for understanding the dynamics of innovation and technological diffusion across countries and firms is that of the National System of Innovation (NSI). The concept of NSI has proved to be a highly useful device for organizing the theoretical and empirical research on innovation. In particular, it helps to identify key institutional and economic variables whose interactions either stimulate or hamper innovation and the building of technological capabilities at the firm, industry and country levels.

The concept of SNI highlights the influence of institutional differences between countries on the relative intensity with which they learn and innovate. Countries differ in their institutional settings, some of which are more favorable to innovation than others. There are clear differences between developed and developing countries in this respect, which gives a measure of the challenge that developing countries face in terms of institution-building. In this paper we will argue that universities play a central role in the process of innovation in developing countries, a role which is still more significant than that they have in the developed world.

The contribution of the paper is to present some new empirical evidence in favor of the importance of cooperation between firms and universities for the intensity of innovation in Brazilian industrial firms. We use the data provided by the *World Bank Investment Climate* (Brazil, 2003), which collects data at the firm level regarding the factors affecting the intensity of the innovation process. This source has not yet been used to discuss the role of the interaction between firms and universities. We believe that it is especially interesting since is based on microeconomic information obtained directly from the firm.

The paper is organized in three sections, besides this introduction and the concluding remarks. Section I briefly revisits the concept of SNI and the role of universities in technological learning. It also reviews the literature discussing the main variables affecting

innovation, which will be used as control variables along with cooperation in the econometric tests. Section II analyzes the impact of cooperation on innovation by applying different econometric tests on the data provided by the World Bank survey.

## **I. The Concept of National System of Innovation and Cooperation Between Firms and Universities**

Although there is in general a consensus that technological innovation is a key determinant of long run growth, there is still an unresolved debate as regards which factors encourage the process of innovation itself. To shed light on these factors, a useful starting point is a set of stylized facts well documented by the empirical literature:

- i) Learning is not a linear process that begins in the scientific laboratories and moves downwards to the firm. On the contrary, innovation and diffusion are interrelated and emerge out of the continuous interaction between groups of heterogeneous agents (both private and public), with different objectives and various institutional forms. Science and technology are not independent spheres, but they are closely articulated with causal links running in both directions (Rosenberg, 1982; Dosi, 1982, 1988).
- ii) To be a successful imitator in the technology race is a complex process that requires strong and persistent investments in education and R&D. Imitate is by non means a problem of just choosing the best technology from the shelves. For a technology to be effectively appropriated and incorporated to the routines of a firm, it is necessary that the firm deploys major efforts at catching-up, which are costly and not always successful.
- iii) Being a backward country implies that there is an opportunity to learn from the technological frontier and thereby to reduce the distance with respect to the frontier. On the other hand, if there are no endogenous efforts at learning, the technology gap will continue to increase and the

potential for catching up will just become a lost opportunity. Concepts like learning by doing, learning by using and learning by interacting imply increasing returns. These virtuous processes are neither automatic nor passive, but a function of investments in technological capabilities at the firm, the industry and the country levels (more in this below). The domestic “absorptive capacity” of each country is crucial to define whether there the trajectory will be one of technological catching up or falling behind (Katz, 1984; Bell e Pavitt, 1993; Narula, 2004; Bell, 2006; Cimoli e Porcile, 2009 a).

- iv) The idea that imitation is driven by endogenous efforts at learning implies that diffusion of technology occurs hand by hand with the adaptation and improvement of the original innovation, giving rise to a stream of incremental innovations. Such a stream represents a response to the specific technological and economic conditions in which diffusion takes place in each country. In effect, the size of the market, the availability of human capital or intermediate inputs, the degree of sophistication of users and producers, are some of the country-specific factors that affect the speed and direction of technological diffusion. These factors vary widely across countries, as resources, technological capabilities and institutional environment vary.
- v) Technological opportunities are unevenly distributed across sectors (Dosi, 1988). The classical classification suggested by Pavitt (1984) points out that there is an inter-sectoral flow of technology and innovation in which some sectors play the leading role as sources of innovation, while others absorb the new technology embodied in capital or intermediate goods. The productive structure matters, as some productive structures produce more externalities and incentives to technical change (Cimoli and Porcile, 2009b).

The concept of National System of Innovation or National System of Learning is a useful short-cut to define the conditions required for a successful process of catching up

(Lundvall, 1992; Nelson, 1993; Freeman, 1995; Metcalfe, 2001). The intensity of learning depends strongly on the institutional framework that coordinates a vast set of objectives, rules and decisions of heterogeneous agents. It is important to stress that the interaction between institutions and learning shows increasing returns and path-dependency: virtuous (vicious) process of catching up (falling behind) tend to be self-sustained and would not be reverted spontaneously. Therefore a key challenge for policy-makers is to devise a set of institutions that either brings about a virtuous cycle or at least stops a downward spiral. This concern has been at the core of the research on national Systems of Innovation and on their influence on North-South technological dynamics (Freeman, 1995; Nelson, 1993; Antonelli, 1995; Metcalfe, 2001; Cimoli and Porcile, 2009 a).

Which are the main agents involved in the learning process?

First of all there are the firms, whose survival and growth depends in many cases on technological innovation. In a world of Schumpeterian competition, they will have to respond to or move ahead of its competitors with new products and process. The approach of these firms to innovation depends, as mentioned, on the sector to which they belong. But also depends on other factors that should be considered among the determinants of learning.

One of these factors is size: the literature points out the existence of thresholds and economies of scale that make more likely that larger firms innovate more than smaller firms. Another factor is the property of the firm. There is still an unresolved debate as regards whether the presence of foreign firms in developing countries stimulates or hampers technological innovation. Some authors argue that they tend just to import technology with very little local effort, while others emphasize that the position of the subsidiaries in the intra-firm division of labor is not completely rigid. Imports of technology necessarily require adaptations that have an impact on local capabilities, both in the subsidiaries and in national competitors. In the same vein, the presence of public firms in the industrial structure might be relevant, although it is not clear if their influence is positive or negative. Public firms have been frequently used to develop local capabilities, but at the same time they tend to be more protected from competition, which reduces the

stimula for technological learning. Last but not least, “success breeds success” and the performance of the firms will feed-back on its innovation effort. Higher profits or a higher rate of capacity utilization are likely to encourage more investment in R&D.

Along with the firms competing in the market, there are also private and public agents specialized in technological and scientific research, which only partially respond to market incentives. For instance, market success is not the main goal of an academic community whose performance is assessed in terms of its ability to shift the scientific frontier, as reflected by publications in leading journals. Another example is given by activities in which the innovator cannot protect its property rights nor prevent innovation from freely diffusing to other agents. The heterogeneity and diversity of objectives and rules governing R&D and scientific research reflect the very nature of the learning process, on which converge various fields, disciplines and interests. Technological and scientific paradigms have rules of its own, but at the same time are sensitive in various degrees to the availability of funding and to market signals (Dosi, 1988)<sup>1</sup>. Such diversity implies that markets alone could not resolve the major coordinating problems related to technological learning. As a corollary, the ability to develop a set of institutions that could organize this heterogeneity and harmonize the various objectives in a mutually reinforcing process of learning is a critical variable in catching up.

It is necessary to go further and be more precise as regards which specific actors are more relevant. Some authors have observed that universities are leading actors not only in “pure” scientific research but also in applied R&D in developing countries (Albuquerque, 2004; Albuquerque et al, 2005; Mowery e Sampat, 2005; Rapini and Righi, 2006). In these economies the productive structure tends to concentrate in commodities or low-tech manufactures, where the endogenous efforts deployed by both local and multinational firms are poor. In general the service sector is concentrated in low-tech services which are act more as a safety net against open unemployment than as effective support to R&D in industrial and agricultural firms. Therefore firms do not have a dynamic network of

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<sup>1</sup> Even in the case of firms which have R&D departments of their own, whose focus is market competition, technological efforts are constrained by the nature of the technological paradigm, which is not shaped exclusively by market forces, particularly in its initial stages (Dosi, 1988).

suppliers of technology or technological services that could support or be a substitute of their own R&D.

In this scenario, characterized by the absence of in-house R&D, and the absence of networks of technology suppliers, the universities have tended naturally to occupy this space. In countries where the NSI is still immature universities occupy a more outstanding position than in countries whose NSI is already developed (Albuquerque, 2004). In Brazil, 68 % of the total scientists and engineers work in the university, while in the case of the USA this percentage is only 13 %. While in Brazil private firms respond for 11 % of total R&D, in the USA this percentage is higher than 70 %. These differences express very well the special role of the universities in the science and technology system of Brazil (Cruz, 2004). In 2000, the Brazilian and the US governments invested similar percentages of the GDP in R&D (0.6 % and 0.7 %, respectively). However, the private sector invested 1.8 % of GDP in R&D, while the Brazilian private sector invested only 0.4 %.

The major role played by universities in Brazil poses another question, namely if there is a good articulation between university R&D and the innovation process at the level of the firms. To what extent the special role of the universities in the developing countries has succeeded in encouraging R&D in private firms? If cooperation with universities is a kind of substitute of intra-firm R&D, how well this institutional specificity of the developing economies performs in terms of innovation? Universities are generally institutions in which the profit objective is fairly less important than in private firms. The prestige and success of academic researchers do not depend (at least not entirely) on having found an innovation that allowed firms to increase their market shares. The system of rewards and penalties, and the ethos of the academic research, are very different from that of a private firms and market competition. Matching the divergent goals of firms and universities is far from trivial. The capacity of public policy in a developing country to foster cooperation between universities and firms is probably insufficient. Hence, how well cooperation works should be carefully assessed. In this paper we intend to contribute to answer the question of whether cooperation agreements between firms and universities have worked in the case of Brazil. We discuss empirically if this cooperation has had an effective impact on the

intensity of the innovation process in private firms. This is the subject to be addressed in the next section.

## **2. The Effects of Cooperation Between Firms and Universities on Innovation**

### *a) Variables and Some Preliminary Evidence*

The objective of this section is to present the variables used in the empirical exercises of the following sections. We will loosely define a function of innovation production, which is just a short-cut for the set of institutional and sector-specific variables shaping the intensity of innovation. We will work with both process and product innovations. The source of data is the *World Bank Investment Climate, Brazil, 2003*, which presents data on the innovative activities of industrial firms in Brazil. The data is collected at the firm-level and in this sense is particularly valuable, as allows for discussing the effect of cooperation using microeconomic data, instead of deriving conclusions from aggregate indicators. To the best of our knowledge this data has not yet been used to discuss the determinants of innovation by the Brazilian firms. The *Survey* presents data obtained from 1642 Brazilian firms which were interviewed in 2003 and whose information refers to the year 2002. The use of weights in the total sample implies that the results obtained are indeed representative of a larger group formed by 17631 Brazilian industrial firms.

It is necessary to define two dimensions in the relationship university-firms, both of which will be analyzed in this paper. The first one is cooperation aimed at producing knowledge and innovation. The second dimension is related to the role of the university as an external source of training of the firms' employees. We will discuss the influence of both types of cooperation on the innovative performance of the firm.

The list of variables to be used in the empirical tests is detailed in Table 1. Table 2 presents some basic descriptive statistics (average and standard deviation) of the variables considered. These statistics are presented separately for five non-excluding groups of firms: (i) all the firms of the sample; (ii) the subset of firms that obtained product innovations; (iii)

the subset of firms that obtained process innovations; (iv) the subset of firms that cooperated with universities in R&D; (v) the subset of firms that trained their employees at the university.

The analysis of Table 1 points out some interesting features which can be summarized as follows:

- i) There is a bias in the sample towards firms which are relatively big, consolidated and innovative. In effect, 65 % of the firms of the sample have obtained product innovations and 64 % process innovations. They have 76 employees and 16 years on average. All these figures are higher than the average values of the population of Brazilian industrial firms;
- ii) The participation of innovative firms in the sub-group of firms that cooperate with the universities is higher than this participation in the total sample. There is a stronger association between cooperation in R&D and product innovation than between cooperation through training and product innovation.
- i) Firms that innovate in product and process tend to have training programs with universities. But the reciprocal is not true: firms that train their employees in the universities do not tend to be more innovative. This may be explained because many firms train their employees in universities just to keep them updated, while those that are innovative train them with a view to reinforce their R&D activities and projects;
- ii) Firms that cooperate with universities are on average older than those that do not cooperate. It seems that the firm should be already consolidated in the market to be able to cooperate with the universities. The positive association between age and training may also reflect the fact that the demand for updating naturally increases with the age of the firm, as employees' knowledge becomes gradually outdated or obsolete;
- iii) There are no significant differences in R&D spending between firms that cooperate and those that do not. Indeed, on average those that cooperate spend less in R&D. This may be suggesting a process of substitution of domestic by

external (university) R&D, or at the very least a low degree of complementary between the two types of technological investments. In particular, firms which obtained product innovations spend much more in R&D than the average of the sub-group of firms that cooperate with the universities.

- iv) An interesting point is that, when cooperation assumes the form of training, R&D investments are much higher than the average of the sample, and also higher than the group of innovative firms (in product and process). How this puzzle can be explained? A possible answer is to acknowledge a qualitatively different approach to training between innovative and non-innovative firms. Those that are non-innovative invest just in updating or maintaining the capabilities of the employees, but with no direct concern with innovation. Inversely, those that innovate invest in training with the specific aim of building up the technological capabilities required to support their R&D and innovative projects, particularly in process innovation. In the latter case, university and in-home R&D efforts are complementary.
- v) The percentage of public and private firms that cooperate with universities is higher than the average, both in R&D and training. But it is not possible to conclude that the property of the firm matters, because there are as well large differences among these firms in other variables (like size and sector). Still, we will come back to this point in the econometric analysis.
- vi) Both forms of cooperation with the universities (in R&D and training) are positively related to indicators of performance, such as the market share and sales per employee of the firm.

In sum, a preliminary analysis of the descriptive statistics provided by Table 2 suggests that firms which cooperate with the university tend to be more innovative and achieve better results in the market than those that do not cooperate. In the next section this preliminary results will be more rigorously tested by estimating a function of the innovative process (the innovation production function). On the left-hand-side we have innovation in product and process as a qualitatively variable, while on the right-hand-side we include a

set of independent variables which are sought to capture the determinants of learning as discussed in section 1.

*b) An econometric test of the effect of university-firm cooperation on the intensity of innovation in Brazilian industrial firms*

As mentioned, we take as a point of departure the innovation production function defined as:

$$y_i^* = x_i \beta_i + u_i$$

In equation (1)  $y_i^*$  is the result of the innovation process,  $x_i$  is a vector of independent variables and  $u_i$  is a random error term. The result of the innovation process is expressed as a latent variable where:

$$\begin{aligned} y_i &= 0 \text{ if } y_i^* < 0 \\ y_i &= 1 \text{ if } y_i^* \geq 0 \end{aligned} \quad (2)$$

$y_i$  is a qualitatively variable which takes the value of one if the firm has obtained an innovation and takes the value zero otherwise. The probability of the firm having obtained an innovation is modeled using (1) and (2) as follows:

$$\begin{aligned} \Pr(y^* > 0 \mid x) &= \Pr(u > -x\beta \mid x) = \\ \Pr(u < x\beta \mid x) &= \Pr(y^* > 0 \mid x) = \\ \Pr(y = 1 \mid x) &= \Psi(y_i^*) \end{aligned} \quad (3)$$

We estimated the model (3) as a dependent binary variable using maximum likelihood methods, in which  $\Psi(y_i^*)^2$  is a probabilistic function (PROBIT model). Estimation outcomes are reported in Table 3, where in column B we present the results of the model in which the dependent binary variable is a product innovation, while in column B is process innovation. Some of the conclusions that can be drawn from Table 3 are the following:

- a) The variable cooperation with the university is highly significant and have the expected (positive) signal;
- b) The coefficient of the variable training as a form of cooperation with the university has a negative influence on product innovation, which is the opposite of what we expected. Still, this coefficient is not significantly different from zero. On the other hand, when the dependent variable is process innovation, the coefficient of the variable training is significant and positive as expected. It is likely that training in the university strengthens the ability of the firm to understand and manage the production process, leading to new or better routines in production;
- c) As expected, R&D expenditures have a positive, significant impact on innovation.
- d) The origin of the capital (foreign or national) has no effect on product innovation, but it does influence the probability of having a process innovation. In effect, foreign firms tend to innovate less in process than national firms. There is no easy answer for the question of why this occurs. A preliminary hypothesis might be that foreign firms tend to use processes which are standardized in a global scale, and they are therefore more rigid than national firms in this respect. This result is an interesting one, and should be scrutinized more carefully in future research.
- e) A higher participation of the public sector is negatively related to innovation. This result is as well surprising, since there are some examples of public firms playing leading roles in their sectors. As in the case of foreign firms, we believe that this result should be studied more carefully.

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¶  $\Psi(y_i^*)$  is the accumulated distribution of a normal function.

As our focus is cooperation between universities and firms, we will not advance further in the discussion of the coefficients of the control variables.

- f) The utilization of capacity does not seem to be systematically related to the rate of innovation. It does not affect product innovation, while the influence on process innovation is ambiguous.
- g) Size (employees) is positively associated with the probability of succeeding in product innovation, but not on that of process innovation. We do not have a clear reason of why this occurs, since it is likely that both types of innovation show economies of scale.
- h) Market shares are positively related to both types of innovation, which is consistent with the idea of increasing returns and cumulateness in technological learning (as suggested by the Kaldor-Verdoorn Law, learning by doing and learning by using). Clearly, the causality may run in the other way round – from innovation to market shares, or even to capacity utilization and the size of the firm. Still, for the purposes of this paper, whose main objective is to identify and measure the influence of university-firm cooperation on innovation, the other are just control variables, included to avoid problems of omitted variables. We do not intend to capture the effects of these other variables or to test the degree in which they may be endogenous.

To have a quantitative measure of the magnitude of the influence of the different variables on the probability of having an innovation, we estimated the marginal effects of each variable on the binary dependent variable (columns C and E of Table 3). The marginal effects are given by the following expression:

$$\frac{\partial \Pr(u = 1 | x)}{\partial x_j} = \frac{\partial \Pr(u = 1 | x)}{\partial x \beta} \frac{\partial x \beta}{\partial x_j} = \Psi'(x\beta) \beta_j = \psi(x\beta) \beta_j \quad (4)$$

$\mathbf{x}$  is a vector of explanatory variables,  $x_j$  is one of the variables of this vector, whose marginal effect on the probability to innovate ( $\Pr(u=1|\mathbf{x})$ ) we intend to measure, and the last

term ( $\Psi(\cdot)$ ) is a density probability function. The analysis of the last columns of Table 3 allows us to draw some conclusions about the quantitative effects of the different explanatory variables.

- i) Cooperation in R&D between university and firms increases in the same magnitude the probability a product innovation and that of having a process innovation.
- ii) Training in the university increases in a higher degree the probability of having a process innovation than that of having a product innovation (the difference amounts to three percentage points).
- iii) The increase in the probability to innovate related to training in the university is lower than that related to cooperation in R&D. This may reflect the fact that cooperation in R&D is specifically directed towards the innovation process, while this is not always the case in training.
- iv) R&D expenditures by the firm are positively related to innovation, as expected.
- v) The influence of market share on the probability of innovation has the same intensity in product and process innovation. Still, it should be recalled that this variable may be endogenous, and that we included it in the econometric test just as a control variable.

In sum, the econometric analysis confirms the idea, set forth in the literature of NSI in developing countries, that cooperation between firms and universities play a significant role in developing countries. Our results are also supports the influence of traditional variables in the theory of innovation, like size, market-share, R&D and increasing returns in the learning process.

## **Conclusions**

The evolutionary literature emphasizes the role of the institutional context in the process of innovation. Technological innovation is characterized by high levels of uncertainty, as well

as by the matching of decisions made by several heterogeneous agents. In addition, cumulateness, information asymmetries, path-dependency and tacitness, are all factors that imply that pure market mechanisms will not produce the optimum amount of innovation and learning. Therefore institutions have to be devised to coordinate these heterogeneous agents and strengthen their interactions in such a way that they lead to a virtuous path of learning and growth.

There is no unique receipt for success regards institution building. Specific local conditions and previous trajectories must be taken into consideration. Still, it seems that in developing countries, where technology-intensive sectors represent a small share of total industrial production, private firms invest very little in R&D and the development of the network of technological services is rather weak, universities should play a particularly significant role. Universities concentrate large part of total research in these countries, and therefore it is crucial to develop mechanisms of cooperation that approximates the knowledge generated by the universities to the needs of the firms competing in the market. This seems to represent an important link for catching up in NSIs which are still immature.

In this paper we have offered an empirical test of the role of these different variables in stimulating innovation in both products and processes. We found evidence favorable to the idea that cooperation with the universities (both in terms of R&D and the training the firms' employees) contribute in a significant degree to the innovative performance of the firm. In some cases we confirmed the importance of traditional variables already identified by the theory of innovation, such as the size of the firm, its own efforts of R&D and increasing returns, included as control variables in the econometric model.

## **BIBLIOGRAPHY**

ALBUQUERQUE. E. M. Sistema Nacional de Inovação no Brasil: uma análise introdutória a partir de dados disponíveis sobre Ciência e Tecnologia. *Revista de Economia Política*. São Paulo. v.16. n.3. p. 438-498. 1996.

- ALBUQUERQUE. E. (2004) Science and technology systems in Less Developed countries: identifying a threshold level and focusing in the cases of India and Brazil. In: MOED. H.; GLÄNZEL. W.; SCHMOCH. U. (eds) *Handbook of quantitative science and technology research: the use of publication and patent statistics in studies of S&T systems*. Dordrecht: Kluwer Academic Publishers. 2004.
- ALBUQUERQUE. E.; SILVA. L.; PÓVOA. L. (2005) Diferenciação Intersetorial na Interação entre Empresas e Universidades no Brasil. *São Paulo em Perspectiva*. São Paulo. v. 19. n. 1. p. 95-104. 2005.
- ANTONELLI. C. (1995). *The Economics of Localized Technological Change and Industrial Dynamics*. London. Kluwer Academic Publishers.
- BELL. M. (2006). "Time and technological learning in industrialising countries: how long does it take? How fast is it moving (if at all)?" *International Journal of Technology Management*. vol. 36. No. 1–3. pp. 25–39.
- BELL. M. and PAVITT. K. (1993). "Technological accumulation and industrial growth: contrasts between developed and developing countries". *Industrial and Corporate Change*. vol. 2. No. 1. pp. 157–210.
- CERRÓN. A.P. (2007) "Cooperação Universidade-Empresa no Paraná: Um Diagnóstico". Seminário sobre Interação Universidade – Empresa. Campinas. Janeiro 2007.
- CIMOLI. M. and DOSI. G. (1995). "Technological paradigms. pattern of learning and development: an introductory roadmap". *Journal of Evolutionary Economics*. vol. 5. No. 3. pp. 243–68.
- CIMOLI. M.; DOSI. G.; NELSON. R.; STIGLITZ. J. (2006). "Institutions and policies shaping industrial development: an introductory note". LEM Working Paper. No. 2006/02. Pisa. Italy. Laboratory of Economics and Management.
- CIMOLI. M. and PORCILE. G. (2009 a) "Sources of learning paths and technological capabilities: An introductory roadmap to development processes". *Economics of Innovation and New Technology*. forthcoming.
- CIMOLI. M. and PORCILE. G. (2009 b) "Growth. Wage Bargaining and Technological Policy in a Multigoods Growth Model". *Metroeconomica*. forthcoming.
- COHEN. W.; NELSON. R.; WALSH. J. Links and impacts: the influence of public R&D on industrial research. *Management Science*. v. 48. n. 1. p. 1-23. 2002.
- CRUZ, C.H.B. (2004) "A Universidade, a Empresa e a Pesquisa", paper presented to the seminar *Brasil em Desenvolvimento*, UFRJ, January 2004.
- DOSI. G. (1988). "Sources. procedures and microeconomic effects of innovation". *Journal of Economic Literature*. vol. 26. No. 3. pp. 1120–71.
- (1982). "Technological paradigms and technological trajectories: a suggested interpretation of the determinant and direction of technological change". *Research Policy*. vol. 11. No. 3. pp. 147–62.
- DOSI. G.; PAVITT. K.; SOETE. L. (1990). *The Economic of Technical Change and International Trade*. London and New York. Harvester Wheatsheaf Press/New York University Press.
- FREEMAN. C. The "National System of Innovation" in historical perspective. *Cambridge Journal of Economics*. v. 19. n. 1. 1995.
- KATZ. J. (1984). "Domestic technological innovations and dynamic comparative advantage". *Journal of Development Economics*. vol. 16. pp. 13–38.

- LUNDVALL. B. *National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning*. London: Pinter. 1992.
- METCALFE. J. S. (2001). "Institutions and Progress." *Industrial and Corporate Change*. Oxford University Press. vol. 10(3). pages 561-86. September.
- (1995). "The economic foundations of technology policy". in P. Stoneman (ed.). *Handbook of the Economics of Innovation and Technical Change*. Oxford. Blackwell.
- MIOZZO. M. and WALSH. V. (2006). *International Competitiveness and Technological Change*. Oxford. Oxford University Press.
- MOWERY. D.; SAMPAT. B. (2005) Universities in National Innovation Systems. In: FAGERBERG. J.; MOWERY. D.; NELSON. R. (2005) *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.
- NARULA. R. (2004). "Understanding Absorptive Capacities in an Innovation Systems Context: Consequences for Economic and Employment Growth". *DRUID Working Paper* n. 04-02. December.
- NELSON. R. R. *National Innovation Systems: A Comparative Analysis*. New York: Oxford University Press. 1993.
- PACHECO, C.A. (2005) "P&D Empresarial no Brasil", IICNCTI, Brasília (available in: <http://www.cgee.org.br/cncti3/Documentos/apresentacoes/CarlosAmericoPacheco.pt#332>)
- PAVITT. K. "Sectoral patterns of technological change: towards a taxonomy and a theory". *Research Policy*. vol. 13. No. 6. pp. 343–75
- RAPINI. M.; RIGHI. H. (2006) O Diretório dos Grupos de Pesquisa do CNPq e a Interação Universidade-Empresa no Brasil em 2004. *Revista Brasileira de Inovação*. 5 (1): 131-156.

**Table 1. List of Variables**

PI (Product Innovation)	Dummy variable: if the firm obtained a product innovation in the 1998 a 2002 period, then PI = 1; PI = 0 otherwise
PRI (Process Innovation)	Dummy variable: if the firm obtained a process innovation in the 1998 a 2002 period, then PRI = 1; PRI = 0 otherwise
Cooperation (with the university)	Dummy variable: Cooperation = 1 if cooperation with the university was one of the three main forms by which the firm obtained information about new technologies; Cooperation = 0 otherwise
Training (with the university)	Dummy Variable: Training = 1 if the firm trained its employees at the university in the last two years; Training = 0 otherwise
R&D p.c (R\$ 2002)	Expenditures in R&D per full time employee in 2002
Employees	Number of full time employees
Age	Age of the firm
Capacity utilization (%)	Percentage of utilization of the firms' productive capacity.
Market share (%)	Share of the firm in the national market for its principal product (as provided by the firm).
Foreign participation (%)	Foreign participation in the total capital of the firm
Public participation (%)	Public participation in the total capital of the firm
Profits per employee (R\$ 2002)	Profits per full time employee, year 2002.
Total net revenues per employee (R\$ 2002)	Net revenues per full time employee, year 2002.
$\Delta$ sells 2000-2002 (%)	Rate of growth of sales between 2000 to 2002.

**Table 2. Descriptive Statistics**

<b>Variables</b>	<b>All firms</b>	<b>Firms that have product innovations</b>	<b>Firms that have process innovations</b>	<b>Firms that cooperate with the university in R&amp;D</b>	<b>Firms that cooperate with the university by training</b>
PI (Product Innovation)	0.65 [0.47]	1.00 [0.00]	0.71 [0.45]	0.81 [0.39]	0.73 [0.44]
PRI (Process Innovation)	0.64 [0.47]	0.69 [0.45]	1.00 [0.00]	0.70 [0.47]	0.70 [0.46]
Cooperation (with the university)	0.017 [0131]	0.021 [0.145]	0.019 [0.136]	1.00 [0.00]	0.072 [0.260]
Training (with the university)	0.07 [0.25]	0.08 [0.27]	0.07 [0.26]	0.29 [0.46]	1.00 [0.00]
R&D p.c (R\$ 2002)	878.10 [4515.21]	1060.89 [5069.92]	941.06 [4410.67]	803.47 [1409.07]	3612.60 [11556.73]
Employees	76.67 [267.57]	84.46 [312.08]	78.94 [287.13]	524.60 [1556.31]	316.37 [780.57]
Age	16.42 [16.07]	17.05 [16.25]	16.08 [16.04]	20.38 [20.93]	25.90 [22.00]
Capacity utilization (%)	73.37 [16.92]	73.64 [16.93]	73.71 [16.99]	76.76 [16.21]	75.44 [17.27]
Market share (%)	10.63 [19.07]	11.59 [20.26]	10.15 [18.81]	13.51 [19.05]	20.89 [26.51]
Foreign participation (%)	3.28 [16.69]	3.77 [18.06]	3.15 [16.41]	5.96 [23.01]	13.31 [33.21]
Public participation (%)	0.06 [1.78]	0.06 [1.45]	0.02 [1.51]	0.45 [2.76]	0.74 [6.50]
Profits per employee (R\$ 2002)	25909 [243968]	19984 [87023]	10055 [28871]	49373 [106168]	100868 [284950]
Total net revenues per employee (R\$ 2002)	120013 [1109961]	96809 [348859]	137514 [1367150]	173968 [425759]	373116 [865616]
$\Delta$ sells 2000-2002 (%)	20.80 [50.98]	21.99 [51.65]	23.18 [50.78]	33.52 [58.67]	33.10 [48.01]
Observations	1642	1109	1114	46	195
Observations weight in the sample	17361	11409	11203	305	1235

Notas: Standard deviations between brackets

Source: Authors' estimations based on World Bank Investment Climate Survey 2003

**Table 3. The Innovation Production Function (Probit)**

Variable (A)	Product Innovation Coefficient (B)	Product Innovation Marginal Effect (C)	Process Innovation Coefficient (D)	Process Innovation Marginal Effect (E)
Constant	0.59 (0.29)***		1.60 (0.42)***	
Cooperation in R&D	0.42 (0.11)***	0.07 (0.01)***	0.23 (0.09)**	0.07 (0.02)**
Training	-0.05 (0.05)	0.02 (0.02)	0.18 (0.05)***	0.03 (0.008)***
R&D p.c * 1000 R\$ 2002	0.008 (0.003)***	0.001 (0.0003)***	0.010 (0.003)***	0.003 (0.0009)***
Foreign participation (%)	0.0009 (0.0007)	0.00006 (0.00004)	-0.002 (0.0006)***	-0.0007 (0.0002)***
Public participation (%)	-0.004 (0.005)	-0.005 (0.006)	-0.011 (0.005)**	-0.0003 (0.0001)**
Employees	0.0001 (0.00007)**	0.000065 (0.000027)**	0.00004 (0.00004)	-0.0001 (0.0003)
Capacity utilization (%)	-0.0009 (0.0007)	0.001 (0.0007)	-0.002 (0.0007)***	0.00009 (0.00003)***
Market share (%)	0.007 (0.0008)***	0.001 (0.0001)***	-0.003 (0.0007)***	0.001 (0.0002)***
Observations	10689	10689	10689	10689

Notes: (1) p-value 1% (\*\*\*), 5% (\*\*) and 10% (\*); (2) All regressions include *dummies* for localização (UF, State of the Federation) and sector (CNAE1); (3) standard deviations between brackets; (4) sample weights.