TECHNOLOGICAL STRATEGIES AND PERFORMANCE OF THE BRAZILIAN INDUSTRIAL FIRMS: A MULTIVARIATE ANALYSIS BETWEEN THE PINTEC'S

Abstract

This work intends to analyze, by using multivariate analysis, the technological strategies from the Brazilian firms that innovated in product and process between 2003 and 2005, and compare it with the innovative behavior that used to take place by them in 2001-2003. We split the analysis in the relationship input-companies-outputs, and use data from PINTEC, RAIS and SECEX. In general, the results showed that there is a clear relationship between probability of innovation and the adoption of the technological strategy. Furthermore, changes in the technological strategies of a triennium to another are, along with knowledge accumulation, the main factor to obtain better results or maintain the same, given the changes in the macroeconomic environment during the period. Also, the main distinctions amid strategies are focused on the importance of innovative activities and the expenditure of these activities.

Key-words: Technological Strategy. Multivariate Analysis. Innovative activity. Performance.

TECHNOLOGICAL STRATEGIES AND PERFORMANCE OF THE BRAZILIAN INDUSTRIAL FIRMS: A MULTIVARIATE ANALYSIS BETWEEN THE PINTEC'S

Beatriz Selan
Mastering degree Student of Economics of FEA-RP/USP
beatriz_selan@yahoo.com.br

Sérgio Kannebley Júnior
Department of Economics of FEA-RP/USP
skj@usp.br

Introduction

The structural changes faced in the Brazilian economy over the 90's shaped the new competitive scenery that firms had to deal with, in which the competition is related with the combination of prices and firms strategy based on technological innovation and quality products. That is, the competitive scenery over the 2000's is characterized by technological and organizational changes leading firms to see the innovation as the foundation of the competitive power they keep. This is translated in the importance of these factors for the firm's competitive advantage, since innovation is one of the forms used to differentiate the competitors by knowing which one has more dense and effective strategies (SPITAL; BICKFORD, 1992; AMOAKO-GYAMPAH; ACQUAAH, 2008).

Empirically, investigations concerned technological strategy have revealed some kind of relationship with the performance of the firm since different possibilities of competitive advantages for the firm are achievable by innovations. So, comparisons between firms' technological strategies are extremely important, because competitive and performance are highly correlated with the technological capacity of the firm by the innovation strategy. In countries like Brazil, the innovation is the key to better results for the firms and can be used to economic development. Also, given the probability of innovation, Kannebley and De Negri (2008) showed that there is an association amid inputs and outputs that represent the technological behavior of the firms.

The path this paper intends to work is to understand the representations of technological strategies from firms that innovated in 2003-2005 and, then, to compare the innovative behavior for the period 2001-2003. We propose to verify if the innovative behavior in 2003-2005 already happened in 2001-2003 and if it depended of the characteristics of the firm, using the relationship among technological effort made by the firms and the results of innovative activity, according with the technological intensity of the sectors. For this proposes, we exploit the information for the two versions of PINTEC (National Innovation Survey) along with RAIS (Annual Relation of Social Information) and SECEX (Escritoire of Exterior Trade) for the period from 2001 to 2005, creating a wide dataset used to characterized the Brazilian firms and the innovative activity.

Thus, the paper is organized to give an initial relationship among firms' strategy, specially the technological strategy, and the outcomes of innovative activity for the firm. The multivariate analysis, the statistical tool, is discussed in section 2. Section 3, on the other hand, makes an effort to characterize the firms. The last section describes the inputs and outputs of innovation and the main results for the representation of technological strategies separated by technological intensity of the sector. Some final remarks are offered to summarize the results found in this work.

1 Firms' strategies and their performance: the technological strategy

The innovative activity can be described as an array of different inputs that may enable the company to solve most problems faced by the firm, being the innovation the result of a process of interaction between market opportunities and basis of knowledge and capabilities of the firm. This precept of innovative activity implies in simultaneity of the events of this process in the company, with representation in the model “link in the chain” that was developed by Kline and Rosenberg (1986 apud VIOTTI, 2003). Padmore, Schuetze and Gibson (1998) argue that such model satisfies the chain of development of knowledge and production, mainly due to the understanding of the search for solutions to the problems that arise at any stage of the production process.

Basically, the innovative activity is conditional on the firm’s technological strategy, which can be understood as a set of decisions or plans about the firm’s innovative behavior that transform the various inputs to achieve results in competitive advantage. Audretsch and Feldman (2004 apud CABRER-BORRÁS; SERRANO-DOMINGO, 2007) had shown that there is a strong relationship between the inputs of innovative activity, whether human capital or R&D, and the results obtained by the firm, as determined by the technological strategy of the firm. Therefore, the Kline and Rosenberg (1986) model reflects, ultimately, the complexity of the technological strategy of the firm (OECD, 1997).

There are several settings that involve dichotomous concepts to the technological strategy as the specialization of knowledge, via acquisition of machinery and equipment, versus the generation of a broader base of knowledge or the technological strategy through the types of technological or market leadership. So, given the impossibility of establishing a single behavior that characterized the technological strategy, some authors felt the need to create a typology for technological strategy according to the type of innovation developed by the company. This was proposed by Antonucci and Pianta (2002), for the international case, and Prochnik and Araújo (2005) for the Brazilian case. Antonucci and Pianta (2002) and Prochnik and Araújo (2005) combine the efforts undertaken by innovative firms and the results obtained by them in order to maximize the choices business strategies through types of innovation, this approach will be used in the paper.

Thus, companies can adopt strategies streamlined cost towards competitiveness via prices, such as the process innovation based on the leadership of costs, with the expansion of productive capacity and jumps in efficiency. In these strategies, the activities in R&D is overcome by high investment in machinery and equipment, which generate growth in productivity through the restructuring of production in addition to maintaining the firm’s market share by reducing production costs. Firms that innovate only in product, moreover, adopt strategies that seek its repositioning in the market or a technological competitiveness through differentiation of product and/or diversification into new market. For these authors, firms that carry out product innovations in general relate high importance to R&D with higher expenditure on innovative activities to create new products, obtaining, therefore, higher productivity through improved quality and range of products and expansion in market participation and the creation of new markets. This kind of innovation is usually associated with the technological frontier market leaders. The product and process innovation, on the other hand, is focused on the search for competitive advantage of firms, adding to innovations in products jumps of technical efficiency using cost and/or differentiation through quality of products and/or diversification into a new market. So, to summarize this information, chart 1 shows the possible breakdown of how technological strategies adopted for each type of innovation, according to Pianta and Antonucci (2002) and Prochnik and Araújo (2005).

Chart 1 – Technological strategies' types

Firms' strategy	Technology innovation	Technological strategy
Technological competitive or market reposition	Product innovation	. High importance of R&D . Expenditure toward new products . Productivity growth through high quality . Differentiation of the product . Expansion and maintenance of *market share* . New markets
Rationalizing costs	Process Innovation	. Some importance of R&D . Expenditure toward machine acquisition . Productivity growth by restructuring the production . Increase of product quality . Cost-cutting . Maintenance of *market share*
Competitive advantage	Product and Process Innovation	. High importance of R &D . Differentiation of the product . Diversification for new markets . Improving quality . Cost-cutting

One could represent the technological strategies by the innovation *surveys* like the Oslo Manual (1997, 2005). They are studies using quantitative and qualitative variables about aspects involving the innovative effort and the results obtained by the firm in a given period. That is, the representation of technological strategies via surveys of innovation is possible by the structure of this type of research that consist in the self-assessment of the importance of various inputs, the expenditures in innovative activities and the impacts that technology generates in terms of products, relations with the market and changes in the production process. As the measurement of innovative activity has to consider the complexity and diversity of the innovative process, the representation of technological strategies by innovation surveys can reflect the interaction between the various components of the innovative activity (OECD, 1997).

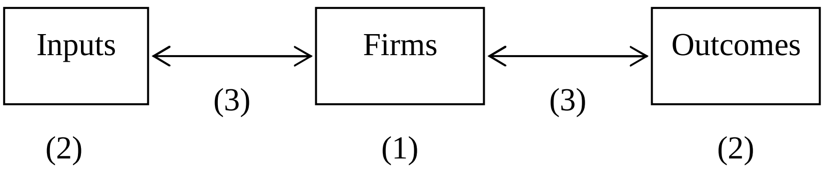
Empirically, Montoya et alii (2007) analyzed the link between technological strategy and productivity develop in the Spanish firms belonging to sector highly intensity in technology from 1994 to 1999. They found out that firms with high investments in a wide type of innovative resources had better results and that the technological strategy had a crucial role in the performance of the firm. Kannebley and De Negri (2008), on the other hand, showed some representations of technological strategies for Brazilian, Argentine and Mexican firms from 1998 to 2001. These authors concluded the export orientation is the distinctive factor of technological strategies causing highly levels of impacts for the technology-intensive sectors of Argentine industries. The main difference on impacts from export firms and non-export firms is the highly expenditure in internal R&D made by the former.

For the Brazilian case, it is interesting to note technological strategies based in wide knowledge and purchase of machines in sectors with low technological intensity, but their impacts are concentrated in internal market and some procurement of patents. To the Brazilian sectors with high technological intensity, the fact that a firm belongs to a corporate group has been seen as the key to a more extensive technological strategy in terms of knowledge, although the outcomes were related to the internal market only. It should be noted in the Mexican case that the highly intensive technology multinational firms have high technological effort which leads to a higher level of impact compared to domestic companies. Finally, Kannebley and De Negri (2008) conclude that, for the three countries analyzed, the heterogeneity of firms (observable characteristics or the probability to innovate in product to market) are important determinants in the adoption of technological strategies, but there is not, however, a standard comparison between the countries.

On the other hand, Vaona and Pianta (2008) analyzed the relationship between the innovation strategies and the size of the firms from 22 industrial sectors in eight European countries from 1994 to 1996. When comparing the technological strategies according to the size of the firms, they found out that firms in small and medium businesses are behaving in a similar way to patents bringing new products and the necessity of the flexibility of new processes and organizational changes. For larger firms, the crucial role of business strategy is to expand the market with the acquisition of new machines that have greater effects on process innovations. That is, small and medium businesses seek new processes that are associated with strategies geared towards flexibility and organizational changes of the firms, while larger firms seek the market power overcoming the technological strategy as the introduction of new products is not effective.

2 Empirical approach

The presence of simultaneity in studies that evaluated the relationship among inputs and outputs of innovative activity demands a way in which we do not establish a casual relationship among the factor. As a result, we propose an association that represents the ex-post technological strategy of the firm by some connection between inputs, firm and outputs just like is represented in the diagram below.



Here, one assumes the existence of a relationship between observed characteristics of a firm and its technological strategy, by the relationship present above. Thus, after determining the observed characteristics, one should define the input and output flows, which allow inferring on the technological strategy used. To do that, we split the empirical approach into three complementary stages: we identify the firms' observed characteristics represented by number 1 in the diagram (using classification and regression trees); create categories of inputs and outcomes from innovative activities (number 2, via clusters analysis); and then we establish the association between these two groups of variables (number 3, by correspondence analysis)[1].

The observable characteristics of innovative firms are identified by estimating classification and regression trees, as described by Kannebley et alii (2005). A classification and regression tree is a rule to predict a categorical dependent variable using the values of its predictor variables. In this analysis, QUEST (Quick, Unbiased, Efficient, Statistical Tree) estimation will be used. The technique simplifies analysis by allowing for binary partition of the nodes, while also making it possible to include different classification costs for different categories and to prune on the basis of a cost/benefit ratio. This methodology, originally proposed by Loh and Shih (1997), splits nodes and selects explanatory variables independently. To determine the subsets of innovative firms, some variables are selected to represent the observed characteristics of the firm and are presented in Chart 2 below. The variables are firm size, export orientation, capital origin, firm's age, employees' skills, participation of the firm in a corporate group and sectoral effects like intensity of the production factors, technological intensity and end-use categories. It was considered that the fact the firm had innovated as the dependent variable, separating it in innovation in product and process and

[1] This representation is methodologically similar to the ones used in Sbragia et alii (2002), and partially similar to Crépon et alli (1998).

innovation only in process. In this paper, we do not consider the product innovation because of the low number of firms that develop this type of innovation.

Chart 2 – Variables for firm characteristics[2]

Variable	Code	Transformations	Databases
Innovation (dependent)	INOVA2	0 = Only Process innovation 1 = Product and process	PINTEC
Firms' size	LNPOE	Log of the total employment share	PINTEC
	LNRLVE	Log of overall revenues	PINTEC
Export Orientation	ATIV_EXPORT	0 = Non-export 1 = Eventually export 2 = Regularly export	SECEX
Corporate group	GRUPO	0 = Independent 1 = Belongs to a corporate group	PINTEC
Firms' age	EMPR_ANO	Continuous variable	RAIS
Skills	Ratio between the skills of the workers and average skills of the company	Proportion of employees with 1 degree (PROP_1GR) Proportion of employees with 2 degree (PROP_2GR) Proportion of employees with 3 degree (PROP_3GR)	RAIS
Capital origin	ORIGEM	1 = Domestic 2 = Foreign 3 = Mix	PINTEC
Sectorial Effects[3]	INTENS_T (technological intensity) INTENS_F (intensity of factors of production) CNAE_USO (categories of use)	1 = Low intensity 2 = Medium-low intensity 3 = Medium-high intensity 4 = High intensity 1 = Natural resources 2 = Labor 3 = Capital and technology 1 = Capital goods 2 = Nondurable consumer goods 3 = Durable consumer goods 4 = Intermediate goods	PINTEC

Inputs were represented by categorical variables that assessed the degree of importance of sources of information, innovative activities, and on the ratio between expenditure and revenues regarding innovative activities. The variables that represent the outcomes of the innovative activity assessed the effects of innovations in terms of product, process and market relations. The set of variables related to inputs and outputs from the innovative process is described in chart 3 below. It is important to acknowledge that the variables allied to the innovative activity's expenditure were built by the ratio of each expenditure and revenue net of sales, while the other variables were related to the importance degree of information sources, innovative activity and the impacts of innovation.

To build these categorical variables it was employed a cluster analysis. This statistical method is an exploratory tool designed to classify data so as to maximize the degree of association between objects in the same group and to minimize it otherwise. In this study, the k-median method

[2] The reasons for the inclusion of these variables can be found in Kannebley et alii (2005).
[3] The construction of the technological intensity is based in Feijó et alii (2003), the production factors intensity uses the proposition of Moreira (1999) and the end-use categories are based in Kannebley e De Negri (2008).

is used due to its being the most stable in for defining cluster centroids. Similar to the k-mean algorithm, this algorithm designates each point in the set for which a given center, termed a centroid, is nearest. In our case, the centroid is the median of all the points in the set, and the number of clusters to be estimated, k, is four.

Chart 3 – Inputs and outcomes of innovation

Variables
Inputs
Innovative activities
. Internal R&D activity (PeDI)
. Acquisition of machines and equipments (AQMEQ)
. Training (TREIN)
. Introduction of market innovations (IMEC)
. Industrial project (PRJI)
Expenditure in innovative activities *
. Internal R&D activity (EPeDI)
. Acquisition of machines and equipments (EAQMEQ)
. Training (ETREIN)
. Introduction of market innovations (EIMEC)
. Industrial project (EPRJI)
* compared to net income from sales
Information Sources
. R&D Department (FPEDI)
. Other departments (FOFI)
. Suppliers of machinery or equipment (FFMQ)
. Customers or consumers (FCC)
. Competitors (FCONC)
. Consulting firms and independent consultants (FECI)
. Universities and institutes of higher education (FUIP)
. Centers for professional training and technical assistance (FCCP)
. Institutes of tests and certifications (FIEC)
. Acquisition of licenses, patents and *know-how* (FPAT)
. Conferences, meetings and publications specialist (FCONF)
. Fairs and exhibitions (FFEIRA)
. Networks of computerized information (FRII)
Outcomes
. Improving product quality (QUALI)
. Expanding the range of products offered (GAMA)
. Maintaining the company's participation in the market (MSHARE)
. Expansion of the company's participation in the market (ASHARE)
. Allow to open new markets (NMERC)
. Increased production capacity (CAPROD)
. Increased flexibility in production (FLEXPROD)
. Reduced production costs (CUSTOPR)
. Reduced labor costs (CUSTOTRAB)
. Reduced consumption of raw materials (CUSTOMP)
. Reduction of energy consumption (CUSTOEN)
. Reduction of water consumption (CUSTOAG)

After these two large sets of categorical variables (terminal nodes and input-output clusters) having been estimated, bivariate correspondence analyses are then used to compare the observable firm characteristics (estimates of tree nodes) and the innovation input-output variables (clusters). Correspondence analysis is a multivariate statistical technique that is useful to explore cross-tabulated categorical data, such as social meaning variables. The technique takes a contingency table composed of categorical variables and represents the table in a two dimensional graph, allowing the researcher to represent and interpret the associations between and among categorical variables within different contexts. Using this type of analysis makes it possible to compare line (terminal nodes) and column (input-output clusters) profiles with their respective mean profiles, in addition to associating lines and columns (GREENACRE; HASTIE, 1987; JOHNSON; WICHERN, 2002; RENCHER, 2002; PEREIRA, 1999). In our case, the latter are inferred by calculating standard residuals from the contingency tables on which the correspondence analyses are based.[4] This third step is summarized in a final report, letting the results of the correspondence analysis to be presented only in the appendix.

2.1 Database

Initially, in an universe of 84.3 thousand firms in triennium 2001-2003, only 10,027 industrial firms innovated in product and process. For 2003-2005, on the other hand, the universe of companies now covers approximately 93 thousand firms, but the number of companies that innovated in product and process remained stable, with only 10,092 industrial enterprises for such innovation. Between 2001 and 2003, the firms were oriented to innovation in product and process, while for the second triennium there was a slight predominance in the innovation process, but a large share of innovative products and processes.

An overview of descriptive statistics, according to the categories of innovation analyzed, can illustrate the expected differences in terms of observable characteristics, effort and technological performance of Brazilian industrial firms in the two trienniums. For this, the table 1 below shows the medium values of observable characteristics. In general, one could realize the stability in the period 2001-205, except for the clear growth in the net revenues from sales in the same proportion from both types of innovation. The mean values still remain virtually unchanged for the trienniums, especially the skills of the workers in the process innovation. On average, companies that have developed product and process innovations are relatively larger than process innovative ones in both indicators of size (number of staff busy and net income from sales). Prevailed firms with national capital, in which the product and process innovative firms present a greater proportion of foreign capital, and firms located in over a decade on the market, especially the process innovative firms. Moreover, it increased the average percentage of firms that export and innovate in product and process in comparison to the process innovation, as well as those belonging to a corporate group. In terms of employees' skills, one has drawn attention the growth in the average proportion of employees with the third degree and reducing the proportion of with the 1st degree that were more expressive in product and process innovation. This is a standard maintained for the period in both skill of the workforce, especially in the product and process innovative firms. Thus, it is an indication of the need for labor-qualified in the development of innovation aimed at gaining the competitive advantage of product and process innovation, as evidenced by Rao et alii (2002). In contrast, there is not a great differentiation between sectors intensity, and, on average, there were firms producing durable goods, that are labor intensive and that belong to sectors of low technological intensity. With this analysis, the descriptive statistics showed which characteristics should be selected by the classification and regression tree in order to distinguish the categories of innovation, namely: age of firms, share of 3rd degree, export activities, to belong to the corporate group and variable in size.

[4] Correspondence analysis is an exploratory multivariate statistical tool that converts a nonnegative data matrix into a particular type of graphical display where rows and columns are depicted as R^n points. It is important to note that the analytical data are generally summarized in a single graph despite its being advisable to interpret the distances that separate the points between the line and column categories without establishing their interrelations. For this type of analysis, it is advisable to use standard residuals. Standard residuals indicate if the difference between the observed and expected frequencies of each cell in the contingency table is statistically different from zero, with a normal distribution being employed to test the hypothesis. For further information concerning the calculation of these residuals, see Pereira (1999).

Table 1 – Observable characteristics – descriptive statistics

	Process		Product and Process	
	2003	2005	2003	2005
Net revenue of sales *	1024.79	1692.98	1319.81	2186.91
Staff busy	34.4	36.9	37.2	40.3
Capital origin	1	1	1.1	1.1
Firm's age	15.2	15.1	11.9	12.8
Proportion of employees with the 1st degree	0.595	0.53	0.58	0.49
Proportion of employees 2nd degree	0.353	0.418	0.354	0.431
Proportion of employees 3rd degree	0.046	0.047	0.059	0.074
Export orientation	0.311	0.314	0.379	0.413
Production factor intensity	2.1	2.1	2.2	2.2
Technological intensity	1.6	1.6	1.7	1.8
End-use categories	3	3	2.9	3
Corporate group	0.035	0.032	0.061	0.067

Source: Own elaboration from data of PINTEC, RAIS and SECEX.
* in thousand Reais.

Table 2, on the other hand, concentrated the average level of importance associated with each of the sources of information. Generally, it is visible a low value of importance for the majority of information sources, without the predominance of high values. For having low importance, educational and research centers, consulting firms and the acquisition of patents are not considered in this initial analysis, while other departments of the firm, customers and suppliers of machinery and equipment were very important. For innovation in process, for example, the use of external sources is the most recurrent kind of information for innovation, particularly suppliers of machinery, emphasizing technological strategies more focused on competitiveness through productive capacity. Product and process innovation, on the other hand, appears to have a technology strategy in terms of sources of information more integrated than in the innovative process, because they attach greater importance to a set of information that includes the information from other departments of the firm and external sources.

Table 2 – Information sources – average values

	Process		Product and Process	
	2003	2005	2003	2005
R&D department	0.301	0.017	0.321	0.132
Others departments	0.595	0.591	0.653	0.567
Suppliers of machinery	0.676	0.745	0.625	0.61
Customers	0.401	0.473	0.588	0.652
Competitors	0.403	0.486	0.396	0.371
Fairs and exhibitions	0.619	0.651	0.58	0.518
Networks of computerized information	0.438	0.537	0.49	0.55

Source: Own elaboration with data from PINTEC.

Table 3 contains the average values for the importance of innovative activities, as well as the percentage of expenditure of these activities on the net revenue from sales during the two trienniums analyzed. First, it was observed that the average values of the importance of innovative activities have remained virtually unchanged, with the difference found between the categories of innovation over the trienniums. The product and process innovative firms have a more integrated strategy that combines internal R&D, introduction of market innovations and implementation of industrial projects. The process innovative firms, in turn, focus on the acquisition of machinery and equipment and the training of staff, representing a technological strategy narrower. These two types of strategies show a great consistence in terms of importance of innovative activities for both innovative firms.

For expenditures on innovative activities, note that there is a change in the average percentage spent on the acquisition of machinery over the trienniums for both groups of innovation, especially for the innovative process. These reductions in expenses with the acquisition of machinery may be related to the macroeconomic scenario, especially the movement of adjustment of inventories by industry which resulted in the fall of investment in the second triennium and depreciation of the exchange rate of the first triennium[5]. This could indicate a change in the technological strategies of firms, especially in the innovative process that reversed their innovative behavior, leaving the specialization in the acquisition of machinery for a strategy similar to the more technological one with high spending on internal R&D activities. Already, the product and process innovation presents a technological strategy that maintained expenditures primarily aimed on internal R&D, with some reduction on expenditures of acquisition of machinery.

[5] The other possibility is some sample problem that could bring these mean results for the reduction of acquisition of machinery.

Table 3 – Innovative activities: importance and expenditure – average values

	Process		Product and Process	
	2003	2005	2003	2005
Innovative activities				
Internal R&D activity	0.047	0.037	0.284	0.284
Acquisition of machinery	0.975	0.987	0.991	0.983
Training	0.605	0.665	0.624	0.659
Introduction of market innovations	0.028	0.084	0.32	0.367
Industrial project	0.281	0.256	0.509	0.508
Expenditure in innovative activities (%)				
Internal R&D activity	1.89	15.49	7.94	7.19
Acquisition of machinery	11.14	7.65	8.99	4.15
Training	0.19	0.27	0.98	0.58
Introduction of market innovations	1.03	16.82	2.17	1.89
Industrial project	5.64	1.71	3.21	3.17

Source: Own elaboration with data from PINTEC.

The table 4 contains the descriptive statistics about some impacts of innovation following the categories of innovation. In general, there is not a considerable variation in the mean impact between the trienniums despite the change in average variable sources of information and innovative activities. Furthermore, the mean values of importance of product and process innovative are relatively lower than the innovative process in terms of quality of product, maintenance/expansion of market share, and changes in the production process. Thus it is clear to distinguish the innovative performances of firms according to the innovative efforts made by it. That is, on average, the process innovations generate productivity growth through restructuring of production, reducing costs and increasing productive capacity, and maintain and/or expand the market share of the firm. This happens especially by the superior importance of improvement of product quality, increase in production capacity and reduction of some costs. Maintaining market share and expanding the variety of products used for diversification into new markets are the main results of product and process innovation. These factors can be identified in the predictions offered in chart 1 for the two types of innovation, although the product and process innovation could be related to some characteristics of product innovation strategy.

Table 4 – Impacts of innovative activities – average values

	Process		Product and process	
	2003	2005	2003	2005
Improving product quality	0.835	0.831	0.487	0.535
Expanding the range of products	0.006	0.132	0.472	0.54
Maintaining the company's *market share*	0.692	0.755	0.528	0.555
Expanding the company's *market share*	0.54	0.626	0.494	0.51
New markets	0.002	0.031	0.21	0.381
Increased production capacity	0.818	0.847	0.486	0.494
Increased flexibility in production	0.664	0.741	0.427	0.436
Reduced production costs	0.538	0.559	0.344	0.31
Reduction of labor costs	0.536	0.555	0.317	0.292

Source: Own elaboration with data of PINTEC.

In short, the product and process innovation have a greater base of knowledge that involves both acquisition of machinery and execution of internal activities of R&D and information from a larger set of sources. However, average results are obtained in smaller proportion than in the innovative process, focusing on diversification of products for new markets and maintaining the participation of market share. Moreover, process innovative firms show the high expenditures toward the purchase of machines, also reflected by the information from suppliers of machinery, but with some relevance to R&D activities that generate internal restructuring of production and cost reduction, and improve product quality and maintain its market share.

3 Characteristics of the innovative firms between 2003 e 2005

The estimated tree for the 2003-2005 triennium includes 13 terminal nodes that characterized the categories of companies, having a good predictive power with an estimated risk of 25.6% which was lower than the proportion of product and process innovative enterprises, which is the seek class that we want to understand[6]. It is important to emphasize that the descriptive statistics presented above indicate certain observable characteristics in the distinction between the two categories of innovative companies such as age of firm, the proportion of staff with 3rd degree, export activities and the variables of firms' size. Corroborating this statement, the main explanatory variables selected by the algorithm of expansion of the tree were: technological intensity, the proportion of staff with 3rd degree and national origin of the capital driver. Sectors with high technological intensity are related to companies with more likely to innovate in product and process, while those most likely to innovate in process are placed in areas of low intensity. Moreover, the proportion of staff with 3rd grade and the national firms have positive relationship with the probability to innovate in product and process. The age of the company (young companies are more likely to innovate in product and process), the sectoral classification in the end-use

[6] It was established a five levels of nodes as an extension of the tree and the maximum frequencies among nodes would be minimum of 100 for parents' nodes and 50 for child nodes. By presenting similarity in the proportions between the categories of innovation, we opted to use symmetric cost of misclassification.

categories, firms' size and export activities are the other variables that are related to the probability to innovate in product and process.

Among companies with high-technology, it can be highlighted those firms with a proportion of staff with 3rd degree over 12%, well above the average value presented in the previous section for the innovative product and process of 7.4%. However, the proportion of staff with 3rd degree is not the determinant for the probability to innovate in product and process for firms producing intermediate goods with a share below the average, bringing us ambiguous evidences in the terminal nodes. For companies producing durable consumer goods, this relationship is reversed, since there is a proportion of staff with 2nd degree higher than the average value and these companies are characterized as large ones. This means that the sector classification and firms' size are important in the classification of companies as innovative product and process. Chart 4 below shows the information about the observed characteristics for each subset of firms, ranked according to the probability of being innovative in product and process. Among the six nodes with higher probability of being innovative in product and process, most companies are allocated in sectors highly intensive in technology. However, there is the possibility of being classified as low-technology sectors such as case of domestic companies, but operating no more than 4 years in the market that have the greatest chance of being innovative in product and process.

It also has a great chance to be innovative in product and process, all the exporting companies, operating more than four years, with a staff of employees with 3rd degree over 12%, selected by the node 24. It can be said that participation in foreign trade, together with the employees' skills, increases the chance to innovate in product and process, because the exportation requests from the company competitive instruments focused on technological innovation, aimed not only the maintenance of market share, but the diversification into new markets. Already the 7,486 domestic non-exporting firms that were created over four years (node 16) are more likely to innovate in process. These firms focus on national market seek to stay innovative in the competitive environment by using the innovation as the means for the restructuring of production.

Chart 4 – Characteristics of the firms

<table>
<tr><th>Node</th><th>N</th><th>Resp %</th><th>Characteristics of the firms</th></tr>
<tr><td>9</td><td>3.852</td><td>92.5</td><td>(intens_tec = 1 | intens_tec = 2) & (origem = 1) & (empr_anos05 <= 4.145)</td></tr>
<tr><td>19</td><td>178</td><td>88.2</td><td>(intens_tec = 3 | intens_tec = 4) & (cnae_uso = 4) & (prop_3grau <= 0.032)</td></tr>
<tr><td>22</td><td>212</td><td>78.3</td><td>(intens_tec = 3 | intens_tec = 4) & (cnae_uso = 4) & (prop_3grau <= 0.121 & prop_3grau > 0.059) & (lnrlv > 14.094)</td></tr>
<tr><td>4</td><td>1.412</td><td>74.2</td><td>(intens_tec = 3 | intens_tec = 4) & (prop_3grau > 0.121)</td></tr>
<tr><td>24</td><td>456</td><td>67.5</td><td>(intens_tec = 1 | intens_tec = 2) & (origem = 1) & (empr_anos05 > 4.145) & (ativ_exp = 2 | ativ_exp = 1) & (prop_3grau > 0.129)</td></tr>
<tr><td>5</td><td>402</td><td>66.4</td><td>(intens_tec = 1 | intens_tec = 2) & (origem = 2 | origem = 3)</td></tr>
<tr><td>18</td><td>1.048</td><td>61</td><td>(intens_tec = 3 | intens_tec = 4) & (prop_3grau <= 0.121) & (cnae_uso = 3) & (prop_2grau > 0.427) & (lnrlv > 13.534)</td></tr>
<tr><td>11</td><td>599</td><td>39.4</td><td>(intens_tec = 3 | intens_tec = 4) & (prop_3grau <= 0.121) & (cnae_uso = 3) & (prop_2grau <= 0.427)</td></tr>
<tr><td>23</td><td>2.068</td><td>38.9</td><td>(intens_tec = 1 | intens_tec = 2) & (origem = 1) & (empr_anos05 > 4.145) & (ativ_exp = 2 | ativ_exp = 1) & (prop_3grau <= 0.129)</td></tr>
<tr><td>17</td><td>181</td><td>34.8</td><td>(intens_tec = 3 | intens_tec = 4) & (prop_3grau <= 0.121) & (cnae_uso = 3) & (prop_2grau > 0.427) & (lnrlv <= 13.534)</td></tr>
<tr><td>20</td><td>90</td><td>30</td><td>(intens_tec = 3 | intens_tec = 4) & (cnae_uso = 4) & (prop_3grau > 0.032 & prop_3grau <= 0.059)</td></tr>
<tr><td>16</td><td>10.272</td><td>27.1</td><td>(intens_tec = 1 | intens_tec = 2) & (origem = 1) & (empr_anos05 > 4.145) & (ativ_exp =0)</td></tr>
<tr><td>21</td><td>110</td><td>25.5</td><td>(intens_tec = 3 | intens_tec = 4) & (cnae_uso = 4) & (prop_3grau <= 0.121 & prop_3grau > 0.059) & (lnrlv <= 14.094)</td></tr>
<tr><td colspan="4">Estimated risk: 0.256</td></tr>
</table>

4 Sets of inputs and outputs of innovative activity: final results

For each of the sets of inputs and outputs, the cluster analyses were conducted according to the methodological specifications. There are presented in table 5 the estimated centroid of the clusters of information sources for the period, always following the decreasing order for the average value of the centroid of the clusters. That is, in all cases the cluster number 1 is that with the highest average value of the centroid, while the number of 4 will be to lower the average value of the centroid.

First, the average centroids made by clusters of sources are relatively low in both trienniums, with a change in the average centroid by increasing the values of the second triennium. Basically, these two clusters of analysis show that the distribution of variables according to groups remains similar, especially in the first two clusters in each analysis. Moreover, it is essential that the scoring average of importance values were low in the FPEDI descriptive statistics, and they are reflected in this analysis. In other words, the information from FPEDI (averaging value less than 0,273 for 2003 and below 0311 to 2005) are less important sources than FOFI, possibly the way in which occurs the overcoming of obstacles through technological innovation. This is clear when one notes that less than 10% of firms in 2003 and 2005 are grouped in the cluster of higher centroid, with the highest level of importance to FPEDI.

In terms of clusters, only 7.9% of Brazilian industrial firms in 2003 were selected by cluster 1 that has a higher accumulated knowledge than the others with higher values of importance to internal sources (FOFI) and external sources (FCC, FCONF and FFEIRA). The second group is primarily oriented towards the external sources to the company (FFEIRAS, FRII and FCC), despite the high importance the sources from FOFI. With approximately 43% of the sample, it is expected that companies here have a intermediate technological effort, as its base of knowledge is more restricted vis-à-vis the cluster 1. Cluster 3 is similar to the first group in the importance of FPEDI (0,272), but gives a degree of minor importance for the other sources of information, restricting itself FFMQ, FCONF and FRII, being specialized and less knowledge base. Finally, the centroidd of the fourth group are well below the other, selecting companies with some importance to FOFI and FFMQ, corresponding to a limited base of knowledge.

The first cluster of 2005 shows that the association between sources of information should enable a broader base of knowledge, seeking both the needs of the market, by FCC and FCONC, as overruns of barriers to internal with FOFI FPEDI. The group 2, representing an important intermediate, is primarily focused on FCC, FFMQ and FOFI. The third cluster has extreme information and has little representative in the analysis, with only 314 companies that focus on external sources, representing a fairly narrow range of knowledge. Already the number of cluster 4 is the lowest degree of importance assigned to information sources and concentrates 37.8% of the sample firms, with FFMQ as the main source.

Table 5 – Information sources from 2001 to 2005 – cluster analysis

	2003				2005			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
FPEDI	0.273	0.055	0.272	0.016	0.311	0.065	0	0.03
FOFI	0.73	0.66	0.196	0.653	0.85	0.714	1	0.339
FFMQ	0.862	0.736	0.553	0.528	0.894	0.825	1	0.408
FCC	0.888	0.791	0.125	0.201	0.924	0.729	1	0.283
FCONC	0.852	0.496	0.215	0.247	0.777	0.505	0	0.27
FECI	0.565	0.127	0.08	0.068	0.588	0.099	0	0.042
FUIP	0.618	0.044	0.115	0.025	0.704	0.057	0	0.035
FCCP	0.771	0.106	0.099	0.056	0.773	0.114	0	0.058
FIEC	0.648	0.11	0.193	0.026	0.864	0.115	0	0.032
FPAT	0.126	0.024	0.044	0.008	0.143	0.06	0	0.025
FCONF	0.889	0.401	0.692	0.118	0.838	0.38	0	0.125
FFEIRA	0.894	0.912	0.44	0.263	0.901	0.768	1	0.235
FRII	0.814	0.801	0.862	0.041	0.919	0.752	1	0.174
N. obs.	**1677**	**9035**	**1069**	**9441**	**2322**	**11698**	**314**	**8725**

Source: Own elaboration using data from PINTEC.

Table 6 below shows the cluster analysis of the importance of innovative activity for the two trienniums. In general, there is a change in the distribution of values of innovative activities, with a considerable decline in the importance of PEDI. Moreover, the main difference between the two trienniums is the allocation of firms according to the groups. This happened because, in 2003, more than half of the firms were concentrated in cluster 3, which represents an effort similar to that of the first cluster, but to a lesser extent, while in 2005 this pattern changes to a group of lower levels, focused solely on the importance of acquiring machines. Indications of Braga and Willmore (1991) suggest that the greater the dependence on external acquisition of technology by a firm, the lower will be its technological effort and thus lower the knowledge base of the firm's technology strategy whereas a combination of acquisitions and internal R&D activities represents a superior technological strategy.

For the triennium of 2001-2003, the first cluster highlights the great important of the majority of innovative activities, especially PEDI (with an average of 0.99) and AQMEQ (0.87), except for minor to TREIN (0.38). Thus, companies that are part of this cluster acquired machines to complement the more established technological strategy. The second group is characterized by extreme values, giving greater importance to the acquisition of machinery, for training and development of industrial projects, being a cluster of very limited base of knowledge. The last two clusters concentrate 81% of the sample and are those in which firms attach high importance to investment in machinery and equipment. Patterns of clusters 1 and 3 are close together, differing by the lesser degree of importance for PEDI (0.25) and greater importance for Training (0.84) in cluster 3. The fourth cluster is characterized by low values of importance to the most innovative activities, and focused solely on AQMEQ. For 2003-2005, the first cluster maintains a profile similar to that presented in 2003, with higher values for all innovative activities, except internal R&D, establishing an integrated strategy, for combining the acquisition of machinery and R&D procedure. The second cluster is very similar to the first group, but differs in terms of trained staff that is an important activity to the first group and zero importance for the second group. Indeed 78% of firms were classified in the last two clusters, which highlights the high degree of importance attributed to investment in machinery, training and to the almost zero level of importance attributed to the activity of R&D procedure. Among them, the main difference is the high importance of TREIN in the third group, consisting of extreme information.

Table 6 – Importance of innovative activities for 2003 and 2005 – cluster analysis

	2003				**2005**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
PEDI	0.99	0	0.251	0.059	0.596	0.493	0	0.075
AQMEQ	0.868	1	0.986	0.951	0.955	0.792	1	0.976
TREIN	0.384	1	0.835	0	1	0	1	0.403
IMEC	0.944	0	0.277	0.031	0.84	0.732	0	0.111
PRJI	0.407	1	0.46	0	0.893	0.802	0	0.361
N. obs.	**691**	**3314**	**11007**	**6210**	**4158**	**1044**	**6023**	**11834**

Source: Own elaboration from data of PINTEC.

It is also known to distinguish between the cluster analyses of expenditures on innovative activities in the two trienniums presented by the Table 7 below. In general, there was a big change in the profiles of clusters in terms of variables allocated and number of firms selected by the cluster. However, it is important to note that the number of associated companies in the cluster analysis does not encompass the entire sample for the small number of respondents. The first cluster of 2003 is one that has increased spending on all innovative activities, mainly EPEDI (73.73%) and EAQMEQ (63.07%) representing a more interconnected, while the second has more to centroid EAQMEQ (10.09%) in spite of doing some expenditure on R&D internally. Already the number of clusters 3 and 4 present centroid for the extremely low expenditures in innovative activities, differentiating itself by the slightly above average in expenditures for all categories of activities in cluster 3. However, we can not fail to note that these last two clusters added approximately 72% of firms considered in the analysis of the 2003, emphasizing the low level of technological effort undertaken by them. For 2005, it is important to note that now the first cluster that is specialized in higher expenditure on in EPEDI (43.64%), while the second shows higher values for EAQMEQ (28.33%) and EPEDI (15.42%), which indicates a more developed and cohesive strategy, differentiating it from 2001-2003 in which there was a concentration of these expenditures in the first group. Already the clusters 3 and 4 present centroid for the extremely low expenditures in innovative activities, differentiating itself by slightly above average in expenditures for all categories of activities in cluster 3, mainly in EAQMEQ, and the last group has the smallest values. These last two groups add approximately 64% of firms used in the analysis of cluster.

Table 7 – Expenditure of innovative activities for 2003 and 2005 – cluster analyses

	2003				**2005**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
EPEDI	73.73*	4.88	3.37	0.3	43.76	15.42	0.98	0.36
EAQMEQ	63.07	10.09	1.74	0.24	3.56	28.33	2.16	0.16
ETREIN	8.2	0.3	0.32	0.03	2.76	6.22	0.2	0.04
EIMEC	15.12	1.66	0.91	0.2	5.45	1.6	0.73	0.15
EPRJI	21.07	5.51	1.18	0.17	4.77	4.5	0.98	0.12
N. obs.	**258**	**151**	**497**	**562**	**342**	**276**	**555**	**533**

Source: Own elaboration using data from PINTEC. * values in %.

Finally, table 8 shows the low variability with regard to the impacts of innovative activities by cluster analysis. Initially, there is a similarity in the values of the centroid of the variables in both trienniums, leading to a small range of impact and differentiation between groups is through a set of variables with low importance. For 2003, the first cluster is the average excess in all areas examined, with market oriented growth. Yet, the cluster 2 selected firms whose importance of the impacts is oriented to both the product and to maintain market share, via FLEXPROD, CAPROD and reduction of production costs, being expected some process innovative companies in this cluster. The last two groups account for 60% of firms, whereas in cluster 3 can be noted that prioritizes QUALI and GAMA, as well as CAPROD, FLEXIPROD and relations with the market, but with little or no importance to the reduction of production costs. On the other hand, the cluster 4 is the one with the lowest impact of innovative activity, focusing only on MSHARE which is possibly formed by companies that made incremental innovations or copies from competitors. For 2005, the first cluster has the highest values, highlighting the importance of impacts of QUALI, market concerned and the production process by reducing costs and productivity growth by the restructuring of production, flexibility and increased productive capacity. Cluster 2 selected companies that prioritized QUALI and GAMA, as well as increasing the capacity and relationships with the market, and lower the importance of the rationalization of costs. This can be the result of any intermediate level of technological effort of product and process innovative firms. Accounting 56% of firms, the latter two clusters have the lowest values for reduction of production costs. Cluster 3 is one that has impacts facing QUALI, MSHARE, FLEXPROD and CAPROD. It has the greatest value to new markets that is a factor sought by the firms that innovate in product and process. The cluster 4, at last, has the lowest impact of innovative activity, and only focused in MSHARE (with 0,162), possibly centering on process innovation that has a more narrow strategy and focused only on the purchase of machinery.

Table 8 – Impacts of innovative activities for 2003 and 2005 – cluster analyses

	2003				**2005**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
QUALI	0.905	0.884	0.898	0.216	0.93	0.889	0.912	0.142
GAMA	0.815	0.223	0.324	0.195	0.381	0.446	0.566	0.139
MSHARE	0.923	0.814	0.838	0.199	0.873	0.897	0.876	0.162
ASHARE	0.923	0.678	0.732	0.165	0.783	0.743	0.791	0.093
NMERC	0.632	0.082	0.137	0.085	0.259	0.322	0.365	0.058
CAPROD	0.914	0.939	0.786	0.15	0.924	0.931	0.814	0.116
FLEXPROD	0.828	0.824	0.648	0.063	0.834	0.745	0.642	0.059
CUSTOPR	0.942	1	0	0.048	0.907	1	0	0.062
CUSTOTRAB	0.946	0.815	0.228	0.034	1	0	0.091	0.049
CUSTOMP	0.845	0.243	0.07	0.034	0.394	0.175	0.108	0.036
CUSTOEN	0.749	0.195	0.091	0.027	0.332	0.226	0.089	0.012
CUSTOAG	0.521	0.038	0.02	0.006	0.144	0.064	0.056	0.006
N. obs.	**937**	**7287**	**5046**	**7296**	**8611**	**1520**	**5868**	**7060**

Source: Own elaboration using data from PINTEC.

In short, the clusters' analyses enable a deepening of the relations presented by the type of technological strategies from the theory section in order to differentiate two types of innovation in process, presented in Chart 5 below. Its construction started from the view that some groups of cluster analysis were mainly characteristic of different types of process innovations that, despite similarities presented in theoretical predictions of chart 1, showed clear distinctions of innovative behavior and in lesser intensity especially focused on the expenditures of innovative activities. Thus, the chart below shows the main divisions presented in chart 1, but including factors that were perceived in cluster analysis and the clusters in which they can find these features according to three new types of innovation. The last two columns present the terminal nodes in which is identified the new classification by some combination of the clusters features. The cluster analyses have allowed some understanding in the low values of the sources of information for both periods, showing they were a minor factor in the firms' performance. The innovative activities are the true delimiters of technological strategies. In this case there is a small subset of companies that actually have a greater innovation effort, with spending on internal R&D and acquisition of machinery, which might lead to wider impacts. With respect to the impacts of innovative activity, despite the extremely positive self-evaluations, it is possible to distinguish two categories with and without cost savings that suggest different types of technological effort. These changes in the typology presented in the theory section are shown in the chart 5.

Chart 5 – Allocation of the clusters by the technological strategy

<table>
<tr><th>Innovation</th><th>Inputs
Outcomes</th><th>Technological strategy</th><th>Cluster 2003</th><th>Cluster 2005</th><th>Nodes 2003</th><th>Nodes 2005</th></tr>
<tr><td rowspan="4">Product and process: competitive advantage</td><td>Information Sources</td><td>Greater importance of internal and external sources</td><td>F1
F2</td><td>F1
F2</td><td rowspan="4">19, 24, 5, 22 and 4</td><td rowspan="4">24, 4, 5 and 22</td></tr>
<tr><td>Innovative activities</td><td>Higher importance for internal R&D activity and acquisition of machinery</td><td>D1
D2</td><td>D1
D2</td></tr>
<tr><td>Expenditure in innovative activities</td><td>High expenditures on R&D activities of internal and acquisition of machinery</td><td>D2-1
D2-2</td><td>D2-1
D2-2</td></tr>
<tr><td>Impacts</td><td>Differentiation of product
Diversification into new market
Increased production capacity
Improving quality
Cost-cutting</td><td>I1
I2
I3</td><td>I1
I3</td></tr>
<tr><td rowspan="4">Narrow Process</td><td>Information Sources</td><td>Greater importance to suppliers of machinery</td><td>F4</td><td>F4</td><td rowspan="4">20</td><td rowspan="4">-</td></tr>
<tr><td>Innovative activities</td><td>High importance for innovative activities of acquisition of machinery</td><td>D3
D4</td><td>D3
D4</td></tr>
<tr><td>Expenditure in innovative activities</td><td>Low expenditures on innovative activities, focusing on acquisition of machinery</td><td>D2-4</td><td>D2-4</td></tr>
<tr><td>Impacts</td><td>Improving the quality of the product
Maintaining market share</td><td>I4</td><td>I4</td></tr>
<tr><td rowspan="4">Integrated Process</td><td>Information Sources</td><td>High importance of external source</td><td>F2
F3</td><td>F2
F3</td><td rowspan="4">16, 23, 11, 17, 18 and 21</td><td rowspan="4">21, 20, 18, 17, 11 and 23</td></tr>
<tr><td>Innovative activities</td><td>Some importance of internal R&D activities and high importance for the purchase of machinery</td><td>D2
D3</td><td>D2
D3</td></tr>
<tr><td>Expenditure in innovative activities</td><td>Expenditures in innovative activities toward machinery and some internal R&D activity</td><td>D2-2
D2-3</td><td>D2-2
D2-3</td></tr>
<tr><td>Impacts</td><td>Productivity growth by restructuring the production
Increase of quality and variety of product
Reduction of costs
Maintenance/Expansion of</td><td>I2
I3</td><td>I1
I2
I3</td></tr>
</table>

		market share				

The standard residuals from contingency tables, presented in appendix, indicated that technological strategies had some adjustment in terms of the chart above. That can be noted by the large adjustment from the typology according to the terminal nodes, especially from the absence of some nodes in the new terminology probably related to some modification in the technological strategy between the trienniums or the inadequacy of the typology above. The adjustment occurs especially in terms of information sources and impacts of innovative activity. The first setting might possibly be related to the low importance of the information sources, while the changes in impacts can be linked to the accumulation of knowledge between periods. Note that some subsets of product and process innovative firms are not presented in the chart since they had different technological strategies from 2001 to 2005.

This chart shows what terminal nodes followed the predictions of strategies when ranked by their representations and shows the variation between periods that leaded some adjustment to the predictions. To make it easier to understand the results, we will separate them according to the probability to innovate in product and process and innovate in process. First, among the seven terminal nodes likely to innovate in product and process, only four were effectively under the new classification during the period, but were not the same for both trienniums. For the 2001-2003 period, the nodes were 9, 24, 5 and 4, while nodes 24, 4 and 22 were the ones that followed the typology presented in chart 5 for the second triennium. Firms in technology-intensive sectors with more than 12% of the employees with higher education and innovative in product and process selected by node 4, clearly use a broader base of knowledge, involving the activity of internal R&D with the acquisition of machinery and training of staff to achieve impacts in terms of product, with increased quality, and market relations and the restructuring of production process including the reduction of costs. The other nodes were in disagreement with the classification, especially in terms of expenditure in innovative activities and impacts. That is, expenditure in innovative activities and impacts from these nodes had features that were related to other types of innovation, especially narrow process innovation. This is the case of node 9, composed by national companies from sectors of low-intensity and installed in no more than 4 years, for the year 2003, as they presented technology strategy clearly linked to the narrow process innovation for all the variables' categories. These firms should be associated with cluster 1, higher spending on R&D and purchase of machinery, but spend little in all the innovative activities. But the results really fit in previous forecasts. In 2001-2003, the firm's strategy was focused only in acquisition of machinery leading to smaller results. Some variations of the strategies set forth above may arise primarily from decentralized business strategies that seek only to overcome the obstacles of the firms in a given period of time or could be related to the competitive environment of the country. Moreover, we can not fail to consider that there may be an accumulation of knowledge that could support the strategies' choices focused more on knowledge to achieve better performance.

There are some cases of stability in the results indicating a relationship between technological strategies and characteristics of firms. This was found mainly in firms that innovated in the integrated process, since five subsets of companies remained in that classification, only changing the allocation of clusters within the categories of expenditure and impact. These are the cases of nodes 11, 17, 18, 21 and 23 that are more likely to innovate in process with a broader base of knowledge and not just focused on the acquisition of machinery and equipment. In the case of firms that follow the strategy of restricted procedure, note that only the names of the node 20 showed this behavior, modifying it in 2005 for innovation in the integrated process. Companies represented by nodes 4 and 24 showed stable results that draw attention in the case of innovative product and process. These results indicate firms with greater proportion of employees with higher education (nodes 4 and 24) provide more focused strategies towards competitive advantage for the product and process firms, while the allocation in sectors highly technology-intensive reflects more integrated strategies for process innovation.

Some highlights have to be made in terms of associations of effort and results for the types of innovation. Therefore, in the case of innovative product and process can be highlighted, in 2003, firms in highly intensive-technology that produce intermediate goods, but have less than 3.2% of its employees with higher education (node 19). These companies had a broader base of knowledge in 2003 with the integration of external factors, mainly the acquisition of machinery, and internal, as the conduct of internal R&D activities. This effort focuses on broader knowledge impacted only on products quality and variety, productive capacity and flexibility, as well as maintenance of market share and to a lesser extent the cost-cutting. Moreover, in 2005, its knowledge base has become very limited, focused on acquisition of machinery, but the results were better than in the previous period, and clearly associated with the classification. So this is a classic case of innovative product and process, although they have impacts in all areas examined their effort to get them was restricted. On the other hand, the firms most likely to innovate in process and technology-intensive with less than 12% of employees with higher education, node 21, purchased machinery and associated it with R&D activities in which their impacts are towards the market, product quality and productivity growth by restructuring the production by increasing the capacity and flexibility of the production process and reducing production costs. Another example can be seen in the firms selected by node 11 that are technology-intensive, producing durable goods. They have a knowledge base similar between periods, in line with the classification of clusters of chart 5, but in 2003 its results were more similar to the innovative product and process, while in 2005 they just follow the predictions.

Moreover, in general, one can note the similarity of the technological effort and impacts made by the three sets of companies that innovated in product and process over the period (nodes 24, 4 and 5). That is, these firms spend most part of their revenue with the implementation of internal R&D activities associated with the acquisition of machinery, to obtain similar results between periods, mainly oriented to quality product and to maintain market share, via FLEXPROD, CAPROD and reduction of production costs. For 2003, QUALI and GAMA, as well as increasing the capacity and relationships with the market, and lower the importance of the rationalization of costs were the results obtained.

For companies that had integrated process strategy, the only factor alike between them was the innovative effort focused on a broader knowledge base, similar the one used by product and process innovative firms. But the results were better in 2003, mainly concerned to all three types of factors analyzed, especially cost-cutting from the highest cluster. However, for 2005, using the same base of knowledge has not brought results as efficient as the previous, but associated results more likely expected of narrow process strategies. That is, focusing on maintaining market share, the quest for improvement of products quality and some importance to the changes in the production process. This may be an indication that the macroeconomic scenario, although enabling the maintenance of the technological strategy chose before, did not favor the expectations of similar results between periods.

Final remarks

This work intended to examine the representations of the technological strategies of Brazilian companies between 2001 and 2005, whereas firms that innovated in product and process or only in process in the period 2003-2005. The analysis of the choice’s dynamics of technological strategies used the statistical tools of multivariate analysis for the trinomial effort-company-results. The representations of the technological strategies of firms in 2003-2005 were compared with the technological strategies retroactive between 2001 and 2003, using data from PINTEC, RAIS SECEX and for the period.

In general, we started with a kind of technological strategies typology that Pianta and Antonucci (2002) and Prochnik and Araújo (2005) provided, which allocates the inputs and outputs according to the type of innovation performed showing their relationship in terms of product, production process as well as the competitive environment. It served as the basis for the determination of a similar typology, separating the firms that innovated in product and process from those that innovated in two types of process innovation: the integrated process and the narrow process by using the cluster analyses. Companies that have a technological strategy from integrated process add to expenditures on acquiring machinery and equipment costs with the activity of internal R&D and get wider results. On the other hand, companies that adopted a narrow process strategy consider a base of knowledge very limited in terms of information sources and focused on the acquisition of machinery whose aim above all was to maintain the competitive market.

First off, it was noted that the likelihood of the company be innovate in product and process is related to the technological intensity of the industrial sector and increases with the proportion of employees with higher level of skills, which could indicate that there is some coordination between innovation and skills-labor. This takes place since product and process innovation seeks the competitive advantage. In terms of technological strategies, it is interesting to note the minor importance of information sources in the differentiation of technological strategies, regardless of industrial sector. On the other hand, innovative activities, on both the importance and the expenditure, had a key role in determining the overall technological strategy. These were two factors that distinguish the strategies for innovative companies in product and process from those that innovated in the process. This occurs since the former coordinates the internal R&D activities to the acquisition of machinery, while the latter focuses only on the acquisition of machinery and equipment.

In general, the results indicated that firms that product and process innovation have a broad base of knowledge in at least one of the trienniums analyzed, which allows the association between internal R&D activities and other innovative activities, increasing the productivity of firm by changing in the production process to improve or maintain their positions in the competitive market. On the other hand, the process innovation can be shown separately. Therefore, the representations of the technological strategies of firms in innovative product and process are best suited to the strategies provided for the period 2001-2003. The second triennium is basically explained by changes in the technological strategies for both types of innovation that in most cases was actually associated with the accumulated knowledge and/or the economic environment, although there were cases in which could be found perfect fits between the new classification made by the clusters and the terminal nodes. Thus, it can be said that the technological strategies of firms that innovate in products and processes use a larger knowledge base, and therefore better results are obtained. Innovative companies of integrated process are similar in some factors on the product and process innovation, but may have different competitive strategies. The narrow process innovation is, in both periods, shaped by those firms whom actually used a limited base of knowledge, and focused only toward the maintenance market.

References

AMOAKO-GYAMPAH, K.; ACQUAAH, M. Manufacturing strategy, competitive strategy and firm performance: an empirical study in a developing economy environment. *International Journal of Production Economics*, 111: 575: 592, 2008.

ANTONUCCI, T.; PIANTA, M. Employment effects of product and process innovation in Europe. *International Review of Applied Economics*. 16 (3): 295-307, 2002.

CABRER-BORRÁS, B.; SERRANO-DOMINGO, G. Innovation and R&D spillover effects in Spanish regions: a spatial approach. *Research Policy*, Sussex, 36: 1357–1371, 2007.

CRÉPON, B.; DUGUET, E.; MAIRESSE, J. Research, innovation, and productivity: an econometric analysis at the firm level. *NBER working paper series*. Cambridge, Working Paper 6696, Aug. 1998.

FEIJÓ, C.A.; CARVALHO, P.G.M.; RODRIGUEZ, M.S. Concentração Industrial e Produtividade do Trabalho na Indústria de Transformação nos anos 90: evidências empíricas. *EconomiA*, Niterói, 4 (1): 19-52, 2003.

GREENACRE, M.; HASTIE, T. The geometric interpretation of correspondence analysis. *Journal of the American Statistical Association*, Alexandria, 82 (398): 437-447, jun. 1987.

JOHNSON, R.A.; WICHERN, D.W. *Applied Multivariate Statistical Analysis*. 5ª ed. New Jersey: Prentice Hall, 2002, 767p.

KANNEBLEY, S. JR.; et alii. Characteristics of Brazilian innovative firms: An empirical analysis based on PINTEC – industrial research on technological innovation. *Research Policy*, Sussex, 34: 872–893, 2005.

KANNEBLEY, S. JR.; DE NEGRI, J.A. Atividade inovativa na América Latina: uma comparação entre indústrias de baixa e alta intensidade tecnológica. *Texto para discussão* n.05. FEARP: Série Economia, 2008.

LOH, W.Y; SHIH, Y.S. Split Selection Methods for Classification Trees. *Statistica Sinica*, Cambridge, 7: 815-840, 1997.

MONTOYA, P.V.; et alii. Does the technological sourcing decision matter? Evidence from Spanish panel data. *R&D Management*, 37 (2): 161-172, 2007.

MOREIRA, M.M. Estrangeiros em uma economia aberta: impactos recentes sobre a produtividade, concentração e comércio exterior. Texto para discussão n.67. Rio de Janeiro: BNDES, 1999.

OECD. Oslo Manual: The measurement of scientific and technical activities. 2nd ed. Oslo: OECD/EC/Eurostat, 1997.

PADMORE, T.; SCHUETZE, H.; GIBSON, H. Modeling systems of innovation: an enterprise-centered view. *Research Policy*, Sussex, 26: 605-624, 1998.

PEREIRA, J.C.R. *Análise de dados qualitativos*: estratégias metodológicas para as ciências da saúde, humanas e sociais. São Paulo: EDUSP. 3º ed., 1999.

PROCHNIK, V.; ARAÚJO, R.D. Uma Análise do Baixo Grau Inovação na Indústria Brasileira a Partir do Estudo das Firmas Menos Inovativas. In: DE NEGRI. J. A.; SALERNO, M.S. (Orgs.) *Inovações, Padrões Tecnológicos e Desempenho das Firmas Industriais Brasileiras*, Brasília: IPEA, 2005.

RAO, S.; TANG, T.; WANG, W. The Importance of Skills for Innovation and Productivity. *Internacional Productivity Monitor*. n.4, Spring, 2002.

RENCHER, A.C. *Methods of Multivariate Analysis*. 2nd ed. New York: Wiley-Interscience, 2002.

SBRAGIA, R.; KRUGLIANKAS, I.; ARANGO-ALZARE, T., Empresas inovadoras no Brasil: uma proposição de tipologia e características associadas. *Série Working Papers FEA/USP* No. 001/003. Disponível em http://www.ead.fea.usp.br/wpapers, 2002.

SHARIF, M.N. Technology strategy in developing countries: evolving from comparative to competitive advantage. *International Journal of Technology Management*, v. 14, ns. 2/3/4, pp. 309-343, 1997.

SPITAL, F.C.; BICKFORD, D.J. Successful competitive and technology strategies in dynamic and stable product technology environments. *Journal of Engineering and Technology Management*, 9: 29-60, 1992.

VAONA, A.; PIANTA, M. Firm Size and Innovation in European Manufacturing. *Small Business Economics*, 30:283–299, 2008.

VIOTTI, E.B. Fundamentos e Evolução dos Indicadores de CT&I. In: VIOTTI, E.B.; MACEDO, M.M. (Orgs.). *Indicadores de Ciência, Tecnologia e Inovação no Brasil*. Campinas: Unicamp, 2003, p. 41-87.

ZAHRA, S.A.; DAS, S.R. Innovation strategy and financial performance in manufacturing companies: an empirical study. *Production and Operations Management*, 2 (1): 15-37, 1993.

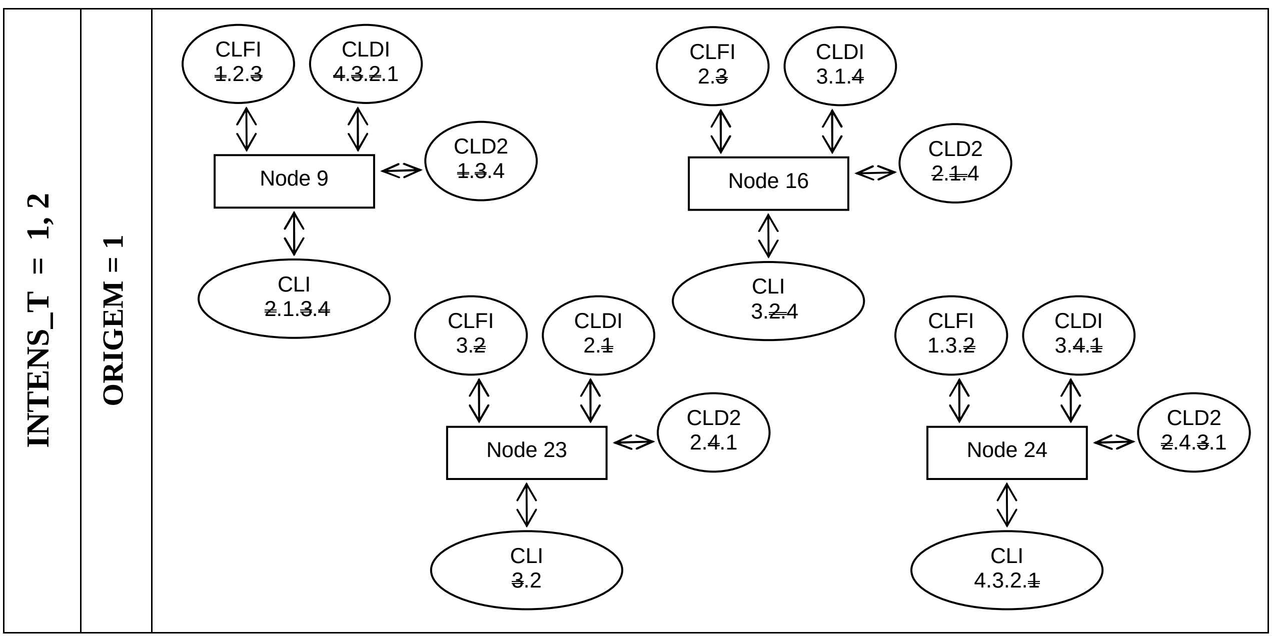
Appendix I – The behavior of technological strategies from 2001 to 2005 using contingency tables

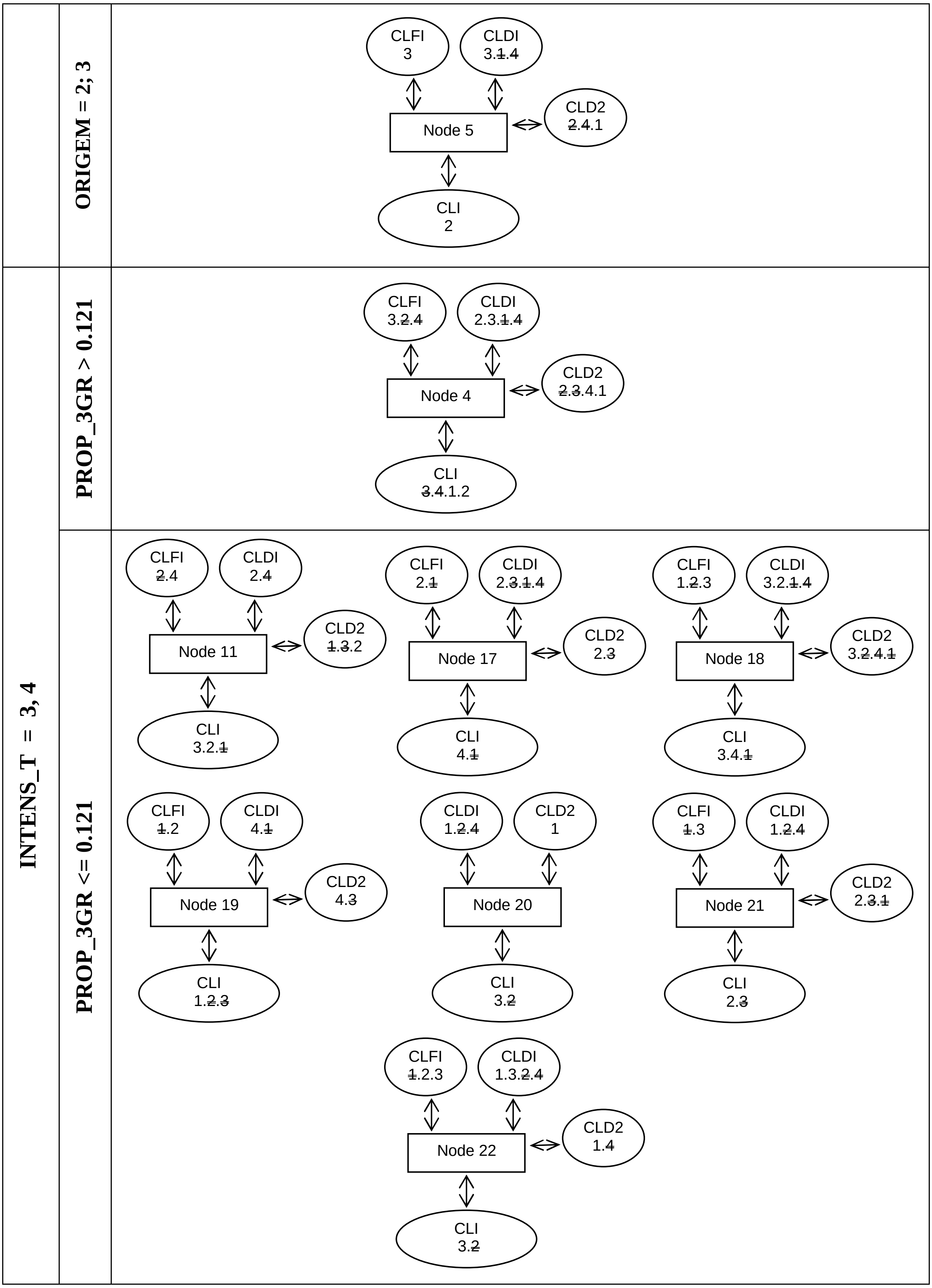
To examine the relationship of the flowchart shown in methodological section, we considered the standard residual of contingency tables used in the correspondence analysis. Thus, Chart I-1 below is divided according to sectors of low and medium-technology and high-and medium-high technological intensity and their second level: the capital origin and the proportion of staff with university level and examines the relationship between inputs and outputs that focus on triennium 2003-2005.

When comparing the subsets of firms presented in the chart below and technological strategies distinguished in chart 5, we found out that for the second triennium there is not a perfect fit for all nodes between what is happening and the previsions for 2003-2005. From 13 terminal nodes examined here, only 5 of them fit perfectly in the typology of chart 5, while the other showed variations around what has been proposed, particularly in terms of impacts of innovative activities and expenditures of innovative activity.

An example is offered by companies in technology intensive sectors, with greater chance to innovate in product and process, which had less than 12% of employees with university level of education, represented by node 19. They have obtained broader results although using a narrower knowledge base, and could indicate some effect of the accumulation of past knowledge for determining the current technological behavior. When compared to 2003-2005, they were responsible for the lowest expenses in innovative activities by focusing on the acquisition of machinery nevertheless they have not only favored results in the production process, but also relations in the market. Also, apparently there is coordination in the technological strategies of firms most likely to be innovative in product and process as in sectors of low-technology strategies and their performances are similar as those in technology intensive strategies, but their results clearly depend on the past and knowledge of the specific firms.

Chart I-1 – Input-company-impact relationship – 2005



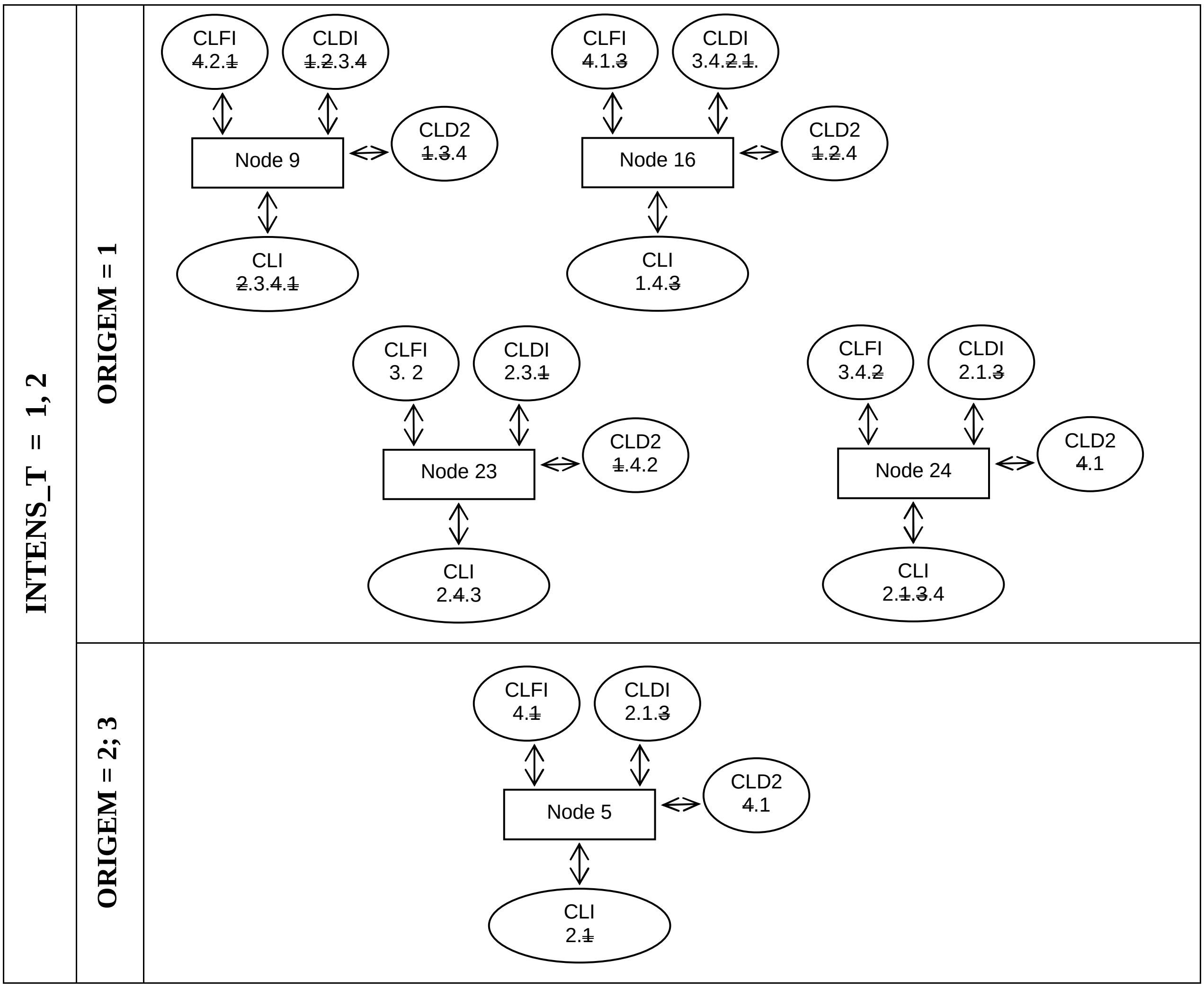


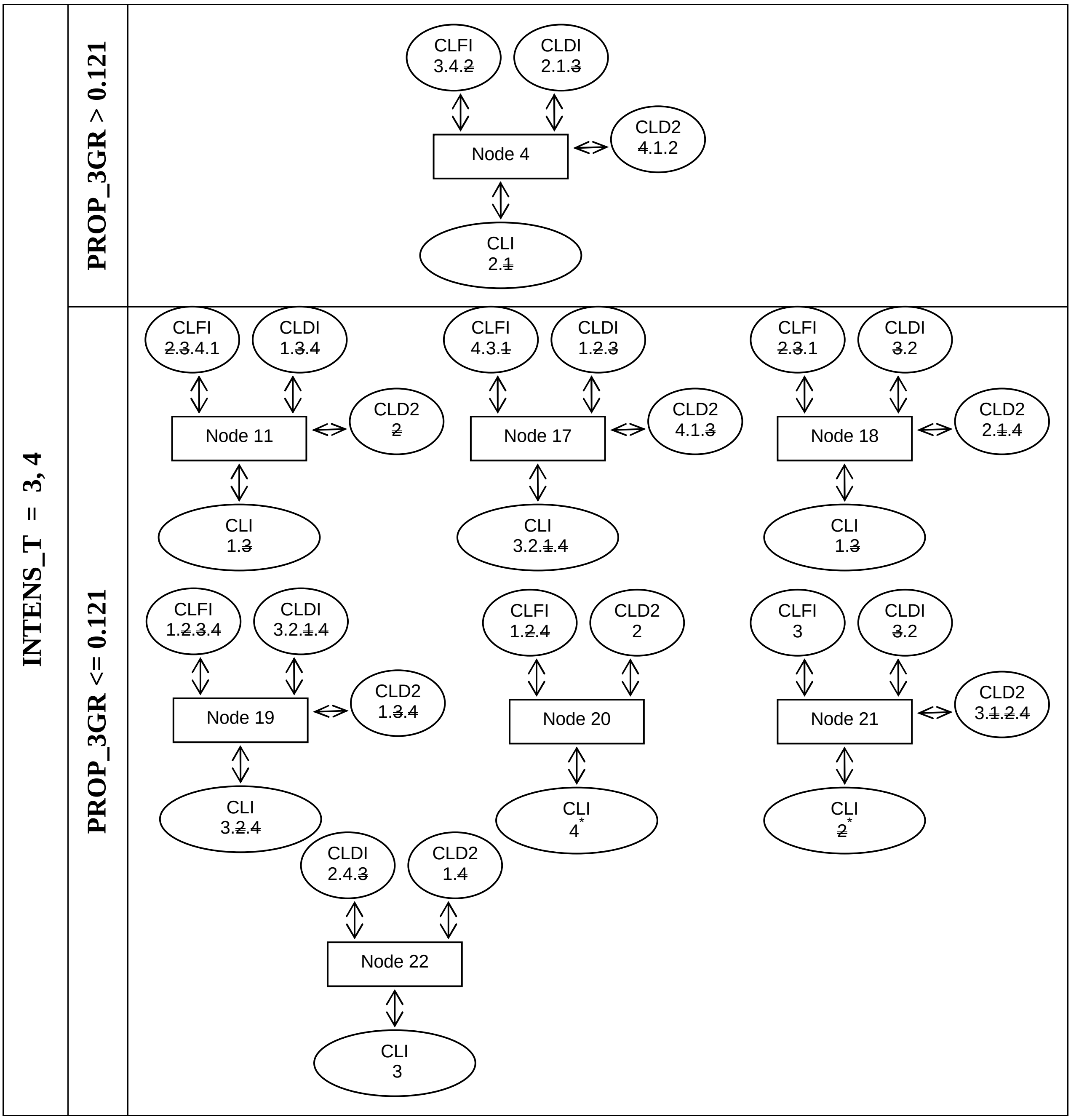
~~C XX~~ characterizes a negative association with, at least, a 5% of significance level.

For the triennium 2001-2003 that should serve as reference for the results in 2003-2005, chart I-2 below follows the same structure of the former. We found out that technological strategies by the firms that innovated in product and process are similar, especially in terms of expenditures and the importance of innovative activity, but some variation in impacts can be observed. This is the case of technology-intensive firms with more than 12% of employees with 3rd degree. They have a larger stock of knowledge, but get results focused on relations of the market and in some modification of the production process. However, when analyzing the proportion of firms with a 3rd degree lower, their technological efforts are alike especially for the expenditures in innovative activities. Thus, they seek to reduce the difference in the effort with a broader base of knowledge, but that does not mean they are efficient to obtain better results in 2001-2003. These companies focus on increasing the quality of products, to maintain market share and to promote some changes in the production line to increase the flexibility and capacity.

For the innovative process, however, the main differences between strategies are not focused on expenditures of innovative activities, and these differences were clearer when comparing the technology sectors. For example, firms in sectors of low-intensity have a narrower knowledge base focusing on the acquisition of machinery and the staff training. However, their results are more characteristic of large firms that innovated in product and process with the restructuring in the production, cost reduction and market relations, both for maintenance and for a wider participation. In contrast, companies in sectors highly intensive in technology spend more and have integrated the acquisition of machinery and internal activities of R&D, but not reduce production costs. They only grow in productivity with the restructuring of the production line, mainly aimed at maintaining market share and improved product quality. So, for the triennium 2001-2003, the results indicate that it is possible to find matches for some types of firms, regardless of branch of the tree analyzed.

Chart I-2 – Input-company-impact relationship – 2003





~~C XX~~ characterizes a negative association with, at least, a 5% of significance level.
* it represents a significance level of, at least, 10%.

Appendix II – Standard residual from contingency tables

	CLF				CLDI				CLD2				CLI			
	2003															
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
4	-1.6	-11.4	8.9	16.9	8.2	10.2	-11.9	-0.9	2.7	3.8	0.3	-8.0	-4.8	11.2	-1.7	1.8
11	5.7	-7.3	-2.8	5.5	9.9	0.5	-8.9	-2.6	1.3	-2.0	-0.2	1.0	4.9	1.0	-5.5	0.2
17	-3.1	-1.3	2.5	6.1	4.8	-3.8	-3.7	-0.2	-6.9	0.7	-3.1	9.9	-2.3	5.3	4.8	-5.5
18	6.5	-6.2	-2.1	1.4	1.8	7.3	-5.9	1.7	-4.7	7.5	1.6	-4.4	6.9	1.9	-7.2	-0.5
19	8.0	-3.6	-4.3	-4.5	-6.4	12.6	4.3	-2.4	6.8	-4.1	-0.7	-2.8	1.3	-4.0	3.7	-3.8
20	3.4	-2.1	-0.4	-2.1	-0.4	0.6	-0.4	0.8	-1.0	2.6	-0.8	-1.2	0.5	-1.3	-1.6	1.9
21	-1.2	-1.2	3.7	1.3	1.7	12.6	-5.4	-1.4	-3.1	-3.0	12.5	-2.1	1.6	-1.8	-1.1	0.4
22	-0.5	-0.2	1.3	0.2	0.1	3.4	-3.2	2.4	2.7	0.2	-1.6	-2.4	-1.9	3.0	-0.8	1.5
5	-2.6	-1.0	1.3	5.5	6.0	4.2	-6.8	-1.7	3.6	-0.6	0.1	-3.8	-3.0	11.7	-0.8	-1.4

9	-11.1	18.2	-0.5	-13.1	-7.6	-5.5	13.1	-3.6	-2.7	0.4	-3.4	5.4	-33.4	-14.7	60.8	-24.4
24	1.4	-6.1	2.6	6.6	5.7	2.3	-5.8	-1.5	4.1	0.1	-1.4	-4.1	-2.9	6.5	-2.5	2.8
23	1.2	2.3	3.7	1.3	-4.1	3.9	5.2	0.9	-3.2	2.7	-1.1	4.8	1.1	5.1	6.2	-4.3
16	3.3	1.1	-3.3	-5.5	-6.9	-9.8	7.0	5.2	-2.2	-5.7	1.1	8.6	26.0	-0.7	-43.4	20.4
2005																
4	1.7	-14.2	21.8	-3.0	-22.3	8.3	43.2	-16.1	2.8	-3.8	-3.8	4.7	-9.8	-2.7	7.8	8.1
11	0.4	-2.0	1.6	2.7	0.1	6.4	0.5	-3.6	-2.2	9.3	-4.9	-0.5	-6.4	2.4	4.8	-1.5
17	-5.0	6.4	-1.4	-1.8	-2.1	15.8	-3.0	-2.6	-1.3	5.3	-2.2	-0.9	-4.3	1.7	-1.7	8.6
18	3.6	-6.8	5.6	-1.1	-13.8	6.5	24.0	-8.2	-4.0	-3.9	10.3	-3.6	-11.6	0.3	5.7	10.5
19	-5.3	5.8	-0.1	-1.7	-2.6	-1.3	-1.8	5.2	-1.0	0.7	-2.4	3.1	10.6	-4.9	-6.8	1.9
20	-1.0	0.0	1.3	0.8	-5.9	-2.5	-0.5	8.3	2.6	-0.8	-1.2	-1.0	-0.3	-2.4	2.3	0.3
21	-2.9	-0.7	6.6	-1.3	5.8	-2.3	-1.4	-4.3	-2.4	8.3	-2.6	-2.0	-0.8	3.6	-2.5	0.1
22	-4.4	3.5	2.4	-1.8	2.2	-2.3	5.3	-6.1	2.7	-0.1	-0.3	-2.6	-1.9	-2.3	4.2	-0.6
5	-1.9	-0.3	4.4	-1.7	-2.7	1.3	9.7	-6.0	5.5	-4.1	2.0	-4.5	-1.2	2.0	-0.9	0.4
9	-18.5	30.5	-17.6	-4.0	28.1	-6.3	-14.0	-16.7	-3.1	-2.0	-4.4	10.2	70.6	-25.2	-40.5	-10.0
24	7.0	-11.3	7.7	-2.1	-5.4	1.5	15.7	-8.2	3.0	-2.6	4.3	-5.7	-8.0	4.3	2.7	2.3
23	0.1	-8.1	6.4	1.6	-4.2	6.0	0.4	1.3	3.9	6.1	0.6	-8.5	0.4	9.7	-8.3	1.5
16	13.6	-11.5	-6.5	6.5	-0.4	-7.7	-31.5	31.5	-2.7	4.8	-2.3	1.1	-39.9	19.2	23.2	-3.8