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Innovation and Employment: The case of Brazil

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Abstract

In this thesis the effects of innovation on employment, at industry level, for the Brazilian economy are investigated. Merging data from Innovation Surveys, Industrial Surveys and the National Account System, a panel of 22 economic sectors was constructed. The main empirical results indicates that demand factors has positive and significant effect on employment while product innovation has a negative effect.

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1. Introduction

The effects of technological change on employment have been part of the theoretical discussion since the classical economists debated about the existence of compensation mechanism. However, in the last 30 or 40 years, with the arrival of new technologies of information and communication a broad discussion about the effect on this process on employment has emerged. Moreover, the loss of relative share of the industrial sector on total GDP is part of a broad discussion that considers not only the effects technological innovation but also structural change. In this sense, it could be affirmed that innovation and structural change are part of the same discussion. Technological innovation is the instrument that allows the emergence of new branches of production that absorb labor as the same time that new machines and methods of production are developed for those sectors that lose labor.

Several essays have been written in order to analyze the effect of innovation on employment at the firm level, both for developed and developing economies. The existence of innovation surveys in a large number of countries allows researchers to investigate the effects of different innovation strategies on employment. Although each country shows different characteristic, there exist a broad consensus about some positive effects of product innovation on employment while it is considered that process innovation has an adverse effect on employment.

The literature related to the effects of innovation on employment at industry level is not as abundant as in the case of the firm level. Few analysis have been performed to investigate the effect of innovation activities at industry level and most of the time for developed economies. In this type of analysis, researchers merge and match data from different sources. Basically, innovation variables are collected from innovation surveys, while other data related with each economic sector, such as value added, labor compensation, exports and so on is collected from national account systems or from the OECD STAN database. The basic objective of this approach is to investigate whether what happens at firm level is replicated at industry level, or the existence of structural mechanism mitigate or change firm effects. Although is not possible to establish a clear relationship between innovation and employment, there are some patterns that repeats in those empirical analysis related with developed economies. In a broad sense, process innovation has a negative effect on employment while product innovation has a positive one.

Following the approach mentioned in the previous paragraph, this thesis is focused on analyzing the effects of innovation on employment for the Brazilian economy. As far as I know, this is the first time that the effects of technological innovation are investigated for Brazil and a Latin American economy at industry level. A series of structural characteristics transform Brazil in an interesting case to be analyzed. First

of all, although Brazil is not a developed economy, it has a large and diversified industrial sector. Secondly, in the last 20 years an unfinished discussion about the performance of the industrial sector and its effects on the whole economy emerged. Third, the heterogeneous productive structure of Brazil, primarily characteristic of Latin American economies, combined with a diversified industrial sector could impose some challenges to the standard view and results obtained for developed economies.

The analysis is performed with data provided by the Brazilian Institute of Geography and Statistic. Following those researches that analyzed the effect on innovation at industry level, data from five Brazilian Innovation Surveys (PINTEC) is merged with data from the National Account System and the National Industrial Survey. A panel of 22 economic sectors is constructed which include both industrial and primary activities. The main drawback of the analysis is that services activities are not included in the panel because it is not possible to match the data from the innovation survey with the National Account data.

The objective of the analysis is to disentangle the effects of innovation variables on employment by sector and an analysis of structural change is considered. The challenge is to analyze the effect of diverse innovation variables, such as the share of firms that carry out product and process innovation, expenditures in R&D activities and machinery, after controlling for structural factors, such as value added and labor compensation. Several estimators are performed including a dynamic specification to solve endogeneity issues and obtain consistent estimators. Following previous empirical works, the basic hypothesis establishes that innovation has a positive effect on employment. Moreover, regarding the type of innovation performed, it could be expected that product innovation has a positive effect on employment while process innovation has a negative one. However, those hypotheses are based on the experience of developed economies. In this sense, the proposed effect could be affected by a series of factors that characterize the Brazilian economy and distinguish it from developed economies. The fact that in the Brazilian economy, most of the innovative activities are related with foreign companies that tend to operate with higher levels of productivity than domestic firms, and moreover, those innovative activities are more adaptive than disruptive, introduce a series of factors which are not present in developed economies.

The main empirical results obtained show some consistent regularity over the different models estimated. First of all, demand factors such as value added and sales have a positive effect on sectoral employment. Secondly, product innovation seems to have a negative effect on employment. Third, variables that in previous results have been considered proxies of product and process innovation, namely R&D and machinery expenditures are not significant. With regard to wages, it has a negative effect on total sector employment whilst in some specification that analyze the effect on employment share it has a positive effect. Regarding process

innovation, although it is not significant in all the models estimated, it seems to have a positive effect on employment.

The results show that it is not possible to establish theoretical relationships between innovations and employment if structural characteristics are not taken into account. The structural characteristics of Latin American economies in which innovative activities are mostly performed by multinational companies explain that some of the positive effect expected in the case of product innovation are not present. Moreover, process innovations could be more related with survival strategies than with productivity growth which in turn mitigate the expected negative effect of process innovation.

2. Theoretical Framework

2.1 The impact of product and process innovation on employment

The introduction of a new product or a new process of production could be considered as a novelty or innovation. In terms of economic theory, innovation both as a result and a process imposes several difficulties to understand the mechanism that governs the economic system. First of all, the mainstream economic theory is built on the notion of equilibrium. The disruptive effects that innovation has on the whole economic system transforms this term in an antonym of equilibrium. Secondly, innovation develops or run faster than economic theory which relegates the later to explain the past. In this sense, a crucial epistemological question that surrounds all the economic theories arises. A social science is the art to understand or explain the functioning of a system while it is suffering modifications. This aspect is not new and corresponds to all issues related with the economic theory, but the fact that innovation has been the driving force of the system in the last 200 years highlights that, although the economic theory experienced a huge development, the crucial piece is partially not understood.

Edquist et al (2001) establish a complex relationship between innovation, growth and employment. According to the authors, the interrelations between this concepts makes difficult to disentangle the effects of innovation on employment. The effects of growth on employment are not unequivocal, on the contrary those effects depends of the type of growth or the quality of growth, namely some regimes could increase labor while others could reduce it. Moreover, innovation is one of the variables that could explain the type of growth that is occurring. In this sense, innovation affects employment directly and indirectly through the regime of growth it defines. A four variable or dimension could be added to this analysis, namely the structural change

factor. Innovation not only affects the rate of growth of the economy but also defines the structural change the economy suffers during this process of growth. As an economy develops, labor tends to move to those more technological advanced sectors and part of that shift is explained both by innovation occurring an affecting all sectors. For example, innovations occurred both in the industrial and service sector, allow labor to move from the agricultural activities to the secondary and third sector. In this process, innovation not only has quantitative effects on growth and employment but also qualitative effects given that the structure is reshaped constantly.

It could be affirmed that the way in which the relationship between the previous mentioned variables is understood depends on the proposed theoretical paradigm. From a neoclassical point of view, innovation is considered a homogenous phenomenon and its disequilibrating nature is neglected. In this approach, technological change is often reduced to a new production process while the emergence of new products is rarely taken into account. On the other hand, evolutionary perspectives, recognize the existence of different types of innovations and the disequilibrating effect imposed to the system. According to Luchesse & Pianta (2012, pp 343), `` *Industry-specific patterns of technological change account for the systemic nature of innovation and for its impact on economic performances. The diversity of technological trajectories shapes the dynamics of industries and the overall process of structural change, innovation and employment´´*.

From an evolutionary perspective a key distinction between different types of innovation should be done, namely process innovation and product innovation. According to Pianta (2004), process innovation is explained by the desire to gain efficiency in production or reduce costs by saving labor, capital or a combination of both. Most of the time, process innovation is introduced through investment in capital goods embodying new technology. Usually, it is expected that process innovation results in higher productivity and loss of jobs. On the other hand, the introduction of new products or the modification, adaptation or improvement of the existing one, generally increase the variety and quality of goods and may open new markets which result in more production and employment. However, if new products only replace old ones or are designed only to reduce cost, the final impact could be similar to that of process innovation. Nonetheless, two crucial aspect should be mentioned. On one hand, a product innovation in an industry or sector could serve as a process innovation in others, the best example is a product innovation in the capital goods industry that is inserted as a process innovation in other sectors. On the other hand, as is stressed by Antonucci & Pianta (2002), the distinction between process and product innovations should not be taken too far. It is possible, that both type of strategies are interlinked, especially in the case of those product radical innovations that also require process innovations.

According to Antonucci & Pianta (2002), both types of innovations should be understood under a broad perspective related with the firm strategy. Process

innovation is related to the search of more productivity and price competitiveness in mature sectors with established markets. On the contrary, product innovation is focused on the search of technological competitiveness based on high productivity rooted in quality advantages and the control of new and dynamic markets.

The distinction between process and product innovation plays a crucial role in the theoretical framework developed in Edquist (1998) and Edquist et al (2001). According to these authors, both process and product innovation could be divided in two general types. On one hand, product innovation is divided in material goods and intangible services while process innovation is divided in technological and organizational innovation.

Regarding product innovations, new goods are material product innovations in the manufacturing and primary sector. On the contrary, new services are intangible and are consumed simultaneously to their production. According to Edquist et al (2001), one crucial point regarding product innovation is related with the distinction between significant and incremental innovations. They assert (pp 14): ``Significant product innovations are often associated with new markets; incremental product innovations are generally associated with existing markets´´.

Edquist et al (2001) established a series of twenty hypotheses and premises regarding the relationship between innovation and employment after analyzing the result of several empirical works. In those hypotheses, the authors claim that there is a positive association between R&D activities, the development of new products and employment. They argue that, although the employment share of the manufacturing sector has been decreasing, those high technology (high intensity of R&D) and high wage subsectors characterized by the development of new products and markets, are the exception within the industrial sector.

Compensation mechanisms

Given that process innovation is understood as the mechanism that allows to produce the same amount of output with less inputs, it is commonly accepted that it has a negative impact on employment. On the other hand, product innovation is understood as the possibility to exploit new markets or in fact create them and as a consequence it is supposed to have a positive impact on employment. However, a broad literature described by Blechinger et al (2002), Pianta (2004) and Vivarelli (2007, 2012) emphasize the existence of some structural factors or compensation mechanisms that could mitigate or counterbalance the most obvious expected effects of innovation on employment. According to Vivarelli (2007, 2012) since the times of Ricardo and Marx, there exist opposite views about the existence of compensation mechanism which could counterbalance the initial effect of innovation. In this sense, the idea of compensation mechanisms was related to the negative effect that it is supposed that process innovation or the substitution of capital for labor has on employment.

Regarding the effects of process innovation a series of compensation mechanism could be mentioned.

1) Decrease in prices and scales economies: Although process innovation has a negative impact on employment, it also leads to a rise in productivity and a decrease in unit cost and prices. The reduction of prices could stimulate demand and thus production and employment. The existence of these mechanism depends on two assumptions. On one hand, it should counterbalance the negative effect that the process innovation causes on demand. In this sense, price effect should be greater than income effect and as it is pointed out by Blechinger et al (2002), this depends on the elasticity of demand. Furthermore, it depends on the existence of competitive markets, In case of oligopolistic competition the reduction in unit cost is not necessarily translated to prices. Moreover, in case of firms facing large markets, the expectative to grow after a process innovation is bigger than in small markets. According to Blechinger et al (2002, pp 11), ``*if a firm has high scale elasticities and provided the elasticity of output demand is high, then labor demand will increase. Cost reductions due to innovations will lead the firm to a stronger output than in a situation of low economies of scale´´*.
2) Decrease in wages: in a neoclassical framework, the labor saving process innovation causes a reduction in nominal wages which could lead to a reverse shift back to labor intensive technologies. These mechanism receives two main criticisms. From a Keynesian point of view, the decreased aggregated demand caused by unemployment and lower wages affects negatively employer's expectation and so they could hire less workers. From an evolutionary point of view the cumulative and irreversible nature of technological change arises. There exist a technological trajectory that imposes some rigidities in terms of factor substitutability which makes the neoclassical assumptions hardly possible.
3) New Investment: On one hand, in the case of monopolistic markets, the cost reductions caused by process innovation are not fully transmitted to prices, which impedes the counterbalance effect on demand. On the other hand, monopolistic firms are able to reinvest more profits which could have a positive effect on demand.

The aforementioned compensations mechanism basically highlight the role of growth. The effects of process innovation are highly influenced by the macroeconomic and industry specific context. The results of process innovations are not similar whether the economy or sector is growing or not. When market is expanding process innovation is more associated to the idea of increasing production than saving labor or defend a market position.

With regard to product innovation, the expected positive effects on employment could be mitigated by the following factors.

1) Degree of novelty: according to Edquist et al (2001) and Blechineger et al (2002), the impact of new products on employment depends on whether this products are substitutes of the existing ones. Edquist et al (2001) affirm that, `` if new products satisfies a completely new kind of demand or serves a new function, the production of the new product contributes to the increased net employment´´. However, the authors recognize that if the new product only replaces and old one, the effects on employment are ambiguous. In this sense, Blenchinger et al (2002) argue that if new products simply act as substitutes for existing ones, there will be positive employment effects only, provided product quality is higher than before and product quality is labor intensive. However, the impact might as well be negative as when new products are produced with a better and cheaper technique. If new products are only substitutes, the market could be saturated and the creation of new needs might be a necessary condition for continuing economic growth and employment

2.2 Theoretical perspectives and structural change in developing economies

The technological improvements and emergence of new products not only affect the behavior of firms and the sector where they occur. They lead to a process of structural change that affect all the main variables of the economy, including employment. Since the industrial revolution one of the central characteristics of the evolution of the economy is the creation of new branches of production and jobs while others tend to disappear. In this sense, when analyzing the impact of innovation on employment, the structural change suffered by the economy should not be avoided.

Krueger (2008), defines structural change as a long term change in the composition of economic aggregates. The author affirms (pp 1): ``Taken together, structural change in the economy implies that some industries or sectors experience faster long-term growth than others, leading to an increase of the shares of these industries or sectors in the total aggregate´´.

The question of technological development and structural change has been the main driving force of the Latin American structuralist school in the last 60 years. According to Cimoli & Porcile (2013), both the structuralist school and the Schumpeterian theory converge in the idea that development is driven by structural change and disequilibrating forces that redefines the productive structure of the economy. Moreover, the structuralist school introduce the idea that the creative destruction which explains both structural change and development occurs in a polarized way at international level. In this sense, the basic idea of the structuralist view is that

creative forces only operates in developed economies or central economies while developing economies in the best of the cases acts as followers.

Although a general theory of structural change does not exist, several efforts to build theoretical approaches have been done in order to understand the phenomena. Some of them are exposed below.

The three sector model

The three sector model approach postulates an evolution of the economy from the primary or agrarian sector to the tertiary or service sector. According to this view, underdeveloped economies are characterized by a high share of agriculture both in GDP and employment and as far as the economy develops it moves to industrial and services activities. Basically, in this approach, technological change leads to different rates of productivity growth between sectors, which under competitive assumptions, determine different profit rates and factor allocations.

Neoclassical models

Baumol (1967) develops a neoclassical model in which economic activities are divided in two classes. On one hand, a sector that shows technological improvements an increases in labor productivity, namely the industrial sector. On the other hand, a sector in which the productivity of labor is constant or only shows sporadic upsurges. Nonetheless, two crucial assumption are made. First, free long run mobility of labor causes wages in the two sectors of the economy to go up and down together. Second, money wages will rise as rapidly as productivity in the sector which shows upsurges in productivity. As a consequence, the cost in the sector that shows constant productivity, namely, service sector, grows without limit while in the industrial sector remains constant. If the demand for the service sector is price inelastic or income elastic, more income expenditures are destined to this sector. According to Baumol (1967), in this unbalanced model, if the ratio of the outputs of the two sectors is held constant, given that more income is destined to the consumption of services, more and more of the total labor force must be transferred to the no progressive sector and the amount of labor in the other sector will tend to approach zero. Finally, the author affirms that the rate of growth of the economy will asymptotically tend to zero. In this sense, the model predicts a structural shift of both expenditures and employment towards the stagnant sector.

Baumol et al (1985) presents a modification to the original model. They introduce a third sector that is considered asymptotically stagnant. At the beginning this sector shows an outstanding productivity growth and declining cost. As time goes, the productivity behavior approaches that of the stagnant sector. This modification allows them to describe the behavior of those sectors such as electronic data processing that showed high productivity rates at the beginning but then stagnated.

Under a neoclassical approach Ngai & Pissarides (2007) developed a multi sector growth model with structural change. They built a model with many consumption goods and a single capital good. All the sectors have the same production function but they exhibit different rates of TFP growth. Consumption is modeled with a constant elasticity of substitution (CES) utility function. In their model, the employment share of each sector depends only on the differences on the TPF growth and the elasticity of substitution between goods. They show that low elasticity of substitution (below one) causes a shift of employment to sectors with low TFP. Additionally, if the utility function has unit inter-temporal elasticity of substitution, during the process of structural change the economy is under balanced growth path. Two crucial question are related with these model. On one hand the authors affirm that the results confirm Baumol´s hypothesis about structural change. On the other hand, the results are obtained without imposing a non-homothetic utility function. According to the authors, the key requirement for these result is the low substitutability between final goods

According to the structuralist theory, the main distinction between the Latin American economies compared with the developed countries is the existence of a heterogeneous economic structure. Structural heterogeneity is defined as the presence of large productivity differences between economic sectors and also within them. Although all the economies are characterized by productivity differences between sectors and in fact, innovation is a variable that causes such differences, this phenomena is the main characteristic of Latin American economies. This heterogeneity in the structure of production has consequences for the whole economic system and introduce several asymmetries in the labor market and income distribution. According to Cimoli & Porcile (2013), this structural heterogeneity is explained by the fact that in developing economies structural change only is absorbed by few sectors and firms (specially multinationals) and the process of diffusion do not expand to the whole system. At the same time, this heterogeneous structure explains the existence of large informal sectors that absorb much of the labor force.

As every theory, the structural approach has gone through a series of modifications and has been enriched by new developments. At the beginning the theory was focused in how to achieve the process of industrialization necessary to catch up the developed countries and to avoid the deterioration of terms of trade highlighted by Raul Prebisch. From this approach surged the main industrial policies established by most of the Latin American countries during the process of import substitution. According to this view, the reallocation of factors to the industrial sector allows to exploit the increasing returns present in this sector, which in turn has a positive effect in the total productivity and income. However, as far as the developed economies entered in the third industrial revolution and the role of R&D became crucial, this view was not necessarily suitable to describe the effect of structural change on

growth. Cimoli et al (2005), as Baumol does, recognize that not all the economic sectors influences the productivity growth of the economy in the same way. Although they still consider the industrial sector as the main driver of productivity growth, they divide the manufacturing sector in three broad subsectors according to the intensity of factors they use. The subsectors are: Labor Intensive Sector, Natural Resources based Sector, and Sector intensive in engineering or diffuser of knowledge. The latter group is form on produced metal products, machinery and electrical machinery, equipment and transport, and technical equipment.

According to the authors, the share of the sector diffuser of knowledge is what explain the main differences in terms of growth and productivity between the developed economies and the developing ones, because it is the subsector that creates and exploit dynamic comparative advantages. The whole industrial sector is not necessarily a good indicator of the structural characteristics of the economy given that some industrial sectors, such natural resources based, only exploit static comparative advantages and in some sense replicates the main problematics that Latin Amercian economies showed when structuralist school emerged.

The existence of a heterogeneous productive structure imposes a new challenge to the theoretical relationships between innovation activities and employment. In developing economies, process innovation is most of the time associated with a survival strategy performed by medium and small domestic firms. This does not mean that the mentioned companies do not carry out product innovation activities, but due to the fact that their technological level is far from big and foreign companies, product innovation is less likely to occur. Furthermore, when big and foreign companies introduce new products, it is quite possible to expect a negative effect on the employment of small and medium firms.

2.3 Lessons from previous Empirical Studies

When analyzing the effect of innovation on employment the level of analysis selected is not a trivial issue. The results and conclusions obtained at firm level are not applicable to the industry level or macro level. According to Antonucci & Pianta (2002), at the firm level empirical analysis have found that innovative firms tends to perform better in terms of production and employment, no matter the industry, size of the firm or other characteristics. Nonetheless, the firm level analysis suffers from a series of drawbacks that should be taken into account. As is pointed out by Mastrostefano and Pianta (2009), two main problems arise with firm level analysis. On one hand, at firm level analysis is not possible to disentangle if the positive effect that innovation has on the level of employment in innovative firms is obtained as the expense of competitors, or which is the net effect at industry level. On the other hand, these type of studies are conducted in base of survey data that not always is representative of the whole industry. However, Mastrostefano & Pianta (2009)

recognize that such a problem has recently been tackled with the use of innovation surveys that are highly representative of all economic activities.

Some of the drawbacks suffered by the firm level analysis can be solved at the industry level. Industry level analysis allows to study the overall effect of innovation given the fact that it takes into account the losses suffered for those non innovative firms or those who do not success. Moreover, as is pointed out by Pianta (2004), at industry level is possible to identify some indirect effects such as the redistribution of output and jobs from low to high innovation firms, and the evolution of demand after the introduction of innovations, given prices elasticities and other structural factors. Furthermore, another distinction between firm and industry level analysis is related with the role of demand. As a difference with firm level, at industry level demand behavior plays a crucial role in order to understand the innovative behavior of firms, given that the whole industry faces demand restrictions that individuals firms do not face.

The topic of demand is not trivial and is also related with structural change. As it was reviewed in the theoretical framework, if structural change is understood as a process in which both innovation and demand factors intervene, the effect of innovation on employment is influenced by those demand factors. Moreover, from a supply side perspective, innovation is the force that causes structural change and shapes new demand patterns affecting the innovative behavior of firms. This imposes several difficulties when analyzing the performance of different industries. It is possible to affirm that new branches that introduce new products are characterized at the beginning by new firms with a series of characteristics. Once the sector begins to develop, new firms with other types of innovative behavior enter in the market. The innovative behavior of new competitors is not only restricted by those who are the leaders but also by the characteristics of demand.

Furthermore, another important issue related with the effect of innovation on employment is related to the behavior that this relationship could have during different phases of the economic cycle. As is described by Lucchese et al (2012 pp: 344), ``in endogenous growth models, recession can stimulate and foster long-term growth through a process of restructuring and reorganization of activities where inefficient firms are crowded out, raising the rate of productivity growth of the whole economic system. Nonetheless, expansive periods can reinforce growth by increasing the stock of capital devoted to training and learning. Furthermore, during upswings periods some firms can overcome financial constraints that impede them to invest in innovation´´. A growing demand context could help firms to overcome some of the difficulties and uncertainties related with innovative activities. In this sense, it could be easier to introduce a new product in a context of growth than during a recession period. Furthermore, it is possible to associate process innovation activities to avoid or reduce losses during recession periods.

In addition to the large amount of literature devoted to the analysis of the relationship between innovation and employment at the firm level, several studies were conducted to investigate the mentioned relationship at industry level. Most of them

combines the results of innovation surveys such as CIS (Community Innovation Survey) with structural data from OECD STAN data base.

Antonucci & Pianta (2002) analyze ten manufacturing industries in eight EU countries using data of the CIS innovation survey 1994-96 and OECD STAN data base. They propose an econometric model in which employment performance by each sector is explained by demand, labor cost, product innovation, process innovation and country factors. They find that employment performance is highly affected by the evolution of demand. Regarding innovation, the results shows a negative impact on employment. According to the authors, these result is explained by the fact that several industries were restructuring during that period. Moreover, they find that product innovation has a modest positive impact on employment. They assert that this result is explained by the fact that most of the product innovation are related with incremental innovations or the replace of old products.

Mastrostefano & Pianta (2009) investigate the determinants of employment change at industry level for ten manufacturing sectors and ten European countries for the period 1994-2001 using two CIS innovation surveys. They find that demand has a positive effect on sector employment while labor cost has a negative effect. The results also show that all types of innovation proxied by the number of innovative firms and the share of turnover from new or improved products have positive effects on employment. According to the authors (pp 735): `` *The basic picture that emerges is that job creation is higher in the industries and countries where demand grows faster, labor costs increase more slowly, and innovation – of all types – is higher´´* .

Bogliacino & Vivarelli (2010) analyze the impact of R&D expenditure on employment at industry level for 15 European countries during the period 1996-2005. As a difference with previous analysis they analyze both industry and services. They consider R&D expenditure as a proxy for product innovation while investment in physical capital is considered as a proxy for process innovation. The results shows a positive effect of R&D expenditures on employment both in manufacturing and service sector.

Using data of CIS innovation surveys (1994-96, 1998-2000), the OECD STAN data base and KLEMS, Bogliacino & Pianta (2010) analyze the effect of innovation on employment at industry level for eight European countries. Accepting the idea that innovation does not have the same effect on all industries the authors proposed a Pavitt taxonomy both for manufacturing and services in order to identify specific patterns of technological change. This taxonomy classifies industries in four groups on the basis of the nature of technological change, the features of production processes, market structures and other characteristics. As expected, they obtain different results for each type of taxonomy. In science based industries, product innovation has a positive effect on employment, while wage and demand growth are not significant. In the case of specialized suppliers industries only demand has a positive and significant effect on employment. The scale intensive sectors is negatively affected by both innovation variables and wages, while demand has a

positive effect. In the case of the supplier dominated industries, process innovation and wages have a negative effect while demand has a positive one.

The issue of economic cycle is addressed in Lucchese & Pianta (2012). The authors analyze the evolution of employment in 21 manufacturing sectors in six European countries for the period 1997-2007, allowing for different coefficient estimation during upswings and downswings. They use a benchmark model that not consider the economic cycle in order to compare the results. Although in the benchmark specification product innovations tend to have a positive effect on employment, when economic cycle is taken into account the results change. During upswings product innovation has a positive effect on employment while wage growth has a negative one. During downswings, product innovation has no effect on innovation while process innovation which not have effect in the benchmark model have a negative effect. In this sense the authors affirms (pp 355): ``*the recession leads to job losses that are associated with a restructuring of industries that is more dramatic where labor saving new processes are more relevant. Conversely, the job creating potential of new products is lost´´*

For a non-developed economy, Merikull (2008) analyzed the case of the Estonian economy both at firm and industry level. The author estimated a model in which current employment is affected by previous employment levels, process and product innovation, real wages and capital stock. Overall, at firm level the results showed that product innovation has a positive effect on employment and process innovation a negative one, whilst lagged values of employment explain much of the variation in current employment. However, at industry level, process innovation has a positive effect on employment.

Although all the papers mentioned previously addressed the question at industry level, no one of them considered the role of the structural change. Judzik (2013), takes into account the reallocation effect that structural change has on employment. The author analyzes, at industry level, the evolution of seven economic sectors in ten OECD countries, during the period 1980-2009. In order to take account the structural change, the author includes as explanatory variable the value added of each sector relative to the total value added. Investment in physical capital is considered proxy of process innovation while R&D is considered proxy of product innovation. The results obtained show that the relative growth of value added has a strong positive effect on employment. R&D or product innovation only has a positive effect on employment in the case of manufacturing sector. Moreover, capital accumulation has positive effect on all the sectors while labor costs has a negative effect on several sectors.

All the mentioned analysis considered the case of developed economies. However, in the last 20 years several developing economies, such as Latin American ones carried out innovation surveys. One of the main drawbacks related to the analysis of innovation and employment in the Latin American case is the inexistence of a structural data base such as OECD STAN data base. Nonetheless, Bogliacino et al (2011) identify the main empirical results of innovation surveys in Latin America.

According to the authors, compared with developed economies, LA shows a weak performance in terms of innovation. The competitive pressure caused by the liberalization policies established during the 1990s directed the innovative efforts to acquire new technology from advanced economies. The author affirm that (pp 240) `` the result is that all indicators of knowledge generation and innovative performance (R&D, product innovation, innovative turnover, etc.) maintain a gap vis-a-vis developed and emerging countries´´. The only exception is the case of Brazil where a high technology industries has emerged. According to the authors, these results are fairly obvious given the fact that developing economies have different technological patterns than those developed ones. In the case of the developed countries most of the innovative effort is directed to operate and move the technological frontier, whilst in the case of developing countries much of the effort is related to the acquisition of new machinery or the imitation of products coming from developed countries.

2.3.1 Some empirical findings in Latin America

In the case of Latin American countries, although there are not investigations related to the effects of innovation on employment at industry level, some papers have been written to describe the innovative behavior of firms and the effect on employment at firm level.

Crespi & Tacsir (2011) analyzed the effect of process and product innovation for the cases of Argentina, Chile, Costa Rica and Uruguay, using data from innovation surveys. They proposed an econometric model in which the effects of old products and new products on employment are distinguished. In a broad perspective, being an innovative firm and the level of sales have a positive and significant effect on employment. Regarding the effects of product and process innovations, with the exception of Chile, the authors found that both variables have a positive effect on employment. According to the authors, there are two plausible explanations for the results obtained regarding process innovation. First, it is possible that process innovation not necessarily causes the productivity increase which have a negative impact on employment. Second, if the productivity gains occur, it is possible that an expansion of demand counterbalance the negative effect on employment, as it was mentioned in the compensation mechanisms section.

Using the World Bank`s Investment Climate Survey, Goedhuys (2007) examined the factors that explain the TFP and firm growth of Brazilian firms over the period 2000-2002. The main empirical findings of this work are related to the behavior of TFP of the firms. According to the results obtained, the current TFP levels are highly explained by its previous levels while R&D activities hardly have any effect. Moreover, organizational innovations such as cooperation with clients, human capital development and ICT usage have a positive effect on TFP. However, process innovations have a negative effect on TFP. According to the author, this unexpected results associated with process innovations could be explained by the fact that those firms that engage in process innovations are forced to do it in order to reduce cost

and survive and not being competed out of the market. This result is related with the thesis highlighted by Crespi & Tacsir (2011) to explain the positive effect on process innovation on employment. It is quite possible that process innovations do not cause the necessary increase in the productivity level which leads to job losses.

Crespi & Zuniga (2012) evaluated the effects of different innovation strategies on employment for four Latin American economies, at firm level. The author distinguished three forms to acquire innovation, namely externally sourced, produce in house (R&D) or a combination of both. According to the results, those firms that tend to develop internal research activities showed the highest positive effect on employment while in the other two forms of innovation behavior the positive effect is smaller. Moreover, they found that produced innovation or R&D activities affect employment through product innovation while external sourced innovation affects employment through process innovation.

Finally, Gonçalves et al (2008) analyzed the determinants of technological innovation for Brazilian companies. According to the authors, Brazilian firms both domestic and multinationals, show low levels of internal research activities and most of the innovative strategies are explained by external acquisition. Moreover, and related with the heterogeneous structure of the economy issue mentioned previously, product innovation is highly associated with multinational companies. In this sense, although foreign firms do not conduct research activities in the country, they are more likely to introduce new products in the market. In terms of employment, it could have different effects than in the case of developed economies where products are introduced through a process of internal research and development.

3. Empirical Analysis

Following the approach of those works that examined the effects of different types of innovation activities on employment at industry level, in this section the case of the Brazilian economy is analyzed.

3.1 Data

The empirical analysis was conducted merging data from different sources. All the data was collected from the Brazilian Institute of Geography and Statistics.
The variables related with innovative activities were obtained from the Brazilian Innovation Survey, which surveys firms of more than ten employees biennially. Data over the five surveys (2000-2003-2005-2008-2011)[1] collected since the year 1998 were collected. The variables collected are the share of firms that carried out product innovation, the share of firms that implemented process innovation, R&D and

[1] Years of Publication

machinery expenditures over total sales by sector. From the available information in the survey it is possible to obtain a panel of 22 sectors which is composed by 21 industrial sectors and the extractive or primary sector, (extractive sector, food and beverage, textile, clothes, leather products, wood products, pulp and paper, publishing, petroleum and combustibles, chemical products, pharmaceutical, rubber and plastic, cement and other non-metallic products, steelmaking and derivatives, metal products, non-ferrous metallurgy, machines and equipment, electrical equipment, car, trucks and buses, parts for the automotive industry, other transport equipment, furniture and various products).

From the National Accounts system, sectoral employment and sectoral constant and current value added was collected. Given that wage variable published by the industrial survey is at current prices, it was deflated by the implicit deflator by sector. The nominal variable was obtained from the National Industrial Survey which is conducted every year.

The service sector was not included in the analysis because the definition of services activities from the innovation survey does not follow the overall classification of the national accounts system. Moreover, only few services sectors were included in the last two surveys. It is not possible to match the value added and employment variables for the service activities included in the innovation survey.

According to Bogliacino et al (2011), the Pintec innovation survey suffers some drawbacks that are crucial to highlight. First of all, while small firms are sampled, all the firms with more than 500 employees are included, which bias the estimation in favor of the latter. Secondly, and related with the first, the authors affirm that the survey is biased towards successful innovative stories of big firms.

The methodological manuals published by the Brazilian Institute of Geography and Statistics also recognize the fact that the survey is focused on those firms in which innovation is more probable to occur. In the brief in which the results of the 2005 innovation survey are published, it is affirmed (Pesquisa de Inovaçion Tecnologica 2005, pp 27): ``*The central hypothesis in which is based on the sample design of PINTEC is that innovation is a rare phenomenon. Since this is a phenomenon that is not verifiable in all selected units, the adoption of traditional designs (usually, stratified random sampling each by location, activity and size of the company) could result in samples that do not adequately represent the fraction of population of companies that have implemented innovations. This finding indicates the need for identify previously, from the selection register, companies that are more likely to be innovative and increase sample fraction for this subset*.´´

3.2 The Brazilian Case: Structural Change and Innovation Patterns

3.2.1 The structure of the Brazilian Economy

Following the prescription of the structuralist school the Brazilian economy underwent a process of structural change since the mid of the twentieth century. In the following tables the structural change process occurred, both in terms of employment and constant value added is shown.

Table1: Structural Change Employment shares

	Agriculture and Mining	Manufacturing	Construction	Services
1950	0,649	0,115	0,036	0,201
1960	0,594	0,118	0,037	0,251
1970	0,495	0,133	0,063	0,309
1980	0,386	0,127	0,089	0,398
1990	0,268	0,147	0,071	0,514
2000	0,226	0,120	0,067	0,586
2010	0,170	0,121	0,075	0,634

Source: GGDC 10 sector database

Table2: Structural Change Value Added shares, constant prices: 2005

	Agriculture and Mining	Manufacturing	Construction	Services
1950	0,140	0,184	0,058	0,618
1960	0,112	0,220	0,059	0,609
1970	0,086	0,218	0,064	0,632
1980	0,059	0,211	0,084	0,646
1990	0,072	0,179	0,063	0,685
2000	0,081	0,197	0,061	0,661
2010	0,089	0,180	0,058	0,673

Source: GGDC 10 sector database

As it is possible to appreciate, since 1950 agriculture and mining have been losing participation both in terms of employment and value added. One striking point is the low level of productivity exhibited by these activities at the beginning of the series given that 64% of the employment used to explain 14% of the value added.

Another remarkable point is given by the fact that in 1950 the service sector share on total value added was more than 60% while its share on employment was 20%. Over time the employment share have increased up to the 63% share, in accordance with the value added share.

The behavior of the manufacturing sector was not continuous over the period of analysis. It increased its participation in total employment, reaching the maximum point in 1986 and then started to decline, although in the last ten years its share tended to stabilize. Regarding manufacturing share on value added it also increased, reaching the maximum point in 1974 and then started to decline, however in the last twenty years it tended to stabilize.

According to Nassif et al (2013), although the import substitution policy received many criticisms, it explains both the high growth rates that the Brazilian economy showed in the period 1947-1980 (approximately 6.4% per year) and the growth of the manufacturing sector which increased at 8.6% per year. Moreover, according to the mentioned authors, since the 1970s the manufacturing sector suffered a broad diversification process explained by the establishment of durable, non-durable, intermediate and capital goods, reaching the last stages of the import substitution strategy.

Katz (2000) analyzed the performance of the Latin American industry over the period 1970 and 1986 and concluded for the case of Brazil that since the mid-1980s the manufacturing sector had been not only losing participation but also shifting to natural resource based industries producers of staple industrial commodities. According to the author, the liberalization policies introduced in the 1990s forced the manufacturing sector to exploit static comparative advantages or exercise lobbying power such as the case of the motor industry which received favorable treatment by the state.

However, the data available for the period 2000-2010 contradicts the view that the manufacturing sector has been shifting only to natural resource based industries. In the following table the composition of the manufacturing sector is shown.

Table 3: Composition of manufacturing sector 2000-2009 by employment and Value Added.

	EMP		VA	
Industry	**2000**	**2010**	**2000**	**2010**
Food and beverage	0,168	0,185	0,110	0,132
Tobacco	0,002	0,002	0,005	0,003
Textile	0,065	0,054	0,038	0,018
Clothes	0,171	0,151	0,059	0,047
Leather	0,056	0,051	0,022	0,017

Wood	0,054	0,040	0,021	0,018
Pulp and paper	0,018	0,017	0,045	0,021
Publishing	0,021	0,018	0,029	0,016
Petroleum and combustibles	0,002	0,002	0,058	0,066
Alcohol	0,006	0,008	0,013	0,006
Chemical products	0,007	0,006	0,039	0,031
Resin and elastomers	0,002	0,002	0,010	0,005
Pharmaceutical	0,009	0,008	0,048	0,042
Pesticides	0,001	0,001	0,003	0,007
Perfumery hygiene and cleanliness	0,017	0,016	0,019	0,018
Enamels lacquers paints and lacquers	0,004	0,003	0,006	0,005
Several chemicals	0,004	0,004	0,007	0,007
Rubber and plastic	0,038	0,040	0,038	0,042
Cement and other non-metallic mineral products	0,056	0,054	0,038	0,043
Steelmaking and derivatives	0,011	0,012	0,017	0,039
Non-ferrous metallurgy	0,010	0,010	0,017	0,012
Metal products - except machinery and equipment	0,065	0,067	0,059	0,077
Machinery and equipment including maintenance and repairs	0,052	0,084	0,073	0,090
Appliances and electrical equipment	0,019	0,021	0,027	0,028
Office machines and equipment, electronics	0,020	0,020	0,035	0,033
Cars trucks and buses	0,016	0,016	0,063	0,067
Parts and accessories for motor vehicles	0,022	0,032	0,024	0,049
Other transport equipment	0,005	0,009	0,023	0,020
Furniture and products of various industries	0,079	0,069	0,054	0,042

Source: IBGE, National Accounts

According to the structuralist view, it is crucial to consider the composition of the manufacturing sector in order to understand the heterogeneous structure of the economy. The first remarkable point is given by the fact that in both years the sum of a natural resource industry (food and beverage) and a labor intensive one (clothes) explain more than 30% of the manufacturing sector employment. Furthermore, although its participation have decreased, natural resources and labor intensive industries explained in 2010 74% of the employment. In terms of value added, the values are slightly similar although the total participation of the previously mentioned industries is 62% in 2010, less than in employment participation. However, some remarkable changes occurred during the period. A gradual shift, both in terms of employment and value added, to the knowledge based industries took place. With the exception of food and beverage industries, the sector that showed the highest increase in shares are those related with knowledge intensive sectors such as machines and equipment and transports and part and accessories

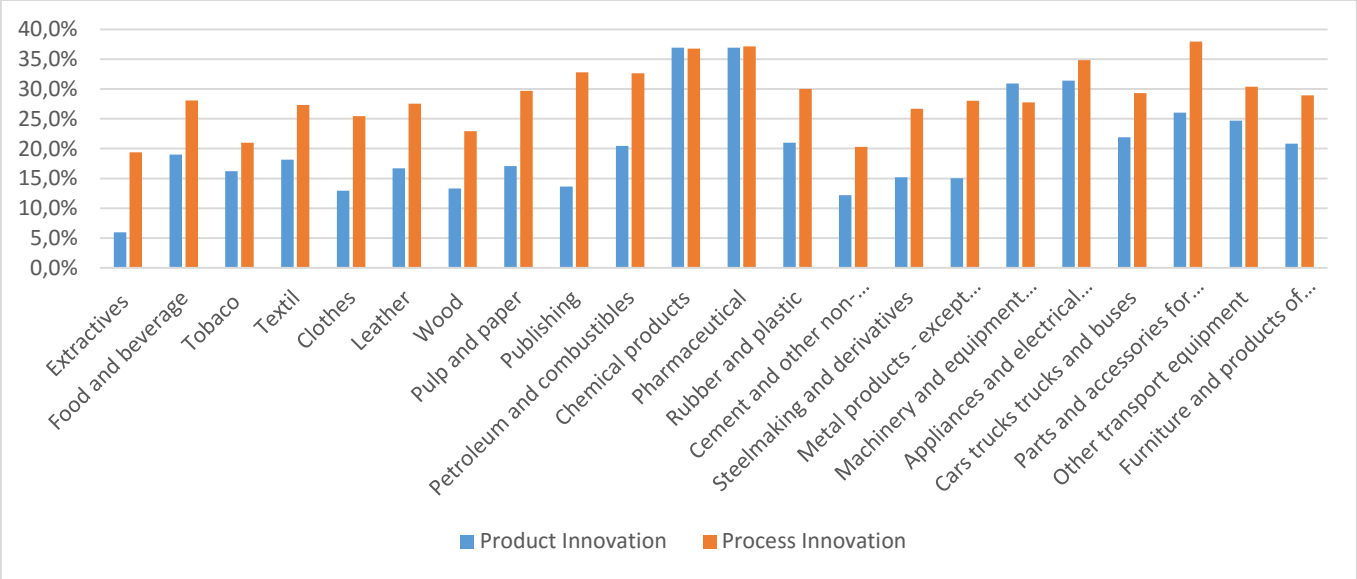
for vehicles. Moreover, the labor intensive sectors such as textile and clothes and some natural resource based such as wood, pulp and paper showed the highest declination in its shares. As a consequence, it is possible to affirm that although the total share of the manufacturing sector remained stable, it has been moving to more sophisticated activities.

3.2.2 Evidence from Innovation data

The composition of both the total GDP and the manufacturing sector is crucial to understand the innovative characteristic of a country. From the Innovation Survey (PINTEC) conducted by the Brazilian Institute of Geography and Statistics several variables can be examined. In order to maintain some analogy with previous studies the proportion of innovative firms, R&D expenditures and machinery expenditures are shown for the period 1998-2011.

In the first graph the proportion of both product and process innovative firms is presented. The variables are the average over the five innovative surveys conducted over the period 1998-2011.

Graph1: % of product and process innovative firms by sector



Source: Pintec

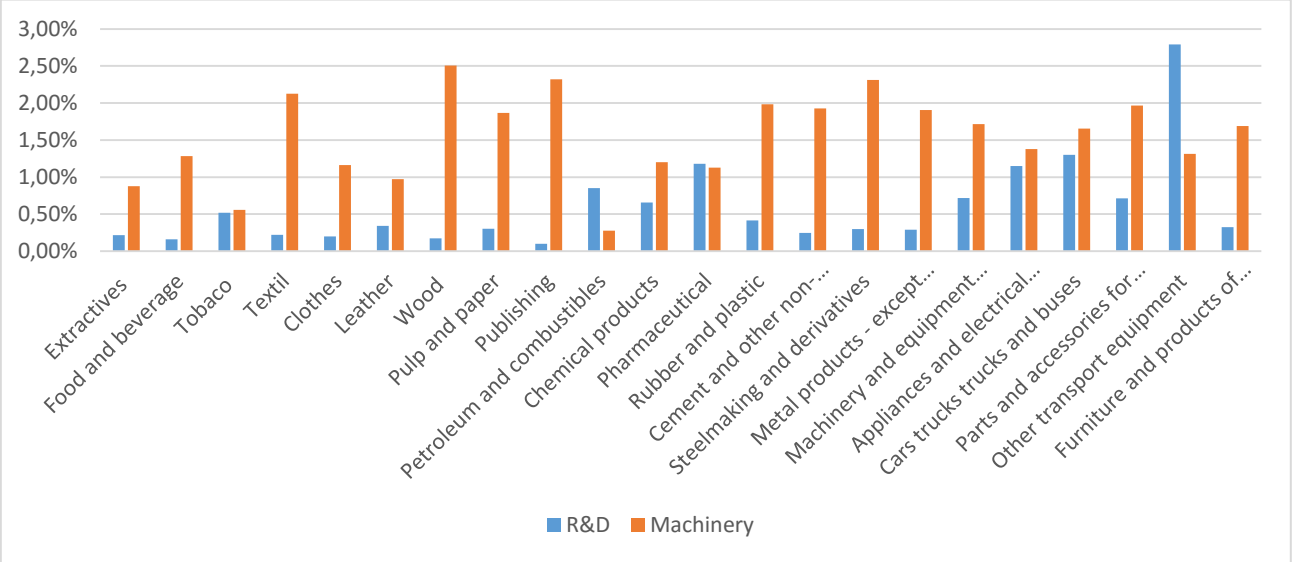
Regarding product innovation, the most innovative sectors are related with knowledge based activities such as pharmaceutical industry, machines and electrical equipment, car, trucks and buses, parts and accessories for the automotive industry.

In terms of process innovation the picture is slightly different. Although some sectors that show high levels of product innovation are the most innovative in terms of

process innovation such as the chemical industry and pharmaceutical industry, electrical equipment and parts and accessories for the automotive industry, some of the sectors that show low levels of product innovation exhibit at least medium levels of process innovation. Especially those labor intensive sectors, such as textile, clothes, leather and some natural resource based, that poorly perform in terms of product innovation show at least medium levels of process innovation. In this sense it is crucial to highlight that process innovation is more evenly distributed than product innovation.

In some empirical works variables such as R&D and machinery expenditures are taken as proxy variables of product and process innovation respectively. They are taken as a proxy because they are considered an input of innovation. There exists some consensus about the idea that R&D is devoted to the development of new products while new machineries are related with process innovation. In the following graph the R&D and machinery expenditures as a share of total sales are shown.

Graph 2: R&D and Machinery expenditures as a share of total sales



Source: Pintec

With the exception of the petroleum and chemical products industry, R&D expenditures is unevenly distributed in favor of those knowledge based activities such as machinery, electrical equipment and transport industry.

Regarding machinery expenditures, as it happens with process innovation, it seems to be evenly distributed and once again sectors that show low levels of R&D expenditures exhibit high levels of machinery expenditures.

It is possible to conclude that knowledge based sectors exhibit more innovative intensity both in terms of product and process innovation than other sectors. On the

other hand, natural resources and specially labor intensive sectors are less innovative and focused on process innovation.

Regarding the impact of the innovative behavior on employment, especially the case of product innovation, it is crucial to know whether new products are new for the firm or for the market. Fortunately, in the innovation survey of Brazil, firms are also asked whether innovations performed, both product and process, are a novelty for the firm and/or for the market. Fortunately, this information is divulged at industry level.

In the following tables, the proportion of both product and process innovation that is a novelty for the firm and or for the market is presented.

Table 4: Product innovation, proportion of firms that innovate for the firm and for the market

Industry		Firm	Market
Extractives	NR	73,7%	30,0%
Food and beverage	NR	92,3%	13,9%
Tobacco	NR	83,0%	34,0%
Textile	LI	91,0%	15,9%
Clothes	LI	96,7%	3,9%
Leather	LI	94,2%	7,6%
Wood	NR	94,1%	8,5%
Pulp and paper	NR	74,3%	32,9%
Publishing	LI	85,6%	17,8%
Petroleum and combustibles	NR	96,5%	3,5%
Chemical products	NR	66,4%	40,8%
Pharmaceutical	KB	76,2%	34,8%
Rubber and plastic	NR	85,7%	20,4%
Cement and other non-metallic mineral products	NR	82,7%	20,0%
Steelmaking and derivatives	NR	70,6%	43,9%
Metal products - except machinery and equipment	NR	76,0%	45,9%
Machinery and equipment including maintenance and repairs	KB	88,3%	16,7%
Appliances and electrical equipment	KB	66,2%	37,2%
Cars, trucks and buses	KB	57,1%	52,6%
Parts and accessories for motor vehicles	KB	51,2%	58,1%
Other transport equipment	KB	61,1%	41,6%
Furniture and products of various industries	LI	90,8%	10,8%
Average		81,8%	23,5%

Source: Pintec

Table 5: Process innovation, proportion of firms that innovate for the firm and for the market

Industry		Firm	Market
Extractives	NR	89,0%	12,6%
Food and beverage	NR	91,1%	12,8%
Tobacco	NR	72,1%	55,8%
Textile	LI	90,4%	13,0%
Clothes	LI	99,3%	3,6%
Leather	LI	97,9%	4,9%
Wood	NR	96,4%	5,5%
Pulp and paper	NR	88,5%	17,0%
Publishing	LI	95,3%	5,7%
Petroleum and combustibles	NR	97,6%	4,2%
Chemical products	NR	82,3%	25,2%
Pharmaceutical	KB	81,1%	26,4%
Rubber and plastic	NR	89,2%	12,4%
Cement and other non-metallic mineral products	NR	91,8%	10,2%
Steelmaking and derivatives	NR	90,0%	16,4%
Metal products - except machinery and equipment	NR	89,3%	25,4%
Machinery and equipment including maintenance and repairs	KB	87,6%	15,6%
Appliances and electrical equipment	KB	87,7%	15,1%
Cars, trucks and buses	KB	81,8%	23,8%
Parts and accessories for motor vehicles	KB	80,7%	25,3%
Other transport equipment	KB	84,2%	24,1%
Furniture and products of various industries	LI	98,1%	6,0%
Average		92,3%	11,0%

Source: Pintec

In both cases the novelty is more related to the firm than for the market. Regarding product innovation, only knowledge based industries show a similar proportion of novelty related with the firm and the market. Labor intensive industries show the biggest difference between the proportion of novelty for the firm and for the market.

In the case of process innovation, it is crucial that labor intensive industries also show the biggest difference between novelty for the firm and for the market. Knowledge based industries show the smallest difference between novelties as it happens in the case of product innovation.

Firms are also asked about the objective and impact of the innovative activities performed. In the following table a resume of the intensity and objectives of Brazilian firms in the year 2000 and 2011 is exhibited.

Table 6: Intensity and objective of activities performed

Activity	Intensity	2000	2010
Increase Quality	High	0,563	0,601
	Medium	0,219	0,219
	Low	0,217	0,181
Maintain Market Participation	High	0,490	0,527
	Medium	0,306	0,301
	Low	0,204	0,172
Gain Market Participation	High	0,369	0,431
	Medium	0,341	0,288
	Low	0,290	0,281
Open new markets	High	0,226	0,367
	Medium	0,221	0,248
	Low	0,554	0,385

Source: Pintec

It is clear that Brazilian firms are more focused on maintaining market participation and introducing incremental innovations than creating new markets via disruptive product innovations. Although a high proportion declares that gaining market participation is an objective, 50% of the firms are focused to maintain their market participation and the desire to open new markets is low although increasing over time.

The innovative behavior of Brazilian firms was examined and compared with other developed and non-developed economies in Baumgratz Viotti & Baessa (2007). According to this authors, three important characteristics shape the Brazilian productive structure, compared with other countries. First, the share of small enterprises, characterized by low rates of innovation. Second, a high share of firms that only innovate with regard to process innovation. Third, the share of large size foreign companies in the total turnover. A crucial point related with multinational companies is given by the fact that these enterprises show higher rates of innovation than domestic firms.

Furthermore, as it was analyzed by Dias de Araujo (2007), although multinational firms have a high share of sales and higher rates of innovation, they R&D expenditures in relation to sales is lower than domestic firms. In this sense, it could be affirmed that, even though multinational companies are more innovative that domestic firms, this innovative behavior is more related with the adaptation of products and process coming from developed economies, than the generation of domestic capabilities.

3.3 Methods

In this section the effects of innovation on employment for the case of Brazil is examined. Folowing Van Reenen (1997), most of the literature focused in the analysis of the impact of innovation on employment usually consider a perfectly competitive industry operating under constant elasticity of substitution production function (CES) with two factors (labor and capital). In each sector, firms face the following production function:

1) $$Y_{it} = T_{it}\left[(A_{it}N)^{(\sigma-1)/\sigma} + (B_{it}K)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}$$

Where Y is output, N is employment, K is capital, T is the Hicks neutral technology parameter, A represents labor augmenting Harrod neutral technology and B represents Solow neutral technological change, subscripts i and t represents industry sector and time respectively.

From the maximization problem the labor demand is derived (after log-linearisation):

2) $$n_{it} = (\sigma-1)a_{it}/b_{it} - \sigma w_{it} + k_{it} + \sigma r_t$$

Lower case letters denote natural logarithms, w represents the real wage and r the cost of capital. Van Reenen (1997) assumed that the technology variables can be proxied by innovation variables and that the cost of capital is constant across sectors but not on time. So the stochastic labor demand function assumes the following form:

3) $$n_{it} = \alpha_{it}INNOV + B_1 w_{it} + B_2 k_{it} + \mu_{it}$$

Where INNOV represents innovation variables. In some specifications, as is done by Judzik (2013) a trend component is added.

A version of the equation three is estimated with different specifications. The main idea is to analyze the effect of both product and process innovation on sectoral employment controlling for structural factors such as demand and labor compensation. Moreover, a model in which the change of the share of sectoral employment of each sector over total employment is estimated. Following Merikull (2008) and Judzik (2013) the econometric equation is defined in the following way:

4)

$$n_{it} = \beta_{it} + \alpha_{it}D + \delta_{it}W + \gamma_{it}inno + \mu_i + \varepsilon_{it}$$

where

n: rate of change of sectoral employment of each sector

D: change in demand

W: change in real wages

Inno: innovation variables

μ: sector specific or fixed effect

ε: random effect

In the following table the list of variables and the sources are listed.

Variable	Source
Value Added y sector	National Accounts System
Wages by sector	Annual Industrial Survey
Share of firms that perform product innovation, by sector	Innovation Survey
Share of firms that perform process innovation, by sector	Innovation Survey
R&D expenditures over sales, by Sector	Innovation Survey
Machinery expenditures over sales, by sector	Innovation Survey

Hypothesis

From a theoretical point of view and taking into account the results obtained in previous analysis done for developed economies, it should be expected that demand factors have a positive effect on employment whilst real wages have a negative one.

Regarding innovation variables, the most conservative hypothesis is to expect that product innovation has a positive effect on employment while process innovation has a negative effect. However, given that Brazil is a large economy characterized by the presence of a heterogeneous productive structure it is possible to expect some different results.

As far as product innovation is concerned, in a heterogeneous productive structure in which there exists large productive and technological differences between and within sectors it is possible to expect that product innovation has a negative effect on employment. On one hand, the presence of big multinational firms with better technological capabilities than domestic and medium and small firms, introducing new products could lead to a process of displacement of labor from those noncompetitive firms. As it was mentioned in the empirical evidence for Brazil, the foreign companies not only are more innovative that domestic firms, but also have a

higher share on total sales. On the other hand, as is pointed out by Edquist et al (2001), a clear distinction exists between radical product innovation and incremental product innovation. The former is related with new markets and thus expected to have a positive effect on employment whilst the latter is related with existing markets which not necessarily has a positive effect on employment. Moreover, product innovation could be associated with labor saving process innovations or not. In this sense and according to the structuralist school, two mutually reinforced factors could lead to a different sign in the effect of product innovation on employment. Multinational companies are not only more innovative than domestic firms, but also the pattern of innovation is more associated with incremental than disruptive innovations. This behavior could lead to a process of shift of labor form less productive companies to more productive enterprises instead of opening new markets as it happens in developed economies.

With regard to process innovation, two aspects that could lead to opposite expected results should be emphasized. As is pointed out by Blechinger et al (2002), in a large economy like Brazil firms could face scale economies that make them to expect production growth after process innovation which in turn could have a positive effect on employment. Moreover, process innovation is associated with an increase in productivity that in turn translates into losses of jobs. However, in some cases this growth in productivity does not necessarily occurs. As it was pointed out in empirical works for Latin American economies, process innovations is not associated with the growth of productivity.

4. ***Estimations and Results***

In this section the results of diverse estimations of the equation four are presented. In the first model the change in total employment is regressed on the change in value added, real wages and innovation variables. The fixed effect and random effect estimators are shown in the following table, although the nature of the data and the performed Hausman test indicates that the fixed effect estimator is more suitable

Four different models are shown in the following table[2]. In order to capture some productivity effect a trend variable is included in one estimation while other model is controlled by year effect. Regarding demand factors, value added has a positive and significant effect in all the estimations. Real wage has a negative effect although it is only significant in the random effect models or in those models that controls by productivity and year effect.
As far as innovation variables are concerned, in all the specifications it is found that product innovation has a negative and significant impact on employment. On the contrary, although not in all specifications, process innovation has a positive and significative effect on employment.

[2] Random models with dummy variables for each sector were estimated and all the variables were significative and maintained the same sign

Regarding innovation variables that could be considered a proxy of both product and process innovation, namely R&D and machinery expenditures, they are not significant both in the model in which are included together with other innovation variables and in the model in which are included alone. These means, that in the case of Brazil, those variables that could be considered as an input of innovation are not significant to capture the effect of innovation on employment.

Table 7: Dependent Variable: Total employment by sector

	FE	RE	FE	RE	FE	RE	FE	RE
	1		2		3		4	
Value Added	0,2986	0,4393	0,279	0,4296	0,221	0,47	0,22	0,4917
t	6,49	7,97	5,6	7,26	4,32	6,54	4,25	6,7
RW	-0,693	-0,2704	-0,529	-0,2514	-0,1647	-0,5	-0,1345	-0,4827
t	-1,03	-3,34	-0,76	-3,02	-2,3	-4,9	-1,92	-4,83
Product Innovation	-0,7728	-1,1744	-0,7543	-1,1132	-1,02	-1,72	-7,49	-1,4622
t	-3,13	-3,78	-2,96	-3,49	-4,04	-4,49	-3,13	-4,04
Process Innovation	0,5318	0,5426	0,5139	0,4901	0,41	0,44	0,4	0,4465
t	2,72	2,16	2,47	1,85	2,14	1,47	2,09	1,45
R&D			-2,5698	-3,27				
t			-0,64	-0,64				
Machinery			-1,6487	-0,34				
t			-0,92	-0,01				
Cons	10,3071	9,3456	10,2166	9,4063	11,01	9,79	10,8	9,4335
t	37,59	25,55	32,03	22,3	27,36	16,26	27,21	16,09
2003					0,02	-0,13		
t					0,78	-0,26		
2005					0,14	0,12		
t					3,08	1,72		
2008					0,2	0,19		
t					3,67	2,22		
2011					0,17	0,15		
t					2,48	1,34		
Trend							0,04	0,03632
t							2,54	1,38
R-Squared	0,6795	0,6491	0,6843	0,6529	0,7369	0,6627	0,7028	0,6193
Obs	109	109	109	109	109	109	109	109
Groups	22	22	22	22	22	22	22	22

The previous analysis does not consider the structural changes that could be operating in the economy. Even though the period of analysis is not long enough to properly analyze the structural change effects, a model in which this issue is considered is estimated. In this case, instead of estimating the effects on total employment, it is estimated the effect of the change in the share of each sector value added and the other variables, on the share of the employment of each sector on the total employment. In the following table the results are shown.

Table 8: Dependent variable change in the share of employment

	FE	RE	FE	RE	FE	RE	FE	RE
	1		2		3		4	
Value Added	0,14	0,23	0,153	0,252	0,2161	0,4583	0,229	0,4682
t	2,79	3,64	3,14	4,01	4,33	6,46	4,32	6,54
RW	0,51	0,107	0,63	0,188	-0,1281	-0,4485	-0,1647	-0,504
t	1,34	0,21	1,77	0,4	-1,91	-4,59	-2,3	-4,9
Product Innovation	-0,6286	-0,874	-0,6064	-0,8744	0,8156	-1,501	-1,019	-1,72
t	-2,55	-2,68	-2,56	-2,76	-3,5	-4,2	-4,04	-4,49
Process Innovation	0,4956	0,5886	0,5208	0,6294	0,4255	0,469	0,4076	0,442
t	2,34	2,08	2,62	2,35	2,23	1,54	2,14	1,47
R&D	-2,8543	-3,49						
t	-0,71	-0,66						
Machinery	-2,4546	-2,53						
t	-1,49	-1,15						
Cons	-5,083	-4,49	-5,11	-4,4866	-4,3347	-2,2999	-4,1111	-1,9068
t	-17,33	-10,75	-17,67	-10,84	-12,01	-4,4	-10,58	-3,46
2003							0,011	0,02866
							0,37	0,61
2005							0,1098	0,2158
t							2,76	3,54
2008							0,1954	0,3916
t							3,89	5,25
2011							0,2021	0,4682
t							3,21	5,05
Trend					0,05067	0,1177		
t					3,29	5,15		
R-Squared	0,2962	0,2704	0,2728	0,2454	0,3577	0,293	0,3994	0,3341
Obs	109	109	109	109	109	109	109	109
Groups	22	22	22	22	22	22	22	22

In this model value added still has a positive and significant effect no matter the specification estimated. However, in the case of real wages results are different from

the previous estimations. In this case, although the variable is significant after controlling for year effects, the effect of real wage on employment seems to be positive rather than negative as in the previous case.

With regard to innovation variables, once more time product innovation is found to have a negative and significant impact on employment while process innovation has a positive effect. Moreover, R&D and machinery expenditures, as in the previous estimations, are found no significant.

Given the fact that during the period of analysis the extractive sector has been losing employment in favor of services and industry maintained its participation stable, it is possible that the previous results are biased by the presence of the primary sector in the panel. As a consequence, the two former estimations were replicate excluding the extractive sector, which shapes a panel of 21 sectors instead of 22.

In the following table the results of the change in total employment excluding the extractive sector are presented.

Table 9: Dependent Variable Total employment by sector (extractive sector excluded)

	FE	RE	FE	RE	FE	RE
	1		2		3	
Value Added	0,3	0,442	0,223	0,47	0,219	0,445
t	6,94	8,02	4,51	6,1	4,62	5,92
RW	-0,393	-0,2639	-0,1079	-0,5847	-0,1347	-0,6108
t	-0,62	-3,25	-1,65	-5,84	-2,01	-5,95
Product Innovation	-0,7508	-1,1356	-0,723	-1,426	-0,9853	-1,6428
t	-3,23	-3,64	-3,25	-3,76	-4,22	-4,12
Process Innovation	0,4598	0,5328	0,3261	-0,4166	0,326	0,4334
t	2,48	2,09	1,78	1,27	1,83	1,36
Cons	9,8	9,156	10,6	9,69	10,8	10,11
t	39,59	25,98	29,16	16,05	29,21	16,27
2003					0,0298	-0,013
t					1,02	-0,03
2005					0,1358	0,1821
t					3,26	2,52
2008					0,2078	0,2716
t					4,06	3,11
2011					0,1798	0,2698
t					2,8	2,46
Trend			0,047	0,0687		
t			2,91	2,49		
R-Squared	0,7281	0,6896	0,7546	0,6326	0,7839	0,6743
Obs	104	104	104	104	104	104
Groups	21	21	21	21	21	21

As in the case of the analysis of total employment including the extractive sector, value added has a positive and significant effect on employment. Although significant after controlling by year effect and in the random effect model with trend, real wage has a negative effect on total employment.

Product innovation has a negative and significant effect no matter the specification estimated, while process innovation, significant without controlling for year or productivity effect, has a positive effect on employment.

In the following table the results of the change in the share of employment excluding the extractive sector are exhibited.

Table 10: Dependent variable change in the share of employment (extractive sector excluded).

	FE	RE	FE	RE	FE	RE
	1		2		3	
Value Added	0,1475	0,2182	0,219	0,445	0,2131	0,4387
t	3,19	3,36	4,62	5,92	4,57	5,87
RW	0,9541	0,3096	-0,1347	-0,6108	-0,1021	-0,5489
t	2,75	0,62	-2,01	-5,95	-1,63	-5,58
Product Innovation	-0,5738	-0,7956	-0,9853	-1,6428	-0,7877	-1,46
t	-2,55	-2,45	-4,22	-4,12	-3,63	-3,9
Process Innovation	0,4272	0,6043	0,326	0,4334	0,3489	0,4465
t	2,36	2,19	1,83	1,36	1,96	1,38
Cons	-5,3861	-4,8633	-4,3517	-1,917	-4,575	-2,328
t	-19,17	-11,5	-11,89	-3,4	-13,93	-4,31
2003			0,01624	0,034		
t			0,58	0,69		
2005			0,1071	0,2679		
t			2,88	4,22		
2008			0,2	0,4572		
t			4,26	5,97		
2011			0,208	0,5688		
t			3,56	6,07		
Trend					0,0525	0,143
t					3,68	6,15
R-Squared	0,3336	0,2946	0,471	0,3433	0,4321	0,3018
Obs	104	104	104	104	104	104
Groups	21	21	21	21	21	21

As in the earlier case in which the change in employment share was analyzed, value added has a positive and significant effect on employment. Regarding real wage, without controlling by year or productive effect it has a positive effect while after controlling it seem to have a negative effect.

Once again, product innovation has a negative and significant effect on employment while with less significance process innovation has a positive one.

The results obtained in the previous estimations show that the Brazilian case present some results different to those results obtained for developed economies in prior research. On one hand, the demand factors are positively related with employment as it happens in developed economies. Real wages are significant regarding total employment but not in the case of employment share. This means that although wages have a negative effect on employment, it depends whether the sector is growing more than the rest of the economy or not. With regard to innovation variables, the Brazilian case exhibits the most astonishing results. Product innovations, instead of having a positive effect on employment, as it happens in developed economies, seems to have a negative effect on employment. Moreover, process innovation, once again, as a difference with developed economies, apparently has a positive effect on employment. In this sense, some of the theoretical considerations regarding the heterogeneous structure of the economy are valid. First, the innovative behavior of Brazilian firms is quite different from firms in developed economies. Process innovation is more related with a survival strategy than productivity growth. More importantly, product innovation is not the result of research and development efforts domestically performed, on the contrary is the results of an adaptation process achieved by foreign companies, which usually enjoy higher levels of productivity and technology than domestic firms. In this sense, the displacement effect on labor is not compensated by any mechanism.

Dynamic Panel

As it is recognized by Merikull (2013) and Judzik (2013), both total and employment share are characterized by a high persistence. In order to capture this effect, a lagged value of the dependent variable could be included in the model, which transform it in a dynamic panel data estimation. Including a lagged value of the dependent variable introduces a new endogeneity problem that is not solved with fixed effect or first difference estimators. Arellano and Bond estimator solves the problem of endogeneity by instrumenting the endogenous variables with its own lagged values, as long as N>T.

In the following tables the results of the Arellano Bond estimator for both total employment and employment share are shown. Given the small number of

observation of the panel, in this case it is not possible to perform a different analysis excluding the extractive sector. Three specifications of the Arellano-Bond estimator are displayed. In the first case, the results of the estimation without any correction is presented. In the other two specifications a correction for small number of observations and the twostep robust estimator to control for autocorrelation and heteroscedasticity is exhibited. Only two lags of the endogenous variable are used as instrument given the fact that with a bigger number of lags or instrumental variables the Sargan test is weak.

Table 11 Dependent Variable Total employment

	AB	AB small	AB Twostep Robust
Employment (t-1)	0,7814	0,7814	1,01
t	7,45	7,1	3,85
Value Added	0,1914	0,1914	-0,1534
t	1,66	1,58	-0,44
RW	-0,1811	-0,1811	0,2309
t	-1,47	-1,4	0,57
Iprod	-0,7019	-0,7019	0,035
t	-1,74	-1,66	0,04
Iproc	-0,392	-0,392	-0,338
t	-0,2	-0,19	-0,77
Cons	1,71	1,71	0,84
t	2,31	2,2	0,63
Sargan P value	0,001	0,001	0,001
Obs	87	87	87
Groups	22	22	22

Table 12 Dependent Variable share of employment

	AB	AB small	AB Twostep Robust
Employment (t-1)	0,8674	0,8674	0,8925
t	16,94	16,14	16,25
Value Added	0,1575	0,1575	0,142
t	2,62	2,49	2
RW	0,03	0,03	0,0155
t	0,78	0,75	0,3
Iprod	-0,6325	-0,6325	-0,53
t	-2,12	-2,02	-1,28
Iproc	0,0154	0,0154	-0,068
t	0,08	0,08	-0,43
Cons	0,1163	0,1163	0,2103

t	0,51	0,049	0,77
Sargan P value	0,085	0,085	0,085
Obs	87	87	87
Groups	22	22	22

Regarding total employment, in all the specification the lagged value of employment is positive and significant which highlights the role of persistence when analyzing employment behavior by sector in short periods of time. Value added and product innovation are only significant at 10% without controlling for small observation, autocorrelation and heteroscedasticity. However they show the same sign than in previous estimations. Process innovation, although with an opposite effect than in earlier models, is not significant whatever the specification.

As far as share of employment is concerned, the lagged value of employment has a positive effect in all the specifications. As a difference with the case of total employment, value added has a positive and significant effect in all the models while real wage is not significant. With regard to innovation variables, product innovation has a negative and significant effect while process innovation is not significant.

Previous results could be biased by the fact that the innovation survey is designed in a way that more innovative firms are overrepresented. In this section, a new analysis that avoids to use structural data (National Account data) is performed. In this estimation, the proxy variable for demand, instead of value added, is the variable total sales published in the innovation survey. The innovation survey also publishes a labor variables which is used in this analysis.

In the following table, the results of fixed effect and random effects models are presented.

Table 13: Estimations using only survey data

	Total Panel		Only Manufacturing	
	FE	**RE**	**FE**	**RE**
Sales	0,6523	0,7472	0,6585	0,7519
t	11,68	13,71	11,41	13,42
RW	-0,4837	-0,6588	-0,4928	-0,6681
t	-6,05	-8,4	-6,07	-8,39
Product Innovation	-0,4174	-0,491	-0,4222	-0,5263
t	-1,97	-1,96	-1,97	-2,05
Process Innovation	0,372	0,4919	0,3911	0,5042

t	2,09	2,26	2,16	2,26
Cons	2,3115	1,1381	2,2516	1,1029
t	3,07	1,52	2,87	1,42
R-Squared	0,5525	0,6158	0,5607	0,6228
Obs	109	109	104	104
Groups	22	22	22	22

As in previous estimations, the proxy of demand has a positive effect on employment while real wages has a negative effect. Regarding innovation variables, product innovation has a negative effect and in this case process innovation is significant with a positive effect whatever the model estimated. Once again, using only survey data, innovation variables have the same effect on employment.

The estimated effects of each variable, obtained over different models, are resumed in the following table.

Table 14: Resume of results

Variable	Level of employment	Share of employment
Lagged Value of Employment	+	+
Value Added	+	+
Sales	+	+
Real Wage	-	+
Product Innovation	-	-
Process Innovation	+	+

5. Conclusion

In this thesis the impact of innovation on employment for the Brazilian economy was analyzed. Following the literature advocated to the analysis of the relationship of both variables at industry level, different specifications were estimated to disentangle the relationship between the mentioned variables. A panel of 22 economic sectors was built merging data from three different sources, namely the Brazilian Innovation Survey (PINTEC), the Brazilian National Industry Survey and the National Accounts System.

There exists a vas literature about the direct possible effects of innovation on employment not only at firm level but also at industry level. Moreover, the discussion of the total effects is influenced by the existence or not of counterbalancing or indirect effects. From both, a theoretical and empirical point of view, there exists a broad consensus about the effects of innovation at firm level. For those researchers advocated to theories that recognize the existence of different type of innovations, namely evolutionary theories, the consensus indicates that product innovation has a positive effect on employment while process innovation has a negative one. However, these researchers stress that at industry level, the sign and intensity of previous effects could be compensated by the influence of compensation or structural factors.

Furthermore, the effects of innovation on employment are influenced and at the same time affected by the structural changes occurring in the economy. In this sense, innovation could be considered as an input and output of structural change which at the same time affects employment.

In this thesis both innovation and structural change were considered in order to analyze the effect on employment. As a consequence, two type of models were performed. On one hand, the total employment of each sector was regressed against innovation variables and structural factors such as value added and wages, on the other hand the analysis was done on the share of sectoral employment on total employment. Although the period of analysis is not long enough to conduct a properly investigation of the effects of structural change, significative coefficients were obtained.

Fixed effects and random effects models were estimated, although the nature of the analysis and the results of the Hausman test indicates that the estimations of fixed effect models are more properly. The main results obtained from these estimations highlight that value added, a proxy of demand, has a positive effect on both total and share of employment. The variable real wages has a negative effect on total employment whilst it has a positive effect on share of employment. However, this variable is not necessarily significant in all the models estimated. Regarding innovation variables, interesting results were obtained. First of all, both for total employment and employment share, product innovation has a negative effect, while process innovation, although not always significant, has a positive effect. Secondly, variables than in other empirical analysis were considered an input of innovation, namely R&D and machinery expenditures are not significant.

The fact that product innovation has a negative effect on employment at industry level, confirms the idea highlighted by the Latin American strucutralist school related with the presence of large technological and productive differences between and within economic sectors, which shapes a heterogeneous productive structure in which innovative and structural outcomes affect the whole system in an opposite direction than in developed economies. Given that the mentioned results could be

influenced by the performance of some extractive activities that had been losing participation, the same models were estimated excluding this sector but the results maintained.

Finally, recognizing the persistent characteristic of labor variable, a dynamic estimation was performed. In the case of total employment, only previous or lagged values of this variable has a significant and positive effect on employment, while both innovation and control variables lost power of explanation. However, when employment share is analyzed, demand factors still have a positive effect and product innovation has a negative one as in the case of static panel estimators.

To conclude, three results could be considered consistent to explain the behavior of employment. First, employment is a persistent variable highly explained by its previous values. Secondly, value added has a positive effect on employment. Third, regarding innovation variables, the most interesting and consistent results is given by the fact that product innovation has a negative effect on employment.

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