IMPACTS OF TECHNOLOGICAL INNOVATION ON EMPLOYMENT:

The Brazilian Manufacturing Case

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Abstract

The aim of this study is to investigate the impacts of technological innovation on employment growth. These impacts are separated according to the type of innovation – process or product innovation - due to possible different correlations between these types of innovation and employment growth. Also, it is verified if the presence of technological innovation has a bias due to qualification. The empirical investigation uses Brazilian surveys database with firm's micro data. The results suggest that process innovation has no significant effect on employment. Product innovation, on the contrary, tends to increase significantly the employment rate. The positive compensation effects due to the employment growth through product innovation are bigger than the negative effect due to productivity gains. And technological innovation bias was not significant after verifying that *skilled labor intensive firms* have the same behavior than the others. This last result pointed out to the absence a technological innovation bias.

Keywords: Technological Innovation, Employment, Cost-Minimization Problem.

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1. Introduction

The Brazilian labor market went through significant changes after the 90'[s], mainly when a new monetary reform, called *Plano Real*, was established. Due to the over valuing of the currency, this reform was like an openness shock: importations and exportations grew up too fast after 1994[3]. As the progress of trade liberalization, the Brazilian trade system had to adapt itself to larger competition than that of a more closed market. Consequently, the comparative advantages of each country were emphasized and firms started to search for more efficient productive processes. In one hand, the market became more exigent with the facility to import and to have access to new products; in the other hand, firms had access to inputs with better technology, which made them more efficient. This competitive process expelled those firms that did not adapt themselves to the globalized world. But those that survived caused expressive impacts on the labor market as consequence of changes in their demands for production factors. Some kinds of activities became less important than others and the employee qualification became the most important requirement for the improvement of the worker productivity and the firm efficiency after innovation[4].

Since the opening shock, technological innovation began to be too stimulated for two reasons: first, it was easier to import inputs with new technology; second, the need to diminish production costs in order to raise the market competitiveness. The import of capital goods brought changes to the firm's labor demand function in relation to the kind of activity performed by the workers, as well as the employees' qualification[5]. Some activities became less demanded, or even unnecessary, due to the possibility of production being carried out by machines, with more efficiency and at lower cost.

In the US labor market, the opening shock and the consequent technological innovation progress happened in the 80'[s.] After the shock, Autor, Katz and Kearney (2006) identified a "labor market polarization" in the sense that there was an increase in the wage inequality and in the demand for qualification. The workers that executed repetitive production tasks suffered a devaluation of their wages, in opposition to those who carried out abstract activities, who began to be more demanded and whose wages were valued. Fernandes and Menezes-Filho (2002), while studying the relative labor demand for three different levels of workers qualification (skilled, unskilled and semi-skilled laborer) in the Brazilian market, found similar results, which suggest a tendency to raise the relative demand for skilled laborer in detriment of intermediate skilled laborer and an increase of the relative demand for semi-skilled laborer in detriment of unskilled laborer[6].

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[3] Figure 1 illustrated at Appendix A shows importation and exportation series given by Brazilian Central Bank. It is shown at: http://www.ipeadata.gov.br

[4] The trade liberalization impacts on the labor qualification is well approached by Beyer, Rojas and Vergara (1999); Hanson, Gordon and Harrison (1995).

[5] The difficulty to separate the openness and the innovation impacts on the market, as well as the impacts on the labor demand is shown by Maia and Arbache (2001).

[6] The model is controlled for labor supply and trade liberalization was the justification for the firms' labor demand movements. However, the authors empathized that the technological innovation process are influenced by trade liberalization in developing countries, so it is difficult to separate each effect of each shock, because they are not mutually excluded.

In Brazil, the industrial sector has had the same behavior as the developed nations in facing the opening process. However, due to the low skill of Brazilian workers, the impacts on the labor market might be tougher. On one hand, the productivity gains are considerable; on the other hand, innovation improves the efficiency of the inputs, thus, diminishing the number of workers per product; and, for the labor market to absorb all the labor force, the economy has to grow at higher rates[7]. Bahia (2006) empirically studied the Brazilian industrial sector and found that an augment of 2% in the firms' sales nowadays creates 35.8% less jobs than this same 2% of increase 10 years ago.

The implementation of a new production process in the firm, with cutting edge technologies, determines that the employer selects more qualified laborers to use the inputs in an efficient way. Consequently, skilled-labor intensive firms can produce at lower costs and create new products more easily than the non-innovator firms and unskilled labor intensive firms. The literature shows that the technological patterns have changed and started to present a qualification bias. And the increase of the demand for qualification has been the most relevant factor for the variability in the proportion of skilled and unskilled labor force participation. There is a large literature pointing out that high technology and skilled labor are complementary. Griliches (1969) declared that high technology and qualification are intrinsically complementary, after observing the intensity of process innovation in the US. Autor, Katz and Krueger showed that 34.6% of US workers with high school degree use computers, while 70.2% of workers with college graduation use computers.

In countries where the market is free from regulations, shocks in the labor market can be fitted with adjustments in wages. And in economies with rigid wages, adjustments directly affect the employment level. Bellman and Shank (2000) investigated the impacts of process and product innovation on the German labor market and described qualification into six different levels. They found that there is a negative correlation between employment growth and just one of those levels, and concluded that the negative effect on this category could be minimized if the wages were more flexible. In the US labor market, the introduction of new technologies enlarged the skill premium in the 20th century (Acemoglu, 2002). The author concluded that the mainly responsible factor for raising the wage inequality was the acceleration of technological innovation process. Innovation became a profitable activity, in the last 60 years, with the increase of skilled labor supply. As a consequence, skilled workers were more demanded and overvalued.

The valuing of schooling can be seen, in Brazil, through the increase in the wage gap and in the employment level for workers with schooling above average. In studying Brazilian wage inequality, Menezes-Filho and Andrade (2005) noticed that the wage gap between skilled and semi-skilled employees increased in the 90$^{'s}$ decade and presume that there is low probability of a decrease in the gap due to the intensification of the trade liberalization and technological innovation processes. As laborers' schooling advances, firms tend to innovate, and to raise the demand for skilled workforce. If the skilled labor supply is below the demand, the wage gap will also increase.

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[7] The thrift effect of labor due to innovation is well investigated by Berman, Bound and Griliches (1994).

The workers have increased their schooling to fit themselves to the new context[8]. The average schooling of Brazilians' workers in manufacturing went from 7.3 to 8.4, between 1998 and 2004. De Negri *et al* (2006), in the study about the influence of labor force profile in the firms' absorption power, concluded that there is a strong simultaneity of innovation and qualification. The skilled-labor intensive firms use to innovate more and have stronger absorption power than the unskilled-labor intensive firms. The first ones recognize the knowledge value and apply it to improve their competitiveness with more ability than the second ones.

The tendency of fall in the employment level after openness and innovation should be transitory. The negative impact on the labor market, due to the decrease in labor demand, is justified by all those commented facts. However, it is expected that the scenario changes, since that the Brazilian firms have gone into international market, which must increase sales, production and labor demand. Thus, in the long run, firms lean to hire more workers in order to enlarge the consumer market. In countries where the modernization happened a long time ago, it is verified that the innovation was not always negatively correlated with employment growth[9].

The Oslo Manual (2006) identifies a technological innovation as a significant change in the novelty level supplied by the firm, as much as concerning inputs as concerning outputs. This novelty can be done by modernizations in the productive process or by the creation or transformation of a new product. As the Manual defines:

> *"A technological product innovation is the implementation/commercialization of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer. A technological process innovation is the implementation/adoption of new or significantly improved production or delivery methods. It may involve changes in the equipment, human resources, working methods or a combination of these."* (Oslo Manual, p. 9)

However, the manual recognizes that the empirical treatment for product innovation and process innovation is subjective and reduced. In spite of difficulty to discriminate process and product innovation, one of the contributions of this study is treating the two kinds of innovation separately, as much as their effects. The product innovation is seldom done without the cooperation of process innovation, whereas the process innovation is more probable to be implemented alone, once it aims to diminish the costs. Its impacts are demonstrated more directly than those of product innovation, through the change in the firm production function and in the production factors demand. It is expected an immediate decrease in the production due to many reasons, one of them being the lower number of workers for the production of a good. But, if the process innovation brings an expressive change in the original product, it must be recognized like a product innovation too. In its turn, the product innovation may present its impact on the market more slowly than the process innovation, because it depends of the consumers´ feed back - and this

[8] About American labor market, Acemoglu (1997) concluded that one of the effects of rise in schooling was the incentive to innovate that, in the short run, decreased the skill premium, but in the long run, increased it.
[9] For positive correlation among technology and employment, see: Benavente and Lauterbach (2006), Garcia, Jaumandreu and Rodrigues (2002)

will be realized through the consumer´s satisfaction with the new product which will raise the demand for it. As soon as the firms reach a larger group of consumers, supplying new products, it is necessary to expand the production, and in the middle and long runs, the labor demand can rise.

Van Reenen (1997) suggests that the innovation effect on the occupations is arbitrary. Despite of the requirement for less workers per product, the firm may hire more if the production costs are reduced and the amount produced enlarges. Thus, the author identifies two consequences of the innovation: the increase in the marginal productivity and the decrease in the production costs. After analyzing the compensatory effect of these two forces, the author concluded that there is high positive correlation between innovation and labor demand. Anyway, the product innovation is more likely to increase labor demand than process innovation. An important note is that the author uses panel data to make the empirical investigation, using an England data base that covers the years from 1976 to 1982. This methodology is able to identify manifestations in the long run that a cross section analysis cannot.

The approach applied in this paper, presented by Jaumandreu (2003), is also used by Petters (2005) in a research for Germany market. The author tests whether the compensatory effect of innovation is bigger than the displacement effect, and she makes a contribution to the model by discerning each kind of innovation (process and product) concerning the level of novelty. The product innovation is classified like "new product for the market and for the firm" and "new product for the firm but not for the market"- the firms of the last kind are called "follower firms". And process innovation is classified like "process innovation aimed at rationality of production factors" and "process innovation aimed at improvements in the product quality". The results show that product innovation is positively correlated with employment, as much as in the firm that supplied a new product for the market, as in the follower firms. The labor supply elasticity in relation to product sales growth rate, in both firms, is unitary and does not present significant differences, which is denying the hypothesis that the innovation impact on employment depends on the novelty level. Otherwise, the impact of process innovation varied from positive to negative and in manufacturing it was always negative and larger than the compensatory effect. This result suggests that, in spite of diminishing of the production costs, the effect caused by the inputs´ rationality is prevalent, reducing the labor demand. Nonetheless, firms that introduced process innovation intending to improve the products´ quality, do not presented reduction on employment level.

The model proposed by Jaumandreu (2003) is able to identify separately the correlations of each type of innovation with employment growth rate. In Brazilian literature we did not find any study that distinguished the process innovation effects and product innovation effects. The results that we have found do not discriminate the kind of technology used by the firms but they discriminate the kind of labor qualification. This paper intends to fulfill this blank, motivated by the hypothesis that these innovations must manifest themselves in different ways on employment: the inputs modernization, by the adoption of a new technology, may destroy repetitive tasks jobs; but the creation of a new good tends to stimulate demand and increase the production and labor demand. Thus, this study plans to answer two questions:

- What is the impact of process innovation and product innovation on employment?
- Do "*skilled labor intensive firms*" and "*unskilled labor intensive firms*" have different reactions due to innovation?

The next section presents the econometric model and a data base description as well as its manipulation. The second chapter contains the results and its comments. The last one is the conclusion.

1. Methodology

a. Econometric Model

The model selected follows up the approach created by Jaumandreu (2003). It supposes that a firm can produce two kinds of products called "new product" and "old product". The new product consists in the creation or a significant improvement of a good and the old one consists of all the products that were not significantly modified[10]. The production growth rate of each product and the employment growth rate were estimated in two periods of time (2001 and 2003). Then, the employment growth rate can be regressed on the production rates. The objective is to verify whether the process innovation brings changes to the employment rate by improving the efficiency, and whether the product innovation increases the employment rate by encouraging demand. The idea is that the decision to innovate does not depend on the employment growth rate that can be explained, partially, by the technological innovation. Thus, there are two periods of time and, in the first period, the firms can produce just old products. We define Y_{it} as the produced amount, Y, of product i at the period t. So, by definition, $Y_{21} = 0$, and if the firm does not create a new product, Y_{22} will be also null.

The econometric model that represents the theoretical relation is given by:

$$l = -(\alpha) + y_1 + \beta . y_2 \tag{1}$$

where l is the employment growth rate, $\left(\frac{L_{i2} - L_{i1}}{L_{i1}}\right)$, the intercept is the increase in efficiency over the period, $\left(\frac{\theta_{12} - \theta_{11}}{\theta_{11}}\right)$, y_1 measures the output growth of old products, $\left(\frac{Y_{12} - Y_{11}}{Y_{11}}\right)$, and y_2 is the share of new product on the total production.

Once real production is very difficult to be observed, the production rate variables are substituted by sales growth rate. The sales rates are not observed directly, but they are built from observations of firms' sales revenue, declared by the firms at the end of the two periods. After correcting by the inflation rate, these proxies make it possible to

[10] For theoretical model details, see Jaumandre (2003).

observe the firms' real sales variation between periods and the sales increase due to product innovation. Because we do not observe the real production, the proxies of sales must be constructed through minimization of price effect, once the objective is to verify the impact of a production increase on employment. But these products might be sold at different prices and after using the proxies with nominal values in the place of production variables, we can observe endogeneity caused by the influence of this change on the error term. To minimize the price effect on the sales growth rate due to the old product, this proxy was fitted with a price index[11]. After proxies substitution we have:

$$l = \alpha + \beta_1 g_1 + \beta_2 g_2 + u \tag{2}$$

where g_1 is the sales growth rate due to the old product between 2001 and 2003 and g_2 is the sales growth rate due to the production of new product.

Equation (2) identifies the employment elasticity faced with a 1% variation on the sales of each product. The coefficient α measures the average increase on the productive efficiency of the old product that displaces the employment growth rate; the parameter β_1 shows the impacts of a percentage variation of the old product sales on employment; and β_2 shows the direct relation between product innovation and employment growth. The variable g_2, that indicates the growth of sales due to new product, is able to directly indicate the product innovation. However, if the new product is complementary or a substitute for the old product, we might find some correlation between this proxy and the variable g_1, because the production of a new good might influence the production of the old ones.

Another problem arises from the substitution of real production variables by nominal sales. As firms endowed with some market power price their products by setting a mark up on marginal cost, it becomes difficult to identify the price effect on variables g_1 and g_2. Even with the correction by the index price, an identification problem remains when firms deviate from the average price behavior[12]. To solve the problem Jaumandreu (2003) suggests to deflate g_1 and subtract it from l, supposing an unitary coefficient, using it as a dependent variable. Thus, the model captures a set of effects on employment, not only the one that comes from variations in the productive factors, but also the price adjustment and production effects, which results in a net effect on employment.

Thus, equation (2) can be written as:

$$l - (g_1 - \pi_1) = \alpha + \beta . g_2 + u \tag{3}$$

Equation (3) becomes an expression for the employment growth per product and identifies the average effect of the productivity on employment growth, if the firms are pricing their products according to the sector average price behavior. However, the identification problem remains when firms endowed with market power price their products above the average, passing the productivity gains to price – in other words, they do not diminish the prices in the same proportion of the decrease on costs.

[11] The prices were fitted using the manufacturing price index (IPA), disaggregated by firm level.

[12] The price effect on the variables are detailed at Appendix B.

Extending equation (3) to include process innovation, we have:

$$l-(g_1-\pi_1)=(\alpha_0+\alpha' d_1)+\beta_2 g_2+u \tag{4}$$

where d_1 is one for firms that introduced any kind of process innovation. We guess it was not necessary to introduce dummy for product innovation, because in the cases of firms that do not produce a new good, the proxy g_2 is null. Otherwise, it is impossible to measure quantitatively the process innovation, the firms answer whether they have introduced significant changes on the production process. This innovation can be done, indeed, through changes in the production structure, and, consequently, in the inputs efficiency. For this reason, the process innovation dummy was included in the intercept. After identifying the presence of process innovation, it is possible to know the effect of productivity changes on employment, as consequence of the innovation. It is expected that firms that have innovated to increase the labor productivity have a negative displacement effect due to innovation. That is, with the increase of labor productivity, the firms tend to hire less employees. We should note that the model can not identify random variations in the old products, due to demand shocks, price variations, whatever. It would be necessary information about the demand side. It implies that the final effect on the labor demand, given process innovation, can be polluted by reasons of the demand side that the model cannot capture.

To give flexibility to the hypothesis of the original model, that imposes homogeneity to the labor, we included a binary variable to evaluate the impact of labor qualification. As the database is made of firms' observations, we had to classify the firm concerning the proportion of qualified workers in the total of employees of each firm. The worker was classified as skilled when he is a high school graduated. The firm that had the proportion of skilled workers per total of employees above the average of its sector was called *skilled labor intensive firm*. This way, we have identified two types of firms: *skilled labor intensive firms* and *unskilled labor intensive firms*. The model with qualification dummy assumed the form:

$$l-(g_1-\pi_1)=\alpha_o+\alpha_1 d_1+\alpha_2 d_q+\beta_1 g_2+u \tag{5}$$

where d_q is the dummy for qualification, and assumes the value one when the firm is classified as a *skilled labor intensive firm*.

b. Data Base

The data used in this paper resulted from the merge among three data base, called: RAIS – Annual Social Information Census; PIA – Annual Industrial Survey and PINTEC – Technological Innovation Survey. All these databases were worked at the firm level: each firm was identified by its respective CNPJ – National Classification of Economic Activity, and all of them come from the Brazilian manufacturing sector. RAIS is a census that covers all the Brazilian formal labor market. PIA and PINTEC are surveys, whose object of investigation is the manufacturing firm. PIA covers all firms with more than five workers and, for firms with more than thirty employees, it is a census. PINTEC investigates firms with more than ten workers, aiming to find any kind of innovation activity. So, it has a bias for the big firms, which brings to the sample all the firms with more than five hundreds employees. Due to the different methodology of sample collection, two initial cares were taken before the merge: first, firms with less than thirty employees were deleted from the sample, because they probably are new firms in growth stage, that use to continuously add changes to their production process, which would not be seen like a process innovation; second, to diminish the bias caused by the big firms, we have used the sample weight from PINTEC.

The data base RAIS was necessary in order to get information about the worker qualification. With this information, it was possible to create the qualification dummy, using the number of employees with high school graduation or more hired in the firm. PIA gives information about the sales net income, between the years 2001 and 2003. At last, PINTEC 2003 informed weather firms had any kind of innovation activity and the type of this innovation. The merge of these data produced a sample consisting of 8.496 firms.

The next section presents the results from the descriptive statistics, the econometric model and the respective analyses.

2. Empirical Results

The following analyses present a general behavior of the firms in the sample. The Appendix C shows the variables definition, as well as the proxies created from them.

Table 1 shows the data base composition, with the classification of the firms concerning the kind of innovation, and the value of the main variables used in the econometric model.

Table 1 – Descriptive statistics of manufacturing firms.

SAMPLE COMPOSITION GIVEN THE TYPE OF INNOVATION	DISTRIBUTION (%)

PROCESS	33,11		
PRODUCT	22,11		
PROCESS AND PRODUCT	42,06		
NON-INNOVATORS	57,94		
AVERAGE OF FIRMS' EMPLOYMENT GIVEN THE TYPE OF INNOVATION	**2001**	**2003**	**AVERAGE OF GROWTH RATE[13] (%)**
PROCESS	394,81	362,77	9,23
PRODUCT	503,60	458,42	7,84
PROCESS AND PRODUCT	443,07	408,72	8,56
NON-INNOVATORS	128,73	138,61	0,32
AVERAGE OF FIRMS' REAL SALES GIVEN THE TYPE OF INNOVATION[14]	**2001**	**2003**	**AVERAGE OF GROWTH RATE (%)**
PROCESS	57.306.729,82	73.895.728,6	37,32
PRODUCT	85.353.895,98	109.174.693,	27,61
PROCESS AND PRODUCT	76.048.174,73	101.757.304,	34,21
NON-INNOVATORS	19.453.008,68	16.562.908,1	44,76
SALES GROWTH (%)	**OLD PRODUCT (G1)**	**NEW PRODUCT (G2)**	
PROCESS	0,2781	0,0951	
PRODUCT	0,0798	0,1963	
PROCESS AND PRODUCT	0,2294	0,1127	
NON-INNOVATORS	0,4476	0	

Analyzing Table 1, we observed a pattern in the employment average behavior and in the real sales income, from 2001 and 2003, in all the firms that have introduced any kind of innovation, no matter of process, product or both. Among these three groups, the average employment decreased, from one period to another, and the sales increased. The opposite has happened with the non-innovators firms: the sales average has fallen and the employment average has risen. This result suggests that the productivity of the innovators firms is bigger than that of the non-innovators. The last ones need to hire a larger number of employees to enlarge production, and the production scale must be decreasing. Besides, they can restrict their consumer market if the production costs are passed on to the prices. Then, it is plausible to suppose that the falling in the sales is a consequence of the lost of competitiveness of the firms that did not innovate.

The real sales growth is positive in all cases. It seems contradictory the fact that this rate is higher for the firm that did not innovate; probably, it is a consequence of a large variance in the observations, due to the fact that the upper tail is pulling up the average. That is, among non-innovators firms, some of them have the sales growth high enough to increase the average.

Applying very closely the model proposed by Jaumandreu (2003), we have found the preliminaries econometrics results. The first model was estimated just to find correlations between the sales and innovation variables and employment growth. The regression includes dummies for process and product innovations. The process innovation might

[13] The average of growth rates was calculated from the sum of each firms´ rate out of the number of observations.
[14] Nominal Values.

increase the factors´ productivity, which enables the innovator firm to make the most of each worker. With this dummy we answer the following question: "Do the innovators firms have a different (average) behavior of the employment growth when they are compared with the non-innovators firms?"

The dummy for product innovation follow the same idea: it is intended to verify whether the employment growth is different for firms that create a new product. In supplying a new product, to the market or to the own firm, the consumer public tends to enlarge. For firms that attend a larger number of consumers, the sales and the production have to raise, and consequently, the employment level too. Therefore, firms the carry out product innovation are likely to present employment growth rate higher than the others.

Thus, we have regressed the employment growth rate (in log) against real sales growth, process innovation and product innovation. Table 2 presents the results[15]. In order to preserve the constant interpretation, we have used the dummies for economic activity with the constraint that their coefficients add up to zero.

Table 2

Dependent Variable: Employment Growth	
Method:	OLS
Explanatory Variables:	
Constant	-0,3110*** (0,0127)
Real sales growth (g)	0,4942*** (0,0071)
Process innovation (d_1)	0,0639*** (0,0115)
Product innovation (d_2)	-0,0077 (0,0130)
R_square = 47,51%	*F_value* = 223,15

*, **, ***, significant at 10%, 5% e 1%, respectively. Standard errors robust after White estimator.

The constant of the model is significant, which suggests that changes in the productivity efficiency bring significant changes in the labor demand. The coefficient of real sales growth indicates that an increase in the real sales raises the labor demand significantly**.** The results show that when the sales increase 1%, the employment level must increase (on average) 0.49%. This result is too close to the result found by Harrison (2005), in which the same model, applied for France, Germany, Spain and United Kingdom, presented the same pattern of the coefficients: all of them are positive and less than one, indicating that 1% of increase in sales causes a return less than one for the employment growth[16].

[15] In all the regressions we controlled the firms for their respective economic activity, using the national classification called CNAE – National Classification of Economic Activity.

[16] The coefficients of sales growth for France, Germany, Spain and UK were 0.43, 0.43, 0.35 and 0.48, respectively.

The dummy variables for process and product innovation point out whether the behavior of the employment growth rate tends to be different in the presence of innovation activities. The firms that have introduced process innovation had the employment growth rate 6.6% higher than the firms that did not carry on this kind of innovation[17]. It is a surprising result because it was expected that the process innovation would save labor. However, this dummy, maybe, has been able to capture two different effects that are very difficult to isolate: the process innovation effect and the firm's growth effect – that is, firms that are growing up, and because of this, they are innovating. In the European countries, this variable presented a negative correlation with employment, with exception for Spain. And the product innovation dummy was not statically significant, but for Europe is was positive in all countries.

To better explore the innovation effects, Table 3 presents a more detailed regression. The objective is to verify the correlation between employment growth and the sales variables of the new and the old product. To investigate whether innovation affects the factors productivity, the dependent variable is now the difference between employment growth and the real sales of old products, controlled by price variations. Thus, we have as dependent variable the rate of employment growth per product (measured through real sales). However, in this model the proxy for product innovation is not a dummy variable but the rise in sales due to new product (that is, the share of new product´ sales on the total sales). The constant value becomes an estimate of the real factor productivity for the old product production.

Table 3

Dependent Variable: Employment Growth per product $[l-(g_1-\pi_1)]$			
Method:	OLS	IV[1]	IV[2]
Explanatory Variables:			
Constant	-0,5478*** (0,0160)	-0,5618*** (0,0203)	-0,5571*** (0,0172)
Sales growth due to new product(g_2)	0,6088*** (0,0499)	0,9507*** (0,2761)	0,8000*** (0,1373)

*, **, ***, significant at 10%, 5% e 1%, respectively. Standard errors robust after White estimator.
[1] The unique instrument used was Increased range.
[2] The instruments used were increased range, clients as a source of information and R&D engagement.

The first column presents an OLS estimation for employment growth concerning to sales due to product innovation. It is useful to note that a negative bias can influence the estimator negatively, due to unobserved differences in the prices between new and old product. As this parameter is measured through the sales income due to new product out of the initial sales income (which, hypothetically, consists just of the old product sales), it is not plausible to suppose that different products are sold at the same prices. This influence brings enodogeneity and simultaneity to the parameter[18].

[17] It is useful remembering that the functional form is semi-log but the dummy variables are in the linear form. So the coefficient has to be calculated in the following way: $(e^{\beta}-1)100$.

[18] The problema rises since that $\mathrm{cov}(g_2,u)$ X 0, causing inconsistence to the estimator.

To correct the endogeneity problem, we have applied a Two Stage Least Square regression substituting the proxy of sales by an instrument. The instrument used was the increase range of new product on the total sales amount. The firms answer, in a scale from 1 to 4, whether the new product collaborates to increase the sales and production one year after the creation of the new product. Thus, the instrument is strongly correlated with the share of the new product on total sales and weakly correlated with the inflation rate.

After solving this problem with the instrumental variable, it was noted a significant increase in the estimator. The instrument corrects the bias and shows that prices create a negative bias in the coefficient. The OLS model has indicated a positive correlation, but with low elasticity, between employment and the product sales. The two stages regression suggests that there is a negative influence of prices on the estimator, once the elasticity becomes almost one.

To test the validity of the used instrument, the same model was regressed again using a set of instruments. The third column presents the 2SLS results adding two instruments to the first stage, which are: R&D engagement and clients as a source of information (to improve the innovation activities). The results keep the same pattern, reinforcing the robustness of the estimates.

In comparing the Brazilian results with those found by Harrison (2005), we observe that they are very similar. The constant of the Brazilian regression is lower than those found for Europe, suggesting that the factors efficiency allocated in the production of old product is worse in the Brazilian case[19]. As to the coefficient of relative efficiency, the same happens: the correction for endogeneity makes the value closer to one in all the cases.

The next step was the inclusion of the process innovation dummy in the intercept to evaluate whether this innovation influences the factors efficiency. Thus, a negative coefficient would show that the factors productivity increases when firms change their traditional inputs by cutting edge technology.

Table 4

Dependent Variable: Employment Growth per product $[l-(g_1-\pi_1)]$		
Method:	IV[1]	IV[2]
Explanatory Variables:		
Constant	-0,5613*** (0,0222)	-0,5501*** (0,0177)

[19] The average factors efficiency allocated for old product production varies from 3.6% in France to 7.4% in Germany.

Process Innovation(d_1)	0,0012 (0,0242)	0,0151 (0,0153)
Sales growth due to new product(g_2)	0,9330** (0,4536)	1,0074*** (0,1615)

*, **, ***, significant at 10%, 5% e 1%, respectively. Standard errors robust after White estimator.
[1] The unique instrument used was Increased range.
[2] The instruments used were: increase range and increase range interacted with process innovation.

Surprisingly, the process innovation coefficient was positive and non significant, indicating that it is not possible to verify productivity gains after process innovation. This result can be a consequence of variations in the price of products. If firms endowed with some market power do not diminish the price proportionally to the decrease in the marginal cost, the process innovation effects on the productivity is not felt. For this reason, the coefficient may be less significant than it should be. However, comparing these results with those found for Europeans countries, we verify similar behavior. The coefficient was positive and non significant for Spain and Germany, but it was positive and marginally significant for France and UK, suggesting a small increase in productivity after process innovation, and consequently, a small impact on employment growth.

Theoretically, it is plausible to suppose that it is more common to find firms that introduce product innovation simultaneously with process innovation, than firms that introduce process innovation and then product innovation. Process innovation is a necessary activity if the firms are intending to improve competition. One of the explanations presented by Harrison (2005) is that new products might induce process innovation in order to reduce the production costs.

Under the hypothesis that product innovation comes with process innovation, we have tested its effects using as instrument the increase range interacted with process innovation. The second column shows that the coefficient varies from 0.93% to 1.01% and becomes more significant. The results found by Harrison (2005) are very close: for France, Germany, Spain and UK they are 0.9, 1.03, 1.03 and 0.89% respectively.

The next regression includes dummy for qualification to investigate whether technological innovation carries out some bias in favor of the skilled workers. The skill labor intensive firms have a propensity to present decrease on the employment level due to the increase in the skilled work productivity. Consequently, the employment growth rate tends to fall.

Table 5

Dependent Variable: Employment Growth per product $[l-(g_1-\pi_1)]$	
Method:	IV
Explanatory Variable:	
Constant	-0,5779*** (0,0191)

Process innovation dummy	0,0126 (0,0155)
Skilled labor intensive firms	0,0153 (0,0141)
Sales growth due to new product (g_2)	0,9963*** (0,1618)

*, **, ***, significant at 10%, 5% e 1%, respectively. Standard errors robust after White estimator.

Table 5 shows that the dummy variables were not significant. Surprisingly, the skilled labor intensive firms did not present different reaction to innovation compared to unskilled labor intensive firms. Nonetheless, other investigation with the same focus, but different functional form and skill classification, should be done. The act of classifying the firms, and not the employee, due to data limitations, can null a result that should be relevant.

In Brazilian literature, we have found papers with opposite results. For example, Menezes-Filho and Giovannetti (2006), testing the hypotheses of technological bias, did not reject the hypotheses. They have used two distinct proxies for qualification – occupation and schooling – and applied two regressions: in the first, they tried to explain the share of skilled and unskilled worker on the total employment, using explanatory variables to capital stock, technological innovation and the firms´ aggregated value. In the second one, they created a modeling to the share of skilled wage and unskilled wage on the total employees' wage, using the same explanatory variables. In this context, the results were robust suggesting that the firms that made innovation activities are likely to demand skilled labor. However, the authors did not discriminate between the kind of innovation.

Conclusions

This study has, empirically, investigated how employment growth rate reacts to different innovation kinds. A distinction was made between the effects, on employment growth, of innovation on process and on product, in the period from the year of 2001 to the year of 2003. Under the hypothesis that non-skilled labor and technological innovation are, to a certain extent, substitute inputs, it was intended to explain the behavior of sensitivity of labor demand in skilled intensive firms labor which carry on process innovation.
The theoretical model followed the one proposed by Jaumandreu (2003). And, to bring to this model information concerning qualification, a *dummy* for the firm's qualification was created.

Some safeguards concerning the limitations of this methodology must be made. First, it is important to emphasize that the coefficients do not reveal the kind of laborer the firm is going to hire after innovation. They only indicate how firms with more skilled or less skilled workers react in front of innovation. Second, the firms were classified by their qualification, while the ideal would be to directly use the workers' micro data. Another point concerns the short period of time the model deals with. Once it is a *cross section* approach, the results are only adequate to short run analysis.

The results show that the elasticity of employment growth rate concerning the sales' increase is significant and less than one. But, discriminating the sales by product type, it was noted that the elasticity of employment growth concerning the new product's sales is almost one. This result suggests two interpretations: one is that, possibly, the effect of the demand for new products is more intensely sensed and, two, the product innovation has positive effects on employment. In all estimated models, after correction for endogeneity due to price influence, the elasticity of employment growth concerning the new product has become one.

Surprisingly, the process innovation did not present negative and significant effects on employment, even after the inclusion of the *dummy* for qualification. The coefficients of the binary variables have indicated that neither process innovation nor skilled labor (employed) had lowered the employment growth rate.
The comparison between the results found and the estimates applied to European countries, it is possible to find certain patterns in some variables. In all of the cases, product innovation has presented an increase in its coefficient after the use of the instruments. This caused the compensation effect, due to the increase in the demand for new products, to overcome the negative effect of the productivity gains on employment.
Another interesting comparison is the difference in the magnitude of the coefficients between Brasil and the European countries. In Brasil, the effect of the variable were much more modest, that is, through the coefficient of process innovation it was noted that the productivity gains are bigger in Europe and the coefficient of product innovation suggests that the market answers in a slower, or more modest, way to the offer of a new good. These facts may be consequences of a less dynamic economy.

The *insights* provided by the empirical results suggest that the probable negative effect of process innovation was not significant and that the positive effect due to demand toward the firm's products presents unitary elasticity of employment. In a extrapolation of the of short run conclusions and making some speculations of medium and long run, we are led to believe that, even in punctual cases in which the process innovation must create negative effects on employment, the increase of the worker's productivity who are not substituted by technology plus the decrease in the production marginal cost, tend to increase even more the firm's sales – and this makes the firm to innovate also in product. This kind of innovation points to the growth both of the firm and the employment.

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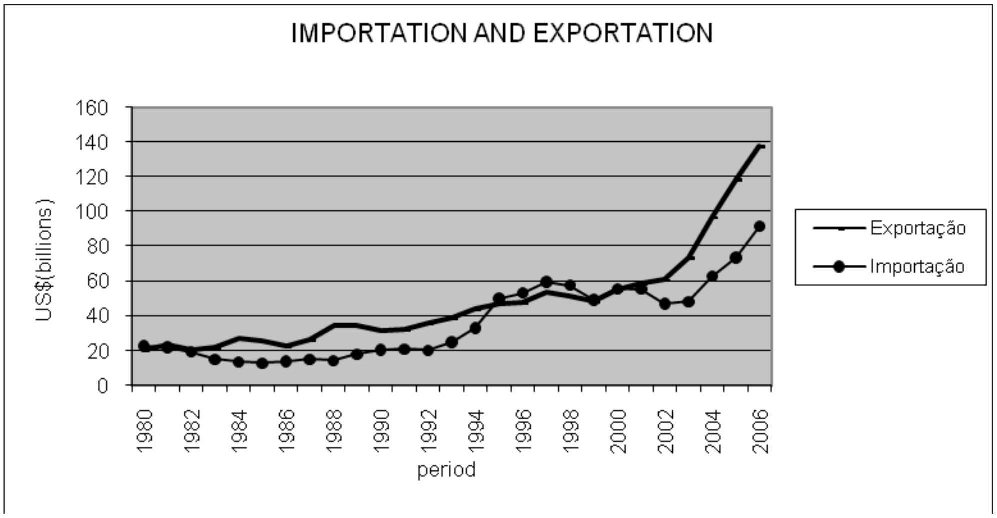
Appendix A

Graph 1



Brazilian Central Bank

Appendix B

An increase in the productive efficiency tends to lower the marginal cost in the same proportion. If the firms price their products according to a constant *mark-up* on the marginal cost, then the variations in price must be proportional to the variations in the productive efficiency, but with the opposite sign. However, firms with some market power will pass on to the prices, in different ways, the reduction in marginal, thus increasing their *mark-up*.

In a formal way:

Suppose that price variations follow the marginal cost variations according to

$$\pi_1 = \pi_0 + \gamma c_{mg}$$

where γ is the proportion of the marginal cost that is passed on to the product's price. So, variations in the marginal cost are related to efficiency gains, *ceteris paribus*, according to

$$c_{mg} = \alpha_1 . d$$

where d is the innovation and α_1 is the variation in the marginal cost that is proportional to the efficiency gains due to innovation. Prices follow the model

$$\pi_1 = \pi_0 + \gamma(\alpha_1 d)$$

However, this "pass on to prices" behavior is unknown. It's impossible to know the real variation in the marginal cost due to innovation, nor the mark-up adjusted to price. The model is able only to estimate the effect on productivity after prices' adjustments.

Appendix C

Selected Variables:

1. L_1 = employment level in the firm in the first period (2001)(PINTEC)
2. L_2 = employment level in the firm in the second period (2003)(PINTEC)
3. RLV_1 = Sales Net Revenue in 2001 (PIA)
4. RLV_2 = Sales Net Revenue in 2003 (PIA)
5. Y_2 = share of new products on the firm's sales (PINTEC)

6. d_1 = *dummy* for process innovation; value 1 for the process innovators firms (PINTEC)

7. d_q = *dummy* for firm's qualification; value 1 for the skilled labor intensive firms; that is, the number of qualified workers in these firms (with high school degree) is higher than the median of the number of qualified workers in its corresponding CNAE. (RAIS)

Proxies Construction:

1. Use (1) and (2) to create the employment growth rate:
2. Use (3), (4) and (5) to create the *proxies* for process innovation (g_1) and product innovation (g_2)

Process Innovation:

Theoretical Variable: $y_1 = \frac{Y_{12} - Y_{11}}{Y_{11}} \Rightarrow$ *Proxy*: $g_1 = \frac{P_{12}Y_{12} - P_{11}Y_{11}}{P_{11}Y_{11}}$

Construction: $g_1 = \frac{RLV_2\left(1 - Y_2\right) - RLV_1}{RLV_1}$

Product Innovation:

Theoretical Variable: $y_2 = \frac{Y_{22}}{Y_{11}} \Rightarrow$ *Proxy*: $g_2 = \left(\frac{P_{22}Y_{22}}{P_{12}Y_{12}}\right)\left(g_1 + 1\right)$

Construction: $g_2 = \left(\frac{Y_2}{1 - Y_2}\right)\left(g_1 + 1\right)$

Appendix D - Variables Definition

VARIABLES	DEFINITION
EMP_01	Employment in the firm in 2001 (PIA)
EMP_03	Employment in the firm in 2003 (PIA)
RLV_01	Firm's sales net revenue in 2001 (PIA)
RLV_03	Firm's sales net revenue in 2003 (PIA)
Y_2	New product's participation in the firm's sales (PINTEC)
g1	Firm's sales growth rate due to the old product, between 2001 and 2003
g2	Firm's sales growth rate due to the new product, between 2001 and 2003
tx_RLV	Firm's sales growth rate, between 2001 and 2003
tx_EMP	Firm's employment growth rate, between 2001 and 2003
tx_EMP_nq	Employment Growth of the firm's unskilled labor, between 2001 and 2003
tx_EMP_q	Employment Growth of the firm's skilled labor, between 2001 and 2003