Innovation, productivity and employment:
Evidence from Colombian manufacturing firms

1. Introduction

Colombia had an outstanding growth performance prior to the global economic crisis that hit in 2008. Between 2003 and 2007 annual growth rates averaged 6 percent, and peaked in 2007 at 7.5 percent. Although growth rates have remained in positive territory throughout the crisis, the country faces the challenge of resuming strong and sustained economic growth to improve the living standards of its citizens. While Colombia has been recently designated an upper-middle income country, it remains one of the most unequal countries in Latin America. In 2006, Colombia's GINI coefficient was the highest compared to other countries in the region and to upper middle income countries[1].

Economic research suggests that innovation can be a driver of economic growth, as it raises total factor productivity (add source). Furthermore, research also suggests that innovation-led growth can lead to substantial increases in the level and quality of employment, therefore leading to broad-based, or shared, economic growth (add source). The government of Colombia has committed to innovation as one of the main drivers of growth in its national development plan. Over the next years, there will be a strong focus on increasing the level of investment in innovation, both through public and private funds, creating human capital for innovation and improving the policies geared towards the promotion of innovation and their coordination. (DNP, 2010)

Although the links between firm innovation, productivity and employment have been empirically established in other countries, in Colombia there has been little research on the topic. This paper seeks to fill in this gap by applying the empirical methods used elsewhere to Colombian data. Specifically, our purpose is to shed light on the following question: do higher levels of innovation lead to higher levels of productivity and employment at the firm level? In addition, this chapter will look at the potential effects innovation may have on different types of employment, for example, on high skilled versus low skilled labor, on permanent versus temporary employment, and on female versus male.

make reference to the models that will be used to analyze the links btw innovation productivity and employment

This exercise is of high relevance given the country's recent commitment to innovation as a motor of shared growth. The results could provide insights into the potential effects of increasing innovation investments on productivity and employment in Colombia, and inform public innovation policy so that it becomes more effective.

The paper is organized as follows. Section 2 reviews the theoretical framework linking firm innovation with productivity and firm innovation with employment. Section 3 outlines the current situation in terms of firm productivity, employment and private innovation investments in Colombia. Section 4 describes the data used in the analysis. Section 5 presents the methodology used to analyze the relationship between innovation and productivity and the results of this exercise. Section 6 presents the methodology used to

[1] Compared to countries for which data is available- WDI and GDF.

analyze the relationship between innovation and employment and presents the results of this analysis. Section 7 concludes.

2. Innovation as engine for growth:

In this section the main hypotheses will be posed and a review of the existing literature (theoretical framework) will serve to support them.

a. Linking innovation and productivity

Technological change has long been regarded by economists as one of the key drivers of economic growth. The mechanism through which technological change affects economic growth is by multiplying the production that can be achieved with a certain level of physical capital and labor, or in other words, by increasing the total factor productivity (TFP). Over the past decades and beginning with the seminal work of Romer in 1986, macroeconomists have found that it is this productivity-enhancing technological change that determines countries long-run growth trajectories and can account for current per-capita income differences (see for example Aghion and Howitt 1992, 1998).

Since then, the Schumpeterian idea that technological change is at least in part the result of private, profit maximizing behavior and not an exogenous phenomenon has become central in economic research. Macro- and micro- economists seeking to understand cross-country differences in income per-capita have sought to understand both the determinants of innovation and technological change as well as their impact.

At the macro level, the literature on *capabilities* for innovation has focused on understanding the necessary conditions for a country to be able to exploit technology to its own advantage and achieve high levels of productivity growth (for a review of this literature see Fagerberg 2009). Also, a number of studies have attempted to quantify the effect of aggregate investment in Research and Development (R&D) on total factor productivity (TFP). Table 3 presents the estimates of the elasticity of TFP with respect to R&D investments arising from several key studies that deal with developed countries. Although the range of estimates is very broad, all of these studies find the effect to be positive and statistically significant.

Table 1: Selected Estimates of the Elasticity of TFP with respect to R&D investments

Study	*Elasticity*	*Independent variable*	*Dependent variable*	*Sample*
Coe and Helpman (1995)	0.08 (Non G7) 0.23 (G7)	R&D stock	TFP	21 OECD +Israel 1971-1990
Australian Industry Commission (1995)	0.02 0.14	Private R&D stock	TFP Output	Australia 1975-1991
Xu and Wang (1999)	0.104-0.149	R&D stock	TFP	21 OECD 1983-1990
Frantzen (2000)	.077-0.091	R&D	TFP	21 OECD 1965-1991
Guellec and van Pottelsberghe de la Potterie (2004)	0.13 0.17	Business R&D Public R&D	TFP	16 OECD Countries panel 1980-1998
Bronzini and Piselli (2009)	0.006-0.077	R&D stock	TFP	Italian regions (19) 1985-2001

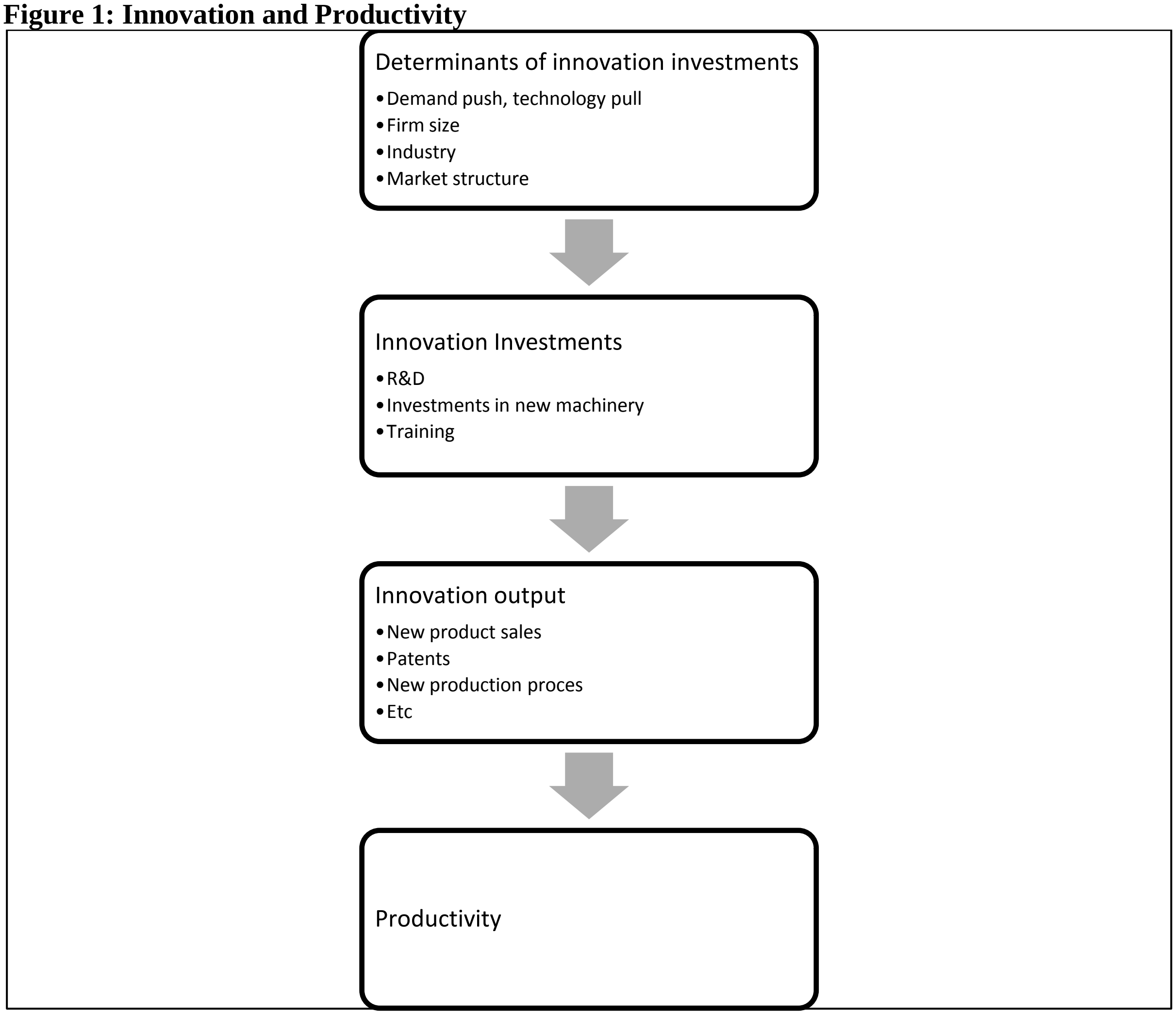
Teixeira and Fortuna (2010)	0.238-0.795	R&D stock	TFP	Portugal 1960-2001

Note: These studies apply the perpetual inventory method to R&D investment data, which means that the stock of R&D is measured as the accumulated expenditures on R&D, which are depreciated over time.

Should we expand on the advantages of micro studies compared to macro studies?

At the micro level, the thrust has been to explore the determinants and impacts of innovation at the firm level, by analyzing data available through various national innovation surveys which appeared in the 1990's and have flourished since. In particular, this paper follows the empirical research line started by Pakes and Griliches(1984) and Crepon *et al.* (1998). Although the technical aspects of the model will be explained in the next section, the theoretical framework behind it is introduced here. Figure 2 summarizes the key elements of this framework.

Figure 1: Innovation and Productivity



The usefulness of this framework lies in that it puts together three strands of literature that had been evolving in parallel: "studies of the determinants of R&D investment, patent or innovation production functions, and production function estimation using R&D, innovation or patents as an input" (Hall and Mairesse, 2006 p.292). Therefore, the framework encompasses the path beginning with the decision to invest in R&D and other innovation activities, leading then to the accumulation of knowledge capital, which with a certain probability can lead to **innovation outputs** and finally to the impact of these innovation outputs on firm productivity through their effect in firm level prices, mark-ups or sales, and ultimately profits.

The definition of innovation that will be used throughout this study will be the broadest possible one. That is, the term innovation will encompass both *radical and incremental* innovations, *product and process* innovations (including organizational and commercialization innovations) as well as *global and contextual* innovations. [2] .

The literature on the determinants of innovation investments, outputs and effects on productivity is vast and cuts across disciplines. The following paragraphs review the main factors considered as independent variables explaining one or more steps of the innovation investment-productivity path in the model: demand and technology factors, firm size and sector and market structures. However, this review is not meant to be exhaustive, as this would be outside the scope if this work.

Innovation determinants

The first determinants outlined in the flow chart are the **"demand pull" and "technology push"** factors. A strand of literature on the economics of innovation has sought to determine the differential importance of the existence of market demand for certain innovations in determining the path of innovation investments compared to the importance of existing technological possibilities available to firms. There is now consensus on the idea that both factors must exist simultaneously for innovation to occur (Nemet, 2009), however, the relative importance of these factors varies with the firms' context [3]. In their first estimation of the model, Crepon et al. (1998) found a positive a significant relationship between both technology-push and demand pull indicators and the decision to invest in innovation, the scale of the investments and the innovation output.

The second box of determinants includes both **industry and firm size.** Firm size as a determinant of innovation investments has been widely explored in the literature. Vaona and Pianta (2006) review this literature and show that the relationship between firm size and innovative behaviour (decision to innovate, scale of investments and innovation outputs) is not linear, but shaped by other factors such as market structure, competition and entry costs, sector characteristics, corporate structure, credit availability and the knowledge environment.

[2] Global innovations are new to the World, while contextual innovations are those that are ether new to the national market or the firm, but not to the international market, which Schumpeter would denominate as "imitations". For a more detailed taxonomy of innovations see Fagerberg (2006).

[3] Some authors find that the relative importance of these elements is dependent on the context in which innovation is taking place. For instance, Benavente speculates that technology-push factors can play a more important role in developing countries "where important channels of diffusion of technology are through FDI, purchasing of new machinery and the introduction of new inputs usually developed overseas and where demand elements, like customer demands, are less relevant" (2006, p.303). Using the same logic, one could expect that in contexts (countries or sectors) that are at the edge of the technological frontier, demand pull factors would play a more important role in determining the R&D and innovation paths chosen by firms.

In this same study, and using European data, Vaona and Pianta (2006) find that the determinants of, and motivations for, engaging in innovation are different for small, medium and large firms respectively. Innovative behavior in large firms is driven by market-expansion strategies (in the case of product innovation) and the purchase of new machinery (in the case of process innovation). Contrastingly, product innovation in small and medium firms is driven by the search of new niche markets through a greater use of patenting and process innovation is driven by the search of flexibility in production.

Another important area of research in the innovation literature explores the importance of belonging to a certain **sector** (or industry) for firms' innovative behavior and performance. Malerba (2006) reviews the frameworks that have been used to understand the different dimensions of sectoral differences in innovation; three of these are summarized in Table 4. The authors of each of these frameworks (column 1) have identified specific factors (column 2) that interact to yield a pattern of innovative behavior for each sector. For instance, Pavitt's (1984) taxonomy of three types of sectoral patterns of technical change (supplier-dominated, production-dominated and science-based) arises from differences in the combination of three factors: the source of technology, the requirements of users and the appropiability mechanisms that prevail in the sector.

Table 2: Frameworks to understand sectoral differences in innovation

Framework	**Factors**
Schumpeterian patterns of innovation Schumpeter (1911, 1942)	Market structure
	Industrial Dynamics
Sectoral patterns of technical change Pavitt (1984)	Sources of technology
	Requirements of users
	Possibilities for appropriation
Technological regimes Nelson and Winter (1982) Malerba and Orsenigo (1996, 1997)	Opportunity
	Appropiability
	Degrees of cumulativeness of technological knowledge
	Relevant knowledge base

The Schumpeterian framework is also relevant for sectoral analysis but differs from Pavitt's in the factors that determine a pattern of innovation. In fact, it's emphasis on market structure and industrial dynamics are closer to another group of determinants of innovation investment: **market structure elements,** such as market share, competition and diversification. As explained by Malerba, in the Schumpeterian tradition some sectors "are characterized by 'creative destruction,' with technological ease of entry and a major role played by entrepreneurs and new firms in innovative activities", while others "are characterized by 'creative accumulation' … with the prevalence of large established firms and the presence of relevant barriers to entry for new innovators" (2006, p.382)

Since Schumpeter, a number of authors have explored the relationship between market structures and innovation. By examining data for British firms, Blundell et al. (1999) arrive at three key findings in this respect: (1) industries with lower level of competition tend to have fewer innovations; (2) within industries, high market share firms tend to commercialize more innovations; however (3) increased competition stimulates aggregate innovative activity.

In a more recent study by Aghion et al. (2005), the findings point to an inverted-U relationship between product market competition and innovation so that competition encourages innovation up to a certain point, and then discourages it afterwards. The logic of their model arises from the effect that the threat of competition can have on the pay-off to innovation. Their model predicts that in some cases an increase in competition can lead to increased innovation, as firms innovate to try to escape the increased competition[4]. However, in other cases, further competition at the frontier can discourage laggards from innovating.

Hall and Mairesse (2006) review five papers following the CDM model or modifications of it, and summarize the findings of these studies.[5] Most of them find a positive and significant relationship between firm size market share and both R&D intensity and innovative sales. The same is true for the indicator for market share. However, in some cases, once the sector is controlled for, one or both of these relationships are no longer significant, as is the case for the studies for China and Sweden.

In other cases, as in the multi-country study by Mohnen et al. the dimension of the firm size effect on innovation intensity varies considerably between low- and high-tech sectors. In the same line, this study finds substantial difference across sector types in the size of the estimates for innovation output, for the effect of competition and proximity to basic research and for the effect of innovation sales on productivity. (Mohnen et al. 2005). All studies, except Benavente (2002), find a positive effect from innovation outputs to firm productivity.

Crespi and Zuniga 2010- evidence from LAC and brief review from other LDC. ?

b. Linking innovation and employment

This section provides a brief summary of the key mechanisms through which innovation can affect employment quantity and quality at the firm level. Thus, it is intended as a starting point to understand the logic underlying the microeconomic framework used to link innovation and employment in this study. The summary, which draws heavily on the work of Garcia et al. 2005 and Harrison et al. 2008, will show how different types of innovation and innovation strategies can have different effects on employment variables, and how these effects can also be shaped by other factors.

Innovation and quantity of employment

The relationship between innovation and the quantity of employment at the firm level is determined by the balance that arises from two different kinds of effects: the displacement effect and the compensation effect. Table 6, extracted from Harrison et al. (2008) summarizes these two effects.

[4] This inverted U-relationship is more pronounced in sectors characterized by “neck-and-neck” competition.

[5] The 5 studies cover the following countries: Chile (Benavente, 2002), China (Jefferson et al. 2002), Sweden (Loof and Heshmati (2002), The Netherlands (Van Leeuwen and Klomp) and a comparison of 7 European countries (Mohnen et al. 2005)

Table 3: Employment effects of innovation

		Displacement effect	Compensation effect	
R&D and other innovative investments	Process Innovation	Productivity effect (<0): less labor for a given output	Price effect (>0): cost reduction, passed on to price, expands demand	Depends on firm agents' behavior ↕
	Product Innovation	Productivity differences of the new product (>0 or <0)	Demand enlargement effect (>0)	Depends on competition

Source: Harrison et al. 2008, p. 37

As depicted in Table 6, the effect of innovation on employment creation depends on the type of innovation introduced. Process innovations are usually introduced to reduce the amount of inputs needed for the production of a certain output. Therefore, if the effect of a process innovation is to reduce the amount of labor needed for production, its introduction would destroy employment; this would be denominated a displacement effect due to productivity gains. However, if this process innovation brings with it a cost reduction that results in lower prices and increased demand for the firm's output, the destruction in labor due to gains in productivity would be offset by increased output and labor. This would be denominated a compensation effect due to demand expansion. The total effect of the process innovation would then depend on the relative sizes of these two effects.

The effect of product innovation on employment is also ambiguous and depends on the balance of the displacement and compensation effects. The most straightforward effect from introducing a new product would be the increase in demand and therefore output and labor (compensation effect). However, there are two other mechanisms by which the introduction of a new product could lead to the destruction of employment. First, if the increase in demand for the new product cannibalizes a portion of the demand for old products, the compensation effect could be reduced and even become negative. Second, if the introduction of the new product entails a change in the input mix it could lead to a reduction in the amount of labor necessary for total production.

The size of the displacement and compensation effects can also be influenced by the degree of competition faced by the firm, as well as by the behavior of workers and employers within the firm. The compensation effect arising from an increase in demand for firm's products can be significantly reduced if competitors adapt the same innovation and reduce their prices to match those of the incumbent firm.

In terms of agents' behavior in the existence of rents from innovation, both workers and the firm can play an important role in determining the size of the displacement and compensation effect. In the case of a cost saving innovation, the compensation effect can be reduced or the displacement effect increased if unions have sufficient bargaining power to negotiate an increase in wages. On the other hand, both in the case of a product and process innovation a firm with sufficient market power can decide not sell its products at a higher price than the marginal cost, limiting this way the growth in demand and output and reducing the compensation effect.

The paragraphs above have reviewed a simple framework in which the mechanisms by which the introduction of a single innovation can affect employment. A more complex question, and one can only be solved empirically is the one that deals with the total effect of innovative activities on employment creation at the firm level. This will depend on the balance of the compensation and displacement effects due to all innovations, as well as by agents' reaction to them. For a review of empirical studies on the effect of innovation on job creation see Pianta (2003) and Harrison et al. (2008).

Innovation and quality of employment

Another strand of literature has researched the relationship between innovation and changes in the composition of skills within a firm. The key idea is that technological change can affect the relative demand of skilled vs. unskilled workers or the relative demand of a specific type of skills. This question has been explored at the macro level by….

(Section incomplete..MISSING: micro framework to explain innovation's effect on the skill composition)

3. Innovation investments, productivity and employment: the Colombian context

As stated in the introduction, the central goal of this paper is to test the hypothesis of whether higher levels of innovation lead to increased productivity and employment in the Colombian manufacturing sector. To place the motivations and results of this study in context, this section provides a brief analysis of Colombian economic performance in terms of innovation investment, productivity and employment in the past decades. This is achieved by drawing on previous literature on the subject and complementing it with new numbers obtained from both the Annual Manufacturing Survey (EAM) and the Innovation and Technological Development Survey (EDIT).

Both surveys, as well as most of the previous studies cited here, deal exclusively with the manufacturing sector. Therefore, although the challenges of productivity, employment and innovation are pervasive across the economy, and perhaps even more critical in the services sector (as suggested in the latest IDB flagship study), our analysis here will mostly deal with the manufacturing sector. Nevertheless, it is important to keep in mind that, due to the evolution of the structure of the Colombian economy, manufacturing now accounts for only 14 percent of the total value added, while services account for 58 percent of it (see Table 1). In terms of employment, industrial participation is even lower, housing only 20 percent of total employment in 2007, compared to 62 and 18 percent in services and agriculture respectively[6]. This numbers highlight the importance of research delving deeper into the issues of innovation, productivity and employment in the services sector; however, data availability continues to be the greatest obstacle to do this.

Table 4: Value added per sector as a percentage of GDP

Sector/year	*1965*	*1970*	*1975*	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2009*
Agriculture	29	26	24	20	17	17	15	9	8	7
Industry	27	28	30	32	36	38	32	29	33	34
of which Manufacturing:	20	21	24	24	22	21	16	15	15	14
Services, etc.	44	46	46	48	47	45	53	62	59	58

Source: World Bank, World Development Indicators

a. Investment in innovation: general trends and policy

[6] World Bank, World Development Indicators

This section will describe the policy efforts and characterize the innovation behavior of manufacturing firms

Colombia's performance in terms of innovation investment can be characterized by two general trends, which will be illustrated in the following paragraphs: (1) low overall levels of investment and (2) low participation of the private sector.

Colombia ranks below other Latin American countries in the total investment made in Science, Technology and Innovation (STI) activities, and particularly in R&D. Investment in STI in 2008 reached 0.4 per cent of GDP, with investments in R&D reaching only 0.15 per cent. These numbers are significantly lower than in Brazil, Argentina, Costa Rica and Uruguay[7].

Furthermore, investments in STI and R&D as a percentage of GDP have declined if compared to the 1995 figures; two loans obtained from the Inter-American Development Bank in 1990 and 1994 enabled a large ramp up in the investments channeled by Administrative Department for Science, Technology and Innovation, *Colciencias,* which more than quadrupled between 1990 and 1997. However, as the external funds were exhausted and those from national sources did not increase, the level of investment once again returned to 1990 levels by 2000.

Since the early 2000's, the government's commitment to science, technology and innovation as a key motor of economic development has been increasing markedly. In addition to a number of policy documents that have guaranteed financial support to STI activities, public resources for Science, Technology and Innovation activities have been on the rise. In 2009, the enactment of Law 1286 consolidated the country's commitment to STI policy. This law transformed Colciencias into an Administrative Department, assigning the institution the role of formulating and coordinating STI policy, and created the National Fund for STI (*Fondo Francisco Jose Caldas*).

In 2010, a new government led by Juan Manuel Santos took office in Colombia and renewed the country's commitment to productivity and innovation-led growth. In the new National Development Plan 2010-2014, innovation is seen as one of the engines of growth; the plan components that seek to promote innovation across the country include: (a) increasing available financing for knowledge and innovation projects in the private sector through tax incentives, the development of venture capital funds, the use of mineral royalties and the transformation of Bancoldex into a regional development agency; (b) promote entrepreneurship by improving the education system's ability to instill entrepreneurship capabilities in the Colombian population and by increasing the efficiency of current public funds for entrepreneurs; (c) ensuring that intellectual property rights are respected in Colombia; and (d) promoting competition in the national markets by improving competition policy and oversight.

It is expected that these developments will lead to a further increase in public resources for STI that will serve to catalyze private investment in innovation. Currently, Colciencias is the largest public player in terms of innovation investment, its investment budget for the year 2009 was 53 percent of the total investment made in STI by central government entities (OCyT, 2010).

Less than half of R&D and STI spending in Colombia is financed by the private sector, whereas in countries with high rates of STI expenditure such as Japan, the United States, Sweden, Finland, Ireland

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[7] RICYT (2010)

and Germany the share of industry-related spending ranges from 65 to 70 per cent[8]. The Colombian Development and Technological Innovation Industrial Survey[9] (EDIT) provides useful information to construct a comprehensive profile of innovation behavior by firms, including their propensity to invest in innovation activities as well as the intensity of their investments and their sources of finance, among others.

This section should be updated in the next draft when I have had time to look at the data from EDIT II and III again* Using the 2003-2004 wave of the EDIT, Arbeláez and Parra Torrado (2010) find that 77% of firms in the manufacturing sector reported having invested in any type of innovation in 2004 up from 69% in 2003. However, only 6 percent of manufacturing firms (384 firms) invested in R&D. *A* similar story can be told when looking at the amount of investment made by firms in each innovation category. While 66 percent of total investment goes to capital-related technologies, followed by 18 and 10 percent invested in management-related and cross-cutting technologies respectively, only 2.4 percent is invested in R&D activities.

The results of the innovation survey also show that innovation investment increases with size. Almost all large firms invest in at least one type of innovation activity compared to 69 percent of small firms and 89 percent of medium-sized firms. This pattern is observed at all innovation investment categories, except in the case of R&D investment where the share of small firms with positive amounts is almost one fourth of the share of large firms making R&D investments. Correspondingly, the total amount invested is in great part coming from large firms. The amount invested by small firms adds up to around 6 percent in the case of any type of innovation activity and 2.5 percent in the case of R&D activities. These percentages are drastically lower than SME's share of gross value added, production, employment, or number of establishments.

In terms of the main sources of finance for innovation investments among manufacturing firms, the most prominent are firms' own resources and private banking. In 2004, resources to finance STI activities in the manufacturing sector ascended to 3.9 Billion pesos, which is equivalent to 2.5 percent of the total amount lent by the financial sector to finance all Colombian economic activities during that year (Becerra, 2010). Most of this amount came from the private sector: 64 percent from firms' own resources, 27 percent from private banking and 3.3 percent from foreign sources. The public sector financed 5.02% with credit and 0.12% through STI programs (Colciencias, SENA and Fomipyme) and export promoting programs (Proexport). Finally, universities, centers for technological development and other sources accounted for 0.14% of all resources. *******

b. Evolution of productivity in the Colombian manufacturing sector

For our analysis of the productivity performance of the Colombian economy, we use the concept of total factor productivity (TFP), which is the measure of the efficiency with which all inputs for the production

[8] Goldberg et al (2006)

[9] The Development and Technological Innovation Industrial Survey (EDIT) constitutes a fundamental tool for characterizing the innovation and technological development activities of manufacturing firms in Colombia[9]. This survey is carried out every two years since 2005 (a first and smaller version was carried out in 1996 –EDIT I) to all industrial firms according to the directory of establishments in the Annual Manufacturing Survey (EAM). In the 2005 round, the EDIT gathered information from all firms registered in the EAM 2003, accounting for 6,670 firms out of which 6,172 firms responded. In 2007, the EDIT gathered information from all firms registered in the EAM 2006, accounting for 6,957 firms out of which 6,080 answered the survey.

of goods and services are used. Before examining the manufacturing sector, it is possible to compare the overall performance of the Colombian economy to other countries and regions of the world.

Analyzing the history of TFP performance for Latin America, Ferreira, et al. (2006) find that from the period starting in 1960 and ending in 2000, Colombia's TFP relative to that of the United States collapsed from 81 to 64 percent. Similarly, according to calculations by the Conference Board (2011), Colombia's TFP between 1995 and 2005 exhibited a worse performance than the average of Latin America, the group of emerging markets and developing countries, and advanced countries. As shown in Table 2, Colombia's TFP during 1995-2005 is estimated to have declined by 1 percentage point on average every year. These numbers mirror some of the worst growth performance in Colombia's recent history. The economic crisis that struck the country between 1995 and 2000 resulted in three consecutive years of negative growth, hitting -4.2 percent in 1999. Growth resumed in 2000 and continued to improve until 2007, when it peaked at 7.5 percent[10]. Improved TFP growth accompanied this positive performance; in 2005-2008 average annual growth turned into positive territory at 1 percent per year and surpassed the average for Latin America and advanced countries, however Colombia still trailed behind the group of emerging and developing countries, who experienced on average annual growth rates in excess o f 2 percent (Conference Board, 2011).

Table 5: Estimated average annual TFP growth rates

Country/Region/Grouping	*1995-2005*	*2005-2008*	*2007*	*2008*
Colombia	-1	1	1.9	-3.3
Latin America	-0.2	0.3	1.2	-0.7
Emerging markets and developing economies	1.4	2.3	3.3	0.7
Advanced countries	0.6	0	0.4	-1.1

Source: The Conference Board Total Economy Database, January 2011, http://www.conference-board.org/data/economydatabase/

Previous studies have estimated the evolution of TFP in the manufacturing sector in Colombia. Eslava et al. (2004) use instrumental variable techniques to estimate TFP before and after the 1990s reforms in Colombia (including labor market and financial reforms, trade liberalization, and the elimination of FDI restrictions). They find that aggregate TFP, as well as the dispersion of TFP, increased after the reforms of the 1990s. Moreover, their study shows that the increase in overall productivity was largely driven by reallocation away from low- and towards high productivity businesses.

In another study using plant level data from 1981 to 2002, Echavarría et al. (2006) estimate annual growth rates of TFP through semi parametric techniques. They show that TFP in the manufacturing sector grew at an annual rate of 0.7 percent during the 1980s and 1.2 percent during the 1990s. In a similar note to Eslava, et al. (2004) they find that the early-90's economic reforms had a positive impact on TFP growth, especially through the reductions in trade barriers and increased imports.

In a study using data from more recent years, Arbeláez and Parra Torrado (2010) show that manufacturing firms' productivity grew consistently but weakly between 1999 and 2006; they estimate an average productivity improvement of less than 1 percent per year. Their results also show that large firms have

[10] WDI, World Bank

been consistently more productive than small and medium firms and that the gap between them has grown larger over the period, meaning that larger firms have performed better in terms of TFP growth.

Introduce results and conclusions from our own estimations of TFP.

Overall these three studies and our own figures point at a consistently positive but weak growth in manufacturing TFP during the 1980's, 1990's and 2000's. Improving this record should be a core goal of Colombian economic policy. Taking measures to improve firm productivity would pave the way to sustainable long-term growth. As highlighted by the studies reviewed above, reforms that allow for increased competition and reallocation of resources towards the most productive firms have been successful in increasing overall productivity in the past. The current paper will suggest whether there is evidence that adopting measures to stimulate firm innovation can support growth through greater increases in productivity.

c. Employment and the Colombian labor market

A key barrier to the achievement of broad based growth in Colombia has been the high level of structural unemployment haunting the country for the past decades. Since 1980, the country has experienced 2-digit unemployment rates with the exception of 8 years, in which unemployment was never below 8 percent. Since 2002, when unemployment peaked at 20 percent, there has been a constant reduction in the unemployment rate in Colombia. However, in spite of the positive growth performance up to the global economic crisis, the average rate of unemployment remained considerably high, at an average of 14 percent in the period 2002-2009.[11] This level of unemployment is further coupled with a high and persistent rate of informality in the labor market; according to a recent World Bank study, 74 percent of the labor force was informal in 2007.[12]

Both high unemployment and informality are particularly persistent among the poor population, creating important limitations for the improvement of their welfare, as labor income represents around 75 percent of the poor's income.[13] Previous analyses of the Colombian labor market have identified two sets of complementary explanations for the high and persistent levels unemployment and informality: one has to do with labor regulations, the other with the low level of skills of a large portion of the population.

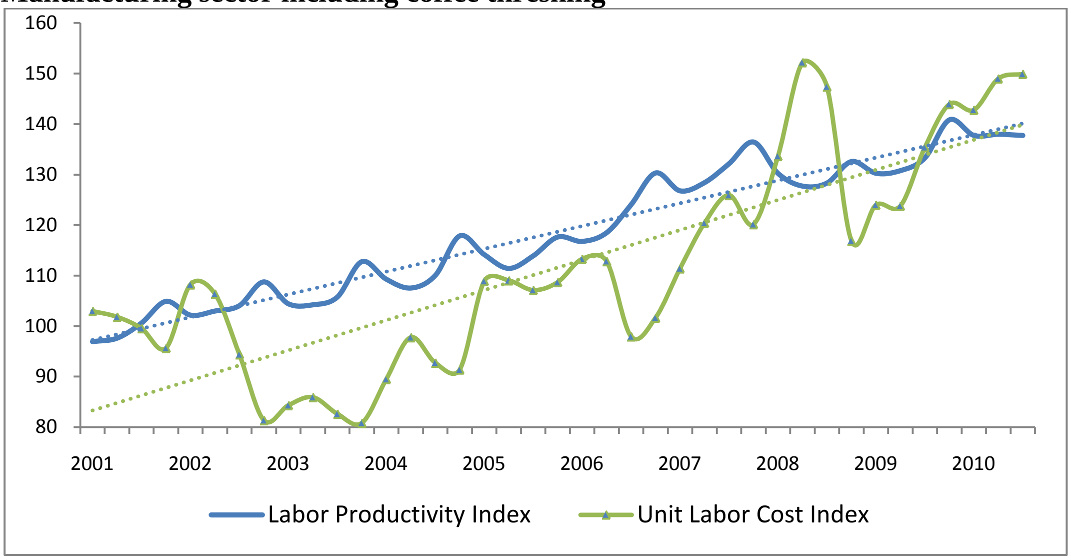
Colombian employment regulation, specifically the legal minimum wage and non-wage employment costs have created a situation in which labor costs tend to be too high relative to labor productivity, severely affecting the possibilities for job creation in the economy. As shown in Figure 1, unit labor costs growth in the Colombian manufacturing sector exceeded labor productivity growth in the period 2001-2010. This is hardly a surprise given the following figures: (1) Colombia's legal minimum wage relative to GDP per capita stands at 52 percent, and is the second highest in Latin America after Nicaragua. (2) The regulation that mandates yearly adjustments of the minimum wage to inflation and productivity lead to an increase of the minimum wage relative to average salary of 15 percentage points between 1996 and 2006 (from 39 to 54 percent).[14] (3) Non-wage costs of labor, which include payroll tax contributions used to finance contributory health insurance, pensions, and professional risk insurance, are the highest in the region,

[11] WB (2010b) -WDI
[12] In this case, informality is measured in terms of workers' contributions to health insurance and pension systems. WB (2010a)
[13] WB(2009)-(NLTA SUMMARY)
[14] Fedesarrollo (2010)

reaching up to 58 percent of total wage costs. A number of studies have found that high non-wage costs and high minimum salary have negatively affected formal employment creation in Colombia.[15]

An important possibility to consider is that innovation could be endogenous to labor market regulations. Strict labor regulations can be placing constrains on firms to acquire the human resources needed to engage in innovation activities, and therefore playing a role in limiting the amount of private investment on innovation. Conversely, the same regulations can be limiting the effect of innovation on employment, leading to an innovation that is less labor augmenting that it would otherwise be.

Figure 2: Colombia, Productivity and Unit Labor Costs 2001-2010, Manufacturing sector including coffee threshing



Source: DANE, Indicadores Laborales (III Trimestre - 2010)

[15] Kugler and Kugler (2003) examine the increase in payroll taxes and *parafiscales* in the first half of the 1990s. They find that the sharp rise in non-wage costs—over 10 percentage points between 1989 and 1996—dampened demand for formal sector workers and likely resulted in higher informality. They estimate that the changes led to a decline in formal employment of roughly 4–5 percent over the period. Cardenas and Bernal (2003) similarly find high estimated wage elasticities that suggest that the increase in non-wage costs in the early 1990s would have led to a substantial drop in labor demand. Sanchez (2008) indicates that a potential elimination of *parafiscales*(taxes to fund training –SENA- and child and family welfare services –ICBF-, and worker clubs -*Cajas deCompensación Familiar*) costs in Colombia, which make up approximately 8 percent of the payroll, would decrease unemployment by 2.3 percentage points.
A World Bank study (2005) finds that unemployment rates in Colombia starting in the late 1990s were between 1.0 and 1.8 percentage points higher than they would have been in the absence of the increase in non-wage costs. The study also finds that increases in non-wage costs contributed to increased informality during the period. In addition to the findings on its effects on unemployment and informality, the study finds that like high minimum wages, high non-wage costs has been an important contributing factor related to the increase in labor market segmentation.
Likewise, Santa Maria et al. (2008) find that the high persistence of self-employment is explained by the strong segmentations of labor markets in Colombia, which most affects the poorest and least educated. This segmentation has resulted in lower quality jobs, especially for self-employed at the low end of the distribution, whose salaries are even lower than salaries of informal salaried workers. Their estimations show that a 1 percent increase in non-wage costs leads to a reduction of 2.9 percentage points in the proportion of wage earners to self-employed workers. The same increase in non-wage costs has an even higher effect on unemployment and informality in the presence of high minimum wages, leading to a 4 percent reduction in the ratio of wage earners to self-employed workers.A World Bank study on informality (2007), finds that both high non-wage costs and the high minimum wage contribute to significant labor market segmentation in Colombia and, as such, serve to keep some workers from formal sector employment. *Extracted from: World Bank (2009) Non-Lending Technical Assistance, Colombia Poverty and Jobs. Washington D.C.*

On the other hand, there is a high degree of skills mismatches which arise mainly due to the low levels of education, labor experience and social capital of the poor. This situation can have two potential implications that are relevant to the scope of this study. First, given the skill-biased nature of innovation and technological change, it is possible that the low level of skills held by the poor in Colombia could considerably hamper their ability to take advantage of the new employment opportunities created by innovative firms. Second, a low level of skills supply in the economy can act as a considerable obstacle for firms to innovate.

Two World Bank studies find that technological change is linked to the supply of highly educated workers (2006-WBI) and that firm level innovation is dependent on the education received by employees in the public education system (2007- Brazil KIK). These studies also present the idea that different kinds of innovation need different levels of skills. For instance, while the creation of new knowledge and technologies through R&D and engineering requires graduate level skills and extensive job training, other kinds of innovation, such as the acquisition and adaptation of foreign technologies require more basic skills, such as the ability to read and understand product manuals, to learn new processes and to resolve problems to adapt the equipment to new settings.

4. Data

This project uses two firm-level datasets gathered by the National Statistics Department (DANE). The first dataset gathers longitudinal plant-level data of the manufacturing sector for the period 2001-2007[16] (EAM) and the second collects information on innovation activities undertaken by firms during 2003 and 2004 (EDIT II) and 2005 and 2006 (EDT III). An advantage of using these datasets is that, since the innovation survey is a rider of the manufacturing survey, it is possible to link them at the firm level and estimate innovation, employment and performance related variables such as total factor productivity for each firm in the sample.

The Annual Manufacturing Survey (EAM) gathers background and detailed information of firms at the manufacturing sector, which allows a deep knowledge of its structure, characteristics and, more importantly, its evolution. The EAM is a nationwide survey of industrial establishments with 10 or more employees and/or an output value that exceeds $120 million in constant 2007 pesos (approximately US$ 65,000 as of today). This feature gives the EAM census-like properties, which makes the sample representativeness not an issue for the universe under study, making it an extraordinary instrument for firm level studies. The firms can be aggregated using the International Standard Industrial Classification (ISIC rev. 3) adapted for Colombia at four-number code level. The data is available annually and in recent years more than 8,000 plants have been surveyed. This sample corresponds to industrial directories reported by the guilds and updated every year by micro-surveys to detect the appearance of new research units.

The survey is structured in nine chapters. The first chapter collects the plant general information and identification. The second chapter collects information on employment disaggregated by gender, level (professional, technical, operations, directives), and by type of contract. The third chapter gathers information on labor costs and expenditures. Chapter four collects other costs and expenditures. The fifth chapter gathers information on energy consumption, electric and other such as fuel, oil, gas, coal,

[16] The EAM has available and homogeneous information since 1997; however for the present study we can only use data from 2001 onwards due to a revision in 2000 of the Central Product Classification (CPC) by the United Nations Statistical Commission.

etc. The sixth chapter collects information on stocks including raw material, unfinished and finished products, and other products not manufactured by the firm. The seventh chapter includes book value information on assets, investments, and technological innovation investments. This chapter also collects information on R&D and technological-innovation employment by academic level. The eighth chapter includes information on production (in quantity and value) as well as other income derived from industrial activities. This chapter is crucial for the present study as it provides detailed information on quantities produced and sold, sales unit and total value, exports, transfers, and stocks by product and by-products. Finally, the ninth chapter gathers detailed information on intermediate consumption including raw materials and packaging.

The Development and Technological Innovation Industrial Survey (EDIT) constitutes a fundamental tool for characterizing the innovation and technological development activities of the manufacturing firms in Colombia17. This survey is carried out every two years since 2005[18] to all industrial firms according to the directory of establishments in the EAM. In view of the fact that EDIT is a rider of the EAM it is possible to merge both surveys at the firm level which is extremely useful for our research purposes. Specifically, by merging the two surveys it is possible to get information related to the innovation behavior of firms and also comprehensive information regarding the firms' production function which allows us to estimate different measures of productivity and firm performance. In the 2005 round, the EDIT gathered information from all firms registered in the EAM 2003, accounting for 6,670 firms out of which 6,172 firms responded. In 2007, the EDIT gathered information from all firms registered in the EAM 2006, accounting for 6,957 firms out of which 6,080 answered the survey.

The survey consists of seven chapters, divided into three parts: the first one corresponds to the identification of the firm, location, general facts, type of organization, social capital share, number of the establishments of the firm and economic activity according to the CIIU rev 3. The second part enquires about technological development activities and objectives of innovation. Lastly, the survey gathers information regarding the financial sources of technological development and innovation activities, public innovation policies and formal protection to innovation.

Within the second part of the survey, there is a chapter that collects detailed information about the investments in technological development and innovation activities undertaken by firms during 2003 and 2004. In the survey, the innovation investment is classified as follows: i) investment on capital-related technologies; ii) management-related technologies; iii) cross-cutting technologies -including patent and license acquisitions as well as ICTs; iv) R&D project; and iv) investment in technological training. Additionally, for each type of innovation investment, there is information about the objective of investment (product, process, management, or commercialization), its importance to the firm and the country of origin. In a different chapter the survey collects information about objectives, outputs and sources of ideas for technological innovation during 2003 and 2004. Particularly, the firms report information about the importance of their innovation objectives, the state of the innovation outputs (accomplished, in process, abandoned) and the factors impeding their achievement. Additionally, it collects information by types of innovation outputs: i) new or significantly improved goods or services to the firm; ii) new or significantly improved goods or services to the national market; iii) new or significantly improved goods or services to the international market; iv) new or significantly improved

[17] DANE runs a similar survey for firms in the service sector. In a future project this analytical and empirical study will be extended to the service sector using the EDIT-S.

[18] A pilot version was carried out in 1996 (EDIT I)

production process for the main production line; v) new or significantly improved production process for a complementary production line, vi) new or significantly improved management procedures and vii) new or significantly improved commercialization procedures. Additionally, this chapter gathers information about the origin of the sources of innovative ideas, for instance, if it the source is internal or external to firm. This information is relevant for the empirical analysis since similar information has been also used in the literature Lööf and Heshmati (2006) and Masso and Vahter (2008). Finally, there is a chapter that gathers information on the firms' personnel per area or department, according to the type of appointment (permanent, temporary), gender, education level and origin. This information is relevant as well because it allows us calculating in a very accurately manner the human capital of the firms. In addition, this chapter collects information on investment in innovation and technological training.

In the third part of the survey there is a chapter dedicated to the financial sources for technological development and innovation activities. It collects information about the types of financing, an evaluation of the usefulness of each type and its specific problems. Additionally, in this part there of the survey there is a chapter that gathers information on the instruments of public policy oriented towards science and technology provided to firms. These chapters are of considerable importance for the research analysis since their information allows us to study the potential financial constraints to innovation and the importance of public innovation policies. Finally, there is a chapter dedicated to formal protections of innovation. It collects information regarding patent applications, industrial design registration, trademark registration, copyright registration and new software registration.

Descriptive Statistics

In Table 3 we present descriptive statistics of the main variables employed in the estimations. After merging the 2004 and 2006 data, we end up using information on a total of 4433 manufacturing firms. On average, only 5% of firms have more than 10% of foreign capital and 38% are located in Bogota, the Nation´s capital.

In terms of employment, firms experienced on average a growth rate of 3 percent. Note though that firms underwent organizational innovation changes experiences a relatively lower growth rate (2.48%) than firms considered product or process innovators (4.33 and 4.64% respectively) and even than non-innovator firms (4.08%).

Regarding the growth of sales it is interesting to note that product and process innovator firms exhibit greater rates (10.65 and 12.11%) than non-innovators (8.77%) and firms that underwent organizational innovation changes (8.84%).

Interestingly, product innovator firms experienced larger labor productivity changes (7.78%) than non-innovators (4.69%) and even than process and organizational innovators (6.01 and 6.35%).

As it has been amply documented elsewhere, only a small set of Colombian manufacturing firms exert R&D effort. In our dataset, only 1.65% of firms engage continuously in R&D activities and the ratio of R&D investment to sales is practically zero. When looking at innovation effort, one finds that 9% of the manufacturing firms are considered product innovators and 8% are both process and product innovators. Finally, the share of sales of new products amounts to 3.24% for the whole sample and to 36.1% when considering the product innovators only.

Table 6. Manufacturing firms: process and product innovators, growth of employment, sales and prices and sources of information

	Mean	Median	Standard deviation	Minimum	Maximum
Number of observations (firms)	4433				
Number of employees at the beginning of (each) survey	60.96	29.00	87.13	3.00	741.00
Foreign Ownsership (10% or more)	0.05	0.00	0.22	0.00	1.00
Located in the capital of the country	0.38	0.00	0.48	0.00	1.00
Employment growth (%) (yearly rate)					
All firms	3.01	2.19	17.61	-144.52	125.62
Non-innovators (no process or product innovations)	4.08	3.51	17.58	-58.16	106.26
Process only innovators (non product innovators)	4.64	3.30	15.48	-33.65	88.65
Organizational change innovator (non product innovators)	2.48	1.62	17.42	-144.52	125.62
Product innovators	4.33	3.30	18.82	-83.25	106.01
Growth wage bill per worker (%) (yearly rate)	13.53	13.22	23.57	-180.66	414.74
Sales growth (%)[2] (nominal growth) (yearly rate)					
All firms	9.52	9.41	20.48	-149.58	197.76
Non-innovators (no process or product innovations)	8.77	9.15	19.23	-75.66	103.34
Process only innovators (non product innovators)	10.65	10.16	16.67	-56.81	57.36
Organizational change innovator (non product innovators)	8.84	8.86	19.70	-126.79	112.89
Product innovators	12.11	11.26	24.38	-149.58	197.76
of which:					
Old products	-10.59	-8.45	20.61	-109.75	65.03
New products	22.69	17.00	20.58	-39.83	247.76
Labor productivity growth (%) (yearly rate)					
All firms	6.50	6.43	19.06	-117.62	113.00
Non-innovators (no process or product innovations)	4.69	5.33	18.85	-97.71	64.98
Process only innovators (non product innovators)	6.01	6.65	16.48	-71.65	41.85
Organizational change innovator (non product innovators)	6.35	6.29	18.72	-112.87	113.00
Product innovators	7.78	7.40	21.01	-117.62	110.54
Prices growth (%) [3]					
All firms	0.03	0.04	0.26	-3.60	3.39
Non-innovators (no process or product innovations)	0.03	0.04	0.12	-0.81	0.57
Process only innovators (non product innovators)	0.03	0.04	0.22	-1.91	1.15
Organizational change innovator (non product innovators)	0.03	0.04	0.28	-3.60	3.39
Product innovators	0.04	0.03	0.18	-1.81	0.82
Knowledge/innovation					
Continuous R&D engagement (0/1)	0.0165			0.00	1.00
R&D/sales	0.00	0.00	0.00	0.00	0.18
Innovation expenditures /sales	0.02	0.00	0.05	0.00	0.67
Innovator (product and process innovation) (0/1)	0.08			0.00	1.00
Product innovation	0.09			0.00	1.00
Share of sales with new products (for the whole estimation sample)	3.24	0.00	12.59	0.00	100.00
Share of sales with new products (for firms with product innovation)	36.10	33.33	24.10	4.17	100.00
Labour productivity	89,579.94	57,847.28	101,790.80	7,157.98	1,549,497.00

Notes:
1. Growth rates are calculated between 2004 and 2006 using the EDIT II and EDIT III surveys. Prices and sales information are calculated using the EAM survey for the same period.
2. Sales growth for each type of firm is the average of variable g and averages for old and new products are the averages of variables g1 and g2, respectively.
3. Prices computed at firm level.

5. Empirical evidence of the impact of innovation on productivity

a. Main questions (as introduction)

b. Empirical Strategy: the CDM Model

c. Results

6. Empirical evidence of the impact of innovation on employment

a. Main questions (as introduction)

b. Empirical Strategy: the Jordi Model

The microeconomic framework used to link innovation and employment follows a structural model developed by Jaumandreu (2003), which has been the base of several recent studies (Peters, 2004 and 2008; Hall, Lotti and Mairesse, 2007; and Benavente and Lauterbach, 2008; and Harrison et al., 2009). The model allows estimating structural parameters separating the effects in employment due to process and product innovation. In what follows, the theoretical and empirical framework will be portrayed[19].

The production problem

The analysis is based in a two-period model in which the firm can produce two different products, the old or marginally modified products denoted by $i = 1$, and the new or significantly improved products denoted by $i = 2$. In the first period ($t = 1$) the firm only produces the old product Y_{11}, hence Y_{21} is equal to zero. However, during the first period the firm can decide to introduce new products for commercialization in the market in which case the production of old and new products in the second period would be positive ($Y_{12} > 0$ and $Y_{21} > 0$, respectively).

The production technology for both products is assumed to present constant returns to scale in capital, labor and intermediate inputs. Hence, it can be written as two identical and separable production functions with different technology parameters θ.

Equation (1) describes the production technology for both the old and new products:

$$Y_{it} = \theta_{it}\, F(K_{it}, L_{it}, M_{it})e^{\eta+\omega_{it}} \qquad i = 1, t = 1,2 \ and \ i = 2, t = 2 \qquad (1)$$

where K, L y M represent capital, labor and intermediate inputs respectively. η is an unobservable productivity fixed effect for each firm, and ϖ represents productivity shocks with $E(\omega_{it}) = 0$.

The cost functions faced by the firm are given by the following:

$$C(w_{it}, Y_{it}, \theta_{it}) = c(w_{it})\frac{Y_{it}}{\theta_{it}e^{\eta+\omega_{it}}} + F_i \qquad (2)$$

where the marginal costs given by $\frac{c(w)}{\theta e^{\eta+\varpi}}$ are functions of the input prices and F corresponds to an exogenous fixed cost.

Given that the firm chooses its input quantities according to a cost minimization problem, the demands for labor for both the old and the new products are obtained by using Shepard's lemma, and therefore can be written as:

[19] This section relies greatly on Benavente and Lauterbach (2007) and Harrison et al. (2009).

$$L_{1t} = c_{wL}(w_{1t})\frac{Y_{1t}}{\theta_{1t}e^{\eta+\omega_{1t}}} \qquad \text{for } t = 1,2$$

and

$$L_{22} = \begin{cases} c_{wL}(w_{22})\dfrac{Y_{22}}{\theta_{22}e^{\eta+\omega_{22}}} & If\ Y_{22} > 0 \\ 0 & Otherwise \end{cases}$$

where $c_{wL}(.)$ represents the derivative of $c(.)$ with respect to the wage, which for simplicity is assumed to be the same for the two products in both periods[20].

The employment equation

Employment growth during the period of analysis can be decomposed into growth of employment due to old products and growth of employment due to the introduction of new outputs as follows:

$$\frac{\Delta L}{L} = \frac{L_{12} - L_{11} + L_{22}}{L_{11}} = \frac{L_{12} - L_{11}}{L_{11}} + \frac{L_{22}}{L_{11}}$$

where by convention the rate of growth of new products is defined as $\frac{L_{22}}{L_{11}}$.

Using a logarithmic rate of growth for old products, as well as the main results and assumptions from the preceding paragraphs, a simple linear equation in terms of productivity and the production of the two different products is derived:

$$\frac{\Delta L}{L} \cong -(\ln\theta_{12} - \ln\theta_{11}) + (\ln Y_{12} - \ln Y_{11}) + \frac{\theta_{11}}{\theta_{22}}.\frac{Y_{22}}{Y_{11}} - (\omega_{12} - \omega_{11}) \qquad (3)$$

According to Equation (3) employment growth depends on i) the change in the efficiency of the production process of old products between the two periods, ii) the rate of change of the demand for old products, iii) the output expansion attributable to new products, and iv) the impact of unobserved productivity shocks[21].

Although efficiency may improve over time due to knowledge spillovers and learning by doing, larger efficiency gains are expected in the production of old products $(\ln\theta_{12} - \ln\theta_{11})$ in those firms that introduce process innovation to produce them.

In addition, given that the marginal cost with respect to wages is equal for old and new products, the effect of product innovation on employment depends on the ratio of the relative efficiency of producing old and new products $(\frac{\theta_{11}}{\theta_{22}})$. Therefore, if new products are produced more efficiently than old products, employment grows less than output due to the introduction of new products.

Econometric model and identification issues

In order to make an empirical estimation Equation (3) above can be written as the following econometric model:

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[20] $c_{wL}(w_{11}) = c_{wL}(w_{12}) = c_{wL}(w_{22})$ is a case where the relative prices of inputs remain constant in both periods and equal for old and new products. Notice that $c(.)$ is homogenous of degree zero and hence $c_L(.)$ is also homogenous of degree zero.

[21] Notice that due to differentiation the individual fixed effects η were eliminated.

$$\ell = \alpha_0 + \alpha_1 d + y_1 + \alpha_2 y_2 + \alpha_3 \vec{X} + \mu \quad (4)$$

where ℓ is the rate of employment growth, α_0 represents (minus) the average efficiency gains in the production of old products, y_1 and y_2 are the rates of output growth due to the production of old and new products respectively, d is a binary variable that indicates if the firm has implemented a process innovation *not associated* with product innovation, $\vec{X}$ is a set of controls variables corresponding to firm-specific characteristics, and $\mu = -(\omega_{12} - \omega_{11}) + \xi$ is a random disturbance with ξ uncorrelated and $E(\xi) = 0$.

Equation (4) identifies two major effects through α_1 and α_2: the displacement effect due to gains in productivity as a consequence of process innovation and the gross positive effect of product innovation on employment. However, there are at least three effects that cannot be separately identified with this model: i) the increase in demand over time due to business cycle or industry effects; ii) the compensation effect induced by prices variations in old products as a result of process innovation; and iii) the demand's substitution effect due to the introduction of new products to the market.

The identification and consistent estimation of the parameters of interest depends on the correlation between the variables representing process and product innovation (d and y_2) and the error term μ. As it was described above, productivity shocks are contained in the error term and hence the consistent estimation of the parameters depends on the timing of the investment decisions and the possible serial correlation between the productivity shocks[22]. Thus, given the possible correlation between variables representing process and product innovation (d and y_2) and the productivity shocks within the error term (μ), OLS estimators may be biased in which case it would be necessary to estimate Equation (4) using instrumental variables or other techniques that allow to correct for such endogeneity problem.

Before proceeding to the empirical application of the model it is necessary to account for some additional difficulties in the estimation resulting from measurement error. Considering that growth in real production is not observed directly we use growth in nominal sales, deflated using firm-level implicit prices, as a proxy. In order to do it so, we adapted the methodology proposed by Eslava et al. (2009) and constructed a price index at the firm level using detailed information from EAM on production quantities and sales value of each product ever produced by the firm[23]. Hence, unlike Harrison et al. (2009) and

[22] See Harrison et al (2009) for a more detailed discussion about this point.

[23] Following Eslava et al. (2009): i) We constructed the share of each product ever produced by the plant in each year and the products not produced in a specific year were assigned a zero share. Hence, we first generated a list of products ever produced in the time period we observe and computed yearly product shares. ii) Then, for each product ever produced by the plant, we estimated the mean of the shares for all years we observe in which the plant reports positive production. iii) We use these shares to calculate the price index given by $lnP_{jt} = lnP_{jt-1} + \Delta P_{jt}$, where $P_{j,2001} = 100$, $\Delta P_{jt} = \sum_{h=1}^{H} \bar{S}_{hjt} \Delta lnP_{hjt}$, $\Delta lnP_{hjt} = lnP_{hjt} - lnP_{hjt-1}$, $\bar{S}_{hjt} = \frac{1}{T}\sum_{t=1}^{T} S_{hjt}$ and j is a subscript for firm, h for product and t for time.

Note that for the years the plant is not producing a product, the product still enters the calculation with a share equal to the calculated product average for the period and with a price annual growth equal to the average of the price growth for that product according to the following: a) price change by the firm´s 4-digit ISIC code, geographical location (department), size and age. b) price change by the firm´s 4-digit ISIC code, geographical location (department) and size. c) price change by the firm´s 4-digit ISIC code and geographical location (department). d) price change by the firm´s 4-digit ISIC code. e) price change by the firm´s 3-digit ISIC code, geographical location (department), size and age. f) price change by the firm´s 3-digit ISIC code, geographical location (department) and size. g) price change by the firm´s 3-digit ISIC code and geographical location (department). h) price change by the firm´s 4-digit ISIC code. i) price change by the firm´s 2-digit ISIC code, geographical location (department), size and age. j) price change by the firm´s 2-digit ISIC code, geographical location (department) and size. k) price change by the

Benavente and Lauterbach (2007) and others, our measurement error comes from the assumptions we have made regarding the first year´s price change of new products at firm level and not from the not observing prices at the firm level as in their case.

Thus, approximating $g_1 = y_1 + \pi_1$ as the nominal growth rate of sales of old products and $g_2 = y_2 + \pi_2 y_2$ as the nominal growth rate of sales of new products, equation (4) can be rewritten as:

$$\ell - g_1 = \alpha_0 + \alpha_1 d + \alpha_2 g_2 + \alpha_3 \vec{X} + \nu \qquad (5)$$

where the new unobserved disturbance $\nu = -\pi_1 - \alpha_2 \pi_2 y_2 + \mu$ now includes price variations given that in some cases we had to impute the price change for the first time a product was produced by a firm.

Therefore, given the measurement error mentioned above and the possible correlation of process innovation and the production of new products with productivity shocks, we follow the related literature and make use of instrumental variables in order to consistently estimate equation (5). For example, Benavente and Lauterbach (2007) use the degree of the firms' utilization of novel inputs as an origin of the innovation ideas. Harrison et al. (2009) use as preferred instrument an *increased range* of goods and services indicator, which basically measures the self-reported relevance of innovation on the increase in the range of new products.

In order to obtain a consistent estimator of the impact of product innovation on employment growth we use two variables as plausible instruments. The first variable is continuous R&D defined as a dichotomous variable equal to 1 if the firm has invested in R&D during all the years it appears in the panel data. It is plausible to think that continuous investment in R&D activities is related to the production of new products and hence to the growth of sales due to new products. However, as continuous R&D is defined as an activity that the firm has done permanently, it is not related to productivity shocks or contemporary prices variations. The second variable to be used an instrument candidate is the growth of sales due to new products between the first and second year the firm appears in the panel dataset. Given that in this version of the document we only present cross section estimates the lagged variable of contemporary growth of sales due to new products (g_2) it may be a good instrument in the sense that it is unlikely that is correlated to current productivity shocks or prices variations. ***NOTE:*** *As it is mentioned in section 5, further work needs to be done in this respect, specifically trying to use other variables as instruments and implementing more econometric tests not run due to technical issues at DANE related to the Stata version. Moreover, given that we will use a relatively long panel we will also estimate the model by GMM following Blundell and Bond (1998).*

c. Results

In this section we present the main estimation results. We first present the results of OLS estimations using employment growth annualized as dependent variable according to equation (4). Then, we present the OLS and IV estimations using employment growth minus the real growth of sales of old products as specified in equation (5). The main results use data entirely from the EAM with the exception of

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firm´s 2-digit ISIC code and geographical location (department). l) price change by the firm´s 2-digit ISIC code. l) price change for the total manufacturing industry for a couple of products not produced.

organizational innovation, which is only available from EDIT. Nevertheless, for comparison and robustness checks we also present results of estimations using data from EDIT. In addition, making use of the richness of EDIT data we include different definitions of innovators. For example, we define process and product innovators using the investment effort (input) just as it is defined using EAM data but also using firms' self-reported innovation output available only from EDIT. Regarding innovation of new products we also use a definition in which we interact sales of new products with self-reported innovation output of new products. The results of these estimations are presented in the Appendix.

Table 4 presents the results of OLS estimations using employment growth as dependent variable. The first column includes an indicator of the firm being either process or product innovator, while the second includes indicator variables for process and for product innovators separately. In the third column the definition of innovator is expanded to include organizational innovation and in the fourth the specification of the second column is replicated but including a separate indicator of organizational innovation. The next four columns replicate these estimations but including additional controls such as dummies for firm's size and age. All specifications include a variable corresponding to sales of old products, an indicator variable of whether the firm is located in the Colombian capital, Bogota, and an indicator of whether the firm has at least 10% of foreign capital participation. In addition, all specifications include 2-digit industry dummies.

From Table 4 and the analogous tables in the Appendix (Table 7A, Table 8A, Table 9A and Table 10A) one observes that product innovation affects employment growth significantly in all specifications except when using the definition based on self-reported innovation output. That is, the sales of new products increase employment at the firm level.

Furthermore, it can be observed that process innovation affects employment growth significantly when defined as innovation effort in most specifications but it is never significant when using the definition based on self-reported process innovation output. Interestingly, when the input based variable is calculated using EAM data, its significant and positive effect on employment growth is robust to the inclusion of additional controls like firms' size and age.

Note also that organizational innovation is never significant regardless of the specification and that the variable of sales of old products is always significant and different from one, rejecting the hypothesis of constant returns to scale.

In some specifications, having foreign capital has a negative and significant effect on employment. Smaller firms experience less employment growth in comparison to large firms. Medium-sized firms show a similar pattern but the effect is not robust to all specifications. Finally, a robust result seems to be a u-shaped pattern with respect to firms' age. Note that employment growth decreases with age at first and after certain point it starts increasing again.

Table 7: Effect of innovation on employment quantity, OLS Estimations
Dependent variable: ℓ (Employment growth-yearly)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TPP (product or process innovator)	5.282**				3.743**			
	(0.480)				(0.497)			
Real sales growth (g1-Π)	0.356**	0.402**	0.348**	0.402**	0.340**	0.387**	0.333**	0.387**
	(0.018)	(0.020)	(0.018)	(0.020)	(0.018)	(0.020)	(0.018)	(0.020)
Product innovator		9.152**		9.281**		8.600**		8.408**
		(0.796)		(0.838)		(0.782)		(0.830)
Process innovator		2.548**		2.506**		1.035*		1.073*
		(0.481)		(0.489)		(0.496)		(0.499)
TPPWIDE (product or process innovator + org. change)			4.418**				2.813**	
			(0.523)				(0.540)	
Organizational change (only)				0.278				-0.396
				(0.516)				(0.523)
Located in the capital	0.484	0.342	0.492	0.350	0.632	0.502	0.644	0.492
	(0.502)	(0.495)	(0.505)	(0.495)	(0.495)	(0.487)	(0.496)	(0.487)
Foreign owned (10% or more)	-0.394	0.081	-0.097	0.047	-2.308*	-1.763	-2.284*	-1.750
	(1.020)	(1.012)	(1.024)	(1.018)	(1.079)	(1.066)	(1.086)	(1.066)
Small					-5.800**	-5.595**	-6.417**	-5.700**
					(0.901)	(0.880)	(0.900)	(0.897)
Medium					-1.398	-1.040	-1.578	-1.083
					(0.887)	(0.863)	(0.888)	(0.866)
Age					-0.302**	-0.305**	-0.317**	-0.305**
					(0.046)	(0.045)	(0.046)	(0.045)
Age square					0.003**	0.003**	0.003**	0.003**
					(0.001)	(0.001)	(0.001)	(0.001)
Constant	-1.804**	-2.051**	-2.125**	-2.160**	8.519**	8.047**	9.233**	8.288**
	(0.424)	(0.417)	(0.499)	(0.466)	(1.381)	(1.345)	(1.417)	(1.394)
2-digit industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4430	4430	4430	4430	4430	4430	4430	4430
R-squared	0.21	0.23	0.20	0.23	0.23	0.25	0.22	0.25

Robust standard errors in parentheses. *** significant at 1%; **significant at 5%; *significant at 10%
Note: ***Product innovator*** defined by a dummy variable equal to 1 if growth of sales due to new products is positive. ***Process innovator*** is defined based on innovation effort (input) according to EAM survey. ***Organizational innovator*** is defined based on innovation effort (input) according to EDIT survey.

In Table 5 we present the results of estimating equation (5) by OLS. In this case again the table contains eight columns out of which the last four replicate the specifications laid down in the first four columns with the additional control variables of firm size and age.

From Table 5 and its comparable tables in the Appendix (Table 11A and Table 12A) we can conclude that sales of new products have a significant positive effect on employment in all specifications.

Observe also that process innovation does not have a robust effect on employment. In fact, in most specifications, it has a negative but insignificant coefficient with the exceptions of Columns 5 and 6 which include the additional controls of firm's size and age but do not include bill wage growth per worker. Moreover, in the estimations including sales of old products set to test constant returns to scale the coefficient becomes positive and significant bringing up an interaction worth further exploration.

From the tables we can see that sales of old products have a negative effect on employment growth. Also, notice that the coefficient is different from one rejecting the hypothesis of constant returns to scale. Given the definition of the dependent variable, the estimated coefficient of g1 would in fact be around positive 0.5, which is close to the estimated 0.4 in Table 4. ***NOTE**: Here I would think we should have also used a dependent variable that does not subtract g1 for comparison purposes.*

In this set of specifications, we find again that smaller firms experience lower employment growth than larger firms. However, the earlier pattern regarding firms' age is not longer robust and it appears slightly in some specifications only (Columns 8).

It seems that location is an important factor for employment growth as we find a positive and significant coefficient to the indicator of location in the capital. This effect disappears though when including sales of old products (Columns 4 and 8).

Table 8: Effect of innovation on employment quantity, OLS Estimations
Dependent variable: *l -(g1-Π)*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Process innovation only (*d*)	-0.467	-0.535	-0.462	2.350**	-1.370*	-1.353*	-1.157	1.004*
	(0.614)	(0.616)	(0.590)	(0.482)	(0.631)	(0.631)	(0.604)	(0.484)
Real sales growth due to new products *(g2)*	0.767**	0.765**	0.784**	0.482**	0.752**	0.751**	0.771**	0.449**
	(0.032)	(0.032)	(0.029)	(0.029)	(0.032)	(0.032)	(0.029)	(0.028)
Foreign owned (10% or more)		2.161	1.492	-0.196		0.947	0.590	-2.032*
		(1.231)	(1.140)	(0.909)		(1.295)	(1.195)	(0.957)
Located in the capital		1.389*	1.520**	0.664		1.452*	1.587**	0.773
		(0.587)	(0.563)	(0.464)		(0.584)	(0.562)	(0.458)
Growth wage bill per worker			-0.213**	-0.164**			-0.212**	-0.161**
			(0.025)	(0.021)			(0.025)	(0.021)
Real sales growth (g1-Π)				-0.551**				-0.564**
				(0.019)				(0.019)
Small					-3.979**	-3.795**	-2.837**	-5.334**
					(0.886)	(0.936)	(0.896)	(0.752)
Medium					-1.544	-1.438	-0.828	-1.078
					(0.925)	(0.950)	(0.903)	(0.750)
Age					-0.114*	-0.119*	-0.134**	-0.266**
					(0.053)	(0.053)	(0.052)	(0.041)
Age square					0.001	0.001	0.001	0.002**
					(0.001)	(0.001)	(0.001)	(0.000)
Constant	-5.364**	-5.967**	-3.207**	-0.193	0.049	-0.618	1.524	8.819**
	(0.397)	(0.459)	(0.522)	(0.443)	(1.372)	(1.430)	(1.375)	(1.171)
2-digit industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4430	4430	4430	4430	4430	4430	4430	4430
R-squared	0.22	0.22	0.27	0.52	0.22	0.22	0.28	0.53

Robust standard errors in parentheses. *** significant at 1%; **significant at 5%; *significant at 10%
Note: ***Product innovator*** is defined based on real growth of sales due to new products. ***Process innovator*** is defined based on innovation effort (input) according to EAM survey.

IV estimations

As it was mentioned earlier, it may be suspected that sales of new products may be endogenous in these estimations as is the case for process innovation. Also, the measurement error associated with the construction of the real sales variables may introduce biased results. In order to correct for these problems we estimate an IV regression using continued R&D effort and lagged (initial period) sales of new product as instruments. Also, we apply the exogeneity test proposed by Davison and MacKinnon (1993) for which the null hypothesis states that an OLS estimator of the same equation would yield consistent estimates.

In Table 6 we present the results of the IV estimations using lagged sales of new products as instruments. The results are practically the same when using both continued R&D effort and lagged sales of new products so we do not show them here to preserve space. When only using the R&D effort the estimation results turn unstable and further exploration is needed.

As it can be observed from Table 6 (and its analogous in the Appendix: Table 13A and Table 14A), based on the p-values of the F-Statistic reported at the bottom of the table we cannot reject the null hypothesis of exogeneity. In fact, the coefficients of all variables, but most importantly of the sales of new products are practically the same as those of the OLS regressions. One explanation for this result is that the variable of sales of new products is not endogenous and that the measurement error is irrelevant for the estimations.

Also, one may argue that other instruments may be explored and tested as the panel is not long enough to assure that the lagged variable of sales of new products is not correlated to current productivity shocks via their own possible serial correlation (productivity shocks may be persistent enough to cause this correlation). Hence, further analysis will be done in this front and it will be presented in the next version.

Table 9: Effect of innovation on employment quantity, IV Estimations
Dependent variable: *l -(g1-Π)*

	(1)	(2)	(3)	(4)	(5)	(6)
Process innovation only (*d*)	-0.326	-0.325	-0.611	3.078**	-1.489	-1.394
	(1.077)	(1.086)	(1.043)	(0.730)	(1.257)	(1.255)
Real sales growth due to new products *(g2)*	0.790**	0.799**	0.760**	0.640**	0.735**	0.745**
	(0.145)	(0.145)	(0.139)	(0.118)	(0.154)	(0.153)
Foreign owned (10% or more)		2.101	1.537	-0.366		0.950
		(1.335)	(1.289)	(1.040)		(1.351)
Located in the capital		1.385*	1.522**	0.698		1.453*
		(0.590)	(0.569)	(0.465)		(0.590)
Growth wage bill per worker			-0.212**	-0.170**		
			(0.012)	(0.010)		
Real sales growth (g1-Π)				-0.521**		
				(0.025)		
Small					-4.042**	-3.816**
					(1.256)	(1.275)
Medium					-1.557	-1.442
					(1.165)	(1.175)
Age					-0.116*	-0.120*
					(0.059)	(0.059)
Age square					0.001	0.001
					(0.001)	(0.001)
Constant	-5.505**	-6.170**	-3.069**	-1.166	0.246	-0.551
	(0.956)	(0.968)	(0.905)	(0.813)	(2.322)	(2.322)
2-digit industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Endogeneity	.8728	.8145	.8614	.1748	.9124	.9697
Observations	4430	4430	4430	4430	4430	4430
Number of ciiu2	21	21	21	21	21	21

Standard errors in parentheses. *** significant at 1%; **significant at 5%; *significant at 10%

Note: ***Product innovator*** is defined based on real growth of sales due to new products. ***Process innovator*** is defined based on innovation effort (input) according to EAM survey.

7. Concluding remarks

8. References

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9. Appendix

Table 10A: Effect of innovation on employment quantity, OLS Estimations
Dependent variable: ℓ (Employment growth-yearly)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TPP (product or process innovator)	5.152**				3.758**			
	(0.487)				(0.502)			
Real sales growth (g1-Π)	0.361**	0.406**	0.351**	0.406**	0.343**	0.388**	0.335**	0.388**
	(0.019)	(0.020)	(0.018)	(0.020)	(0.019)	(0.020)	(0.018)	(0.020)
Product innovator		9.424**		9.550**		8.701**		8.507**
		(0.790)		(0.830)		(0.777)		(0.823)
Process innovator		1.995**		1.941**		0.643		0.704
		(0.480)		(0.489)		(0.502)		(0.505)
TPPWIDE (product or process innovator + org. change)			4.285**				2.867**	
			(0.516)				(0.536)	
Organizational change (only)				0.277				-0.402
				(0.516)				(0.523)
Located in the capital	0.524	0.377	0.557	0.383	0.667	0.514	0.691	0.505
	(0.501)	(0.496)	(0.504)	(0.496)	(0.494)	(0.488)	(0.495)	(0.488)
Foreign owned (10% or more)	-0.009	0.342	0.176	0.308	-2.093	-1.710	-2.138*	-1.696
	(1.019)	(1.016)	(1.024)	(1.021)	(1.074)	(1.067)	(1.084)	(1.066)
Small					-5.821**	-5.786**	-6.412**	-5.885**
					(0.894)	(0.882)	(0.899)	(0.897)
Medium					-1.273	-1.070	-1.530	-1.110
					(0.884)	(0.862)	(0.886)	(0.865)
Age					-0.312**	-0.309**	-0.322**	-0.308**
					(0.046)	(0.045)	(0.046)	(0.045)
Age square					0.003**	0.003**	0.003**	0.003**
					(0.001)	(0.001)	(0.001)	(0.001)
Constant	-1.689**	-1.832**	-1.999**	-1.936**	8.658**	8.400**	9.279**	8.631**
	(0.425)	(0.423)	(0.500)	(0.469)	(1.370)	(1.353)	(1.410)	(1.398)
2-digit industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4430	4430	4430	4430	4430	4430	4430	4430
R-squared	0.20	0.22	0.20	0.22	0.23	0.25	0.22	0.25

Robust standard errors in parentheses. *** significant at 1%; **significant at 5%; *significant at 10%
Note: ***Product innovator*** defined by a dummy variable equal to 1 if growth of sales due to new products is positive. ***Process innovator*** is defined based on innovation effort (input) according to EDIT survey. ***Organizational innovator*** is defined based on innovation effort (input) according to EDIT survey.

Table 11A: Effect of innovation on employment quantity, OLS Estimations

Dependent variable: ℓ (Employment growth-yearly)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TPP (product or process innovator)	-0.026				0.267			
	(0.836)				(0.826)			
Real sales growth (g1-Π)	0.344**	0.408**	0.344**	0.408**	0.328**	0.388**	0.328**	0.388**
	(0.019)	(0.020)	(0.019)	(0.020)	(0.018)	(0.020)	(0.019)	(0.020)
Product innovator		9.620**		8.774**		8.722**		8.222**
		(0.785)		(1.052)		(0.773)		(1.042)
Process innovator		-1.385		-1.000		-1.002		-0.774
		(0.809)		(0.904)		(0.797)		(0.896)
TPPWIDE (product or process innovator + org. change)			0.181				0.534	
			(1.039)				(1.012)	
Organizational change (only)				-0.975				-0.580
				(0.809)				(0.806)
Located in the capital	0.438	0.344	0.439	0.339	0.615	0.514	0.622	0.511
	(0.509)	(0.496)	(0.510)	(0.496)	(0.498)	(0.487)	(0.498)	(0.487)
Foreign owned (10% or more)	0.759	0.719	0.758	0.701	-2.175*	-1683	-2.183*	-1683
	(1.022)	(1.008)	(1.021)	(1.007)	(1.086)	(1.068)	(1.086)	(1.067)
Small					-7.437**	-6.045**	-7.442**	-6.020**
					(0.878)	(0.844)	(0.879)	(0.845)
Medium					-1.773*	-1.188	-1.778*	-1.182
					(0.886)	(0.856)	(0.886)	(0.857)
Age					-0.328**	-0.309**	-0.328**	-0.310**
					(0.046)	(0.045)	(0.046)	(0.045)
Age square					0.003**	0.003**	0.003**	0.003**
					(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.974	0.137	0.778	0.650	11.888**	9.760**	11.629**	10.049**
	(0.844)	(0.825)	(1.052)	(0.876)	(1.491)	(1.458)	(1.621)	(1.479)
2-digit industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4430	4430	4430	4430	4430	4430	4430	4430
R-squared	0.18	0.22	0.18	0.22	0.22	0.25	0.22	0.25

Robust standard errors in parentheses. *** significant at 1%; **significant at 5%; *significant at 10%

Note: ***Product innovator*** defined by a dummy variable equal to 1 if growth of sales due to new products is positive. ***Process innovator*** is defined based on innovation output according to EDIT survey. ***Organizational innovator*** is defined based on innovation output according to EDIT survey.

Table 12A: Effect of innovation on employment quantity, OLS Estimations

Dependent variable: ℓ (Employment growth-yearly)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TPP (product or process innovator)	-3.026				-2.762			
	(1.605)				(1.508)			
Real sales growth (g1-Π)	0.344**	0.343**	0.344**	0.343**	0.328**	0.328**	0.329**	0.328**
	(0.019)	(0.019)	(0.019)	(0.019)	(0.018)	(0.019)	(0.018)	(0.018)
Product innovator		0.351		-0.596		0.511		-0.547
		(1.264)		(1.702)		(1.217)		(1.617)
Process innovator		-1.731*		-1.655		-1.311		-1.226
		(0.864)		(0.868)		(0.862)		(0.867)
TPPWIDE (product or process innovator + org. change)			-3.990*				-3.665*	
			(1.966)				(1.839)	
Organizational change (only)				-2.162				-2.418
				(2.357)				(2.261)
Located in the capital	0.429	0.463	0.397	0.435	0.609	0.635	0.580	0.604
	(0.509)	(0.509)	(0.510)	(0.511)	(0.498)	(0.498)	(0.499)	(0.500)
Foreign owned (10% or more)	0.837	0.752	0.850	0.785	-2.112	-2.176*	-2.096	-2.141*
	(1.021)	(1.024)	(1.022)	(1.024)	(1.084)	(1.087)	(1.085)	(1.087)
Small					-7.463**	-7.431**	-7.446**	-7.430**
					(0.878)	(0.878)	(0.879)	(0.879)
Medium					-1.818*	-1.820*	-1.802*	-1.816*
					(0.885)	(0.886)	(0.886)	(0.886)
Age					-0.325**	-0.327**	-0.327**	-0.328**
					(0.046)	(0.046)	(0.046)	(0.046)
Age square					0.003**	0.003**	0.003**	0.003**
					(0.001)	(0.001)	(0.001)	(0.001)
Constant	3.880*	2.139	4.863*	3.024	14.796**	12.783**	15.713**	13.784**
	(1.612)	(1.271)	(1.984)	(1.667)	(2.054)	(1.804)	(2.327)	(2.081)
2-digit industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4430	4430	4430	4430	4430	4430	4430	4430
R-squared	0.18	0.18	0.18	0.18	0.22	0.22	0.22	0.22

Robust standard errors in parentheses. *** significant at 1%; **significant at 5%; *significant at 10%

Note: ***Product innovator*** defined based on innovation output according to EDIT. ***Process innovator*** is defined based on innovation output according to EDIT survey. ***Organizational innovator*** is defined based on innovation output according to EDIT survey.

Table 13A. Effect of innovation on employment quantity, OLS Estimations
Dependent variable: ℓ (Employment growth-yearly)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TPP (product or process innovator)	-0.896				-0.504			
	(0.874)				(0.852)			
Real sales growth (g1-Π)	0.343**	0.403**	0.343**	0.403**	0.327**	0.383**	0.328**	0.384**
	(0.019)	(0.020)	(0.019)	(0.020)	(0.019)	(0.020)	(0.019)	(0.020)
Product innovator		9.288**		7.888**		8.423**		7.453**
		(0.798)		(1.074)		(0.791)		(1.067)
Process innovator		-1.783*		-1.093		-1.358		-0.880
		(0.821)		(0.897)		(0.807)		(0.894)
TPPWIDE (product or process innovator + org. change)			-1.183				-0.672	
			(1.116)				(1.070)	
Organizational change (only)				-1.607				-1.121
				(0.821)				(0.814)
Located in the capital	0.447	0.345	0.428	0.334	0.623	0.517	0.612	0.509
	(0.509)	(0.497)	(0.510)	(0.497)	(0.498)	(0.488)	(0.498)	(0.488)
Foreign owned (10% or more)	0.750	0.677	0.773	0.657	-2.182*	-1.781	-2.168*	-1.771
	(1.023)	(1.006)	(1.021)	(1.005)	(1.087)	(1.069)	(1.085)	(1.068)
Small					-7.443**	-6.223**	-7.434**	-6.165**
					(0.879)	(0.853)	(0.879)	(0.855)
Medium					-1.800*	-1.298	-1.788*	-1.279
					(0.886)	(0.862)	(0.886)	(0.865)
Age					-0.327**	-0.312**	-0.327**	-0.312**
					(0.046)	(0.045)	(0.046)	(0.045)
Age square					0.003**	0.003**	0.003**	0.003**
					(0.001)	(0.001)	(0.001)	(0.001)
Constant	1.759*	0.654	2.070	1.442	12.584**	10.419**	12.755**	10.926**
	(0.892)	(0.848)	(1.141)	(0.931)	(1.543)	(1.498)	(1.704)	(1.545)
2-digit industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4430	4430	4430	4430	4430	4430	4430	4430
R-squared	0.18	0.22	0.18	0.22	0.22	0.24	0.22	0.24

Robust standard errors in parentheses. *** significant at 1%; **significant at 5%; *significant at 10%
Note: ***Product innovator*** defined based on both innovation output according to EDIT survey & positive growth of sales due to new products.. ***Process innovator*** is defined based on innovation output according to EDIT survey. ***Organizational innovator*** is defined based on innovation output according to EDIT survey.

Table 14A: Effect of innovation on employment quantity, OLS Estimations

Dependent variable: l -(g1-Π)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Process innovation only (*d*)	1.266	1.319	1.34	2.383**	1.126	1.163	1.169	1.994**
	(0.880)	(0.882)	(0.860)	(0.687)	(0.884)	(0.886)	(0.863)	(0.677)
Real sales growth due to new products *(g2)*	0.775**	0.774**	0.793**	0.472**	0.769**	0.768**	0.786**	0.447**
	(0.032)	(0.031)	(0.028)	(0.029)	(0.032)	(0.032)	(0.029)	(0.028)
Foreign owned (10% or more)		2.086	1.432	0.367		0.880	0.537	-1.898*
		(1.228)	(1.136)	(0.903)		(1.296)	(1.196)	(0.954)
Located in the capital		1.413*	1.543**	0.631		1.488*	1.619**	0.769
		(0.587)	(0.563)	(0.464)		(0.585)	(0.562)	(0.458)
Growth wage bill per worker			-0.213**	-0.164**			-0.212**	-0.161**
			(0.025)	(0.021)			(0.025)	(0.020)
Real sales growth (g1-Π)				-0.545**				-0.563**
				(0.019)				(0.019)
Small					-3.565**	-3.401**	-2.502**	-5.684**
					(0.864)	(0.916)	(0.878)	(0.733)
Medium					-1.561	-1.467	-0.863	-1.247
					(0.927)	(0.950)	(0.905)	(0.747)
Age					-0.102	-0.108*	-0.124*	-0.268**
					(0.053)	(0.053)	(0.052)	(0.041)
Age square					0.001	0.001	0.001	0.002**
					(0.001)	(0.001)	(0.001)	(0.000)
Constant	-5.712**	-6.352**	-3.566**	0.306	-1.093	-1.749	0.535	9.214**
	(0.327)	(0.401)	(0.500)	(0.430)	(1.295)	(1.359)	(1.320)	(1.126)
2-digit industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4430	4430	4430	4430	4430	4430	4430	4430
R-squared	0.22	0.22	0.27	0.52	0.22	0.22	0.28	0.54

Robust standard errors in parentheses. *** significant at 1%; **significant at 5%; *significant at 10%

Note: ***Product innovator*** is defined based on real growth of sales due to new products. ***Process innovator*** is defined based on innovation effort (input) according to EDIT survey.

Table 15A: Effect of innovation on employment quantity, OLS Estimations

Dependent variable: l -(g1-Π)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Process innovation only (*d*)	-0.708	-0.686	-0.138	1.473	-0.966	-0.903	-0.293	1.091
	(1.122)	(1.126)	(1.108)	(0.894)	(1.129)	(1.132)	(1.117)	(0.906)
Real sales growth due to new products *(g2)*	0.770**	0.769**	0.788**	0.467**	0.764**	0.763**	0.782**	0.442**
	(0.031)	(0.031)	(0.028)	(0.029)	(0.031)	(0.031)	(0.028)	(0.028)
Foreign owned (10% or more)		2.066	1.399	0.271		0.856	0.507	-1.961*
		(1.228)	(1.136)	(0.905)		(1.297)	(1.196)	(0.957)
Located in the capital		1.396*	1.531**	0.628		1.470*	1.608**	0.767
		(0.587)	(0.563)	(0.465)		(0.585)	(0.562)	(0.459)
Growth wage bill per worker			-0.213**	-0.165**			-0.212**	-0.161**
			(0.025)	(0.021)			(0.025)	(0.021)
Real sales growth (g1-Π)				-0.545**				-0.562**
				(0.019)				(0.019)
Small					-3.563**	-3.400**	-2.485**	-5.606**
					(0.864)	(0.916)	(0.877)	(0.736)
Medium					-1.483	-1.389	-0.785	-1.113
					(0.925)	(0.949)	(0.903)	(0.749)
Age					-0.104	-0.110*	-0.127*	-0.272**
					(0.053)	(0.053)	(0.051)	(0.041)
Age square					0.001	0.001	0.001	0.002**
					(0.001)	(0.001)	(0.001)	(0.000)
Constant	-5.497**	-6.124**	-3.370**	0.550	-0.867	-1.512	0.728	9.425**
	(0.315)	(0.390)	(0.477)	(0.419)	(1.285)	(1.347)	(1.307)	(1.125)
2-digit industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4430	4430	4430	4430	4430	4430	4430	4430
R-squared	0.22	0.22	0.27	0.52	0.22	0.22	0.28	0.53

Robust standard errors in parentheses. *** significant at 1%; **significant at 5%; *significant at 10%

Note: ***Product innovator*** is defined based on real growth of sales due to new products. ***Process innovator*** is defined based on innovation output according to EDIT survey.

Table 16A: Effect of innovation on employment quantity, IV Estimations

Dependent variable: l -(g1-Π)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Process innovation only (*d*)	1.338	1.435	1.2	2.992**	1.008	1.096	0.837	2.340**
	(1.082)	(1.08)	(1.038)	(0.802)	(1.11)	(1.108)	(1.066)	(0.813)
Real sales growth due to new products *(g2)*	0.791**	0.800**	0.762**	0.642**	0.744**	0.754**	0.715**	0.539**
	(0.145)	(0.144)	(0.139)	(0.119)	(0.150)	(0.149)	(0.143)	(0.124)
Foreign owned (10% or more)		2.075	1.446	0.366		0.879	0.532	-1.807
		(1.305)	(1.259)	(1.029)		(1.349)	(1.301)	(1.052)
Located in the capital		1.407*	1.550**	0.656		1.492*	1.639**	0.776
		(0.591)	(0.569)	(0.466)		(0.591)	(0.571)	(0.457)
Growth wage bill per worker			-0.212**	-0.171**			-0.210**	-0.164**
			(0.012)	(0.011)			(0.012)	(0.010)
Real sales growth (g1-Π)				-0.510**				-0.543**
				(0.027)				(0.028)
Small					-3.600**	-3.421**	-2.608*	-5.454**
					(1.121)	(1.152)	(1.115)	(0.932)
Medium					-1.565	-1.47	-0.880	-1.214
					(1.161)	(1.172)	(1.131)	(0.908)
Age					-0.105	-0.109	-0.132*	-0.254**
					(0.057)	(0.057)	(0.055)	(0.046)
Age square					0.001	0.001	0.001	0.002**
					(0.001)	(0.001)	(0.001)	(0.001)
Constant	-5.784**	-6.469**	-3.436**	-0.573	-0.900	-1.64	1.058	8.321**
	(0.734)	(0.754)	(0.705)	(0.698)	(1.814)	(1.838)	(1.752)	(1.645)
2-digit industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Endogeneity	.9124	.8567	.8206	.1441	.865	.9226	.6152	.4492
Observations	4430	4430	4430	4430	4430	4430	4430	4430
Number of ciiu2	21	21	21	21	21	21	21	21

Robust standard errors in parentheses. *** significant at 1%; **significant at 5%; *significant at 10%

Note: ***Product innovator*** is defined based on real growth of sales due to new products. ***Process innovator*** is defined based on innovation effort (input) according to EDIT survey.

Table 17A: Effect of innovation on employment quantity, IV Estimations
Dependent variable: l -(g1-Π)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Process innovation only (*d*)	-0.627	-0.562	-0.260	2.047	-1.072	-0.960	-0.602	1.416
	(1.410)	(1.409)	(1.360)	(1.071)	(1.425)	(1.423)	(1.376)	(1.064)
Real sales growth due to new products *(g2)*	0.789**	0.798**	0.760**	0.645**	0.740**	0.750**	0.713**	0.540**
	(0.146)	(0.145)	(0.139)	(0.120)	(0.150)	(0.150)	(0.144)	(0.124)
Foreign owned (10% or more)		2.048	1.419	0.239		0.857	0.514	-1.878
		(1.308)	(1.261)	(1.032)		(1.349)	(1.302)	(1.052)
Located in the capital		1.389*	1.537**	0.656		1.474*	1.627**	0.775
		(0.591)	(0.570)	(0.467)		(0.592)	(0.571)	(0.458)
Growth wage bill per worker			-0.212**	-0.172**			-0.210**	-0.165**
			(0.012)	(0.011)			(0.012)	(0.011)
Real sales growth (g1-Π)				-0.508**				-0.541**
				(0.027)				(0.029)
Small					-3.602**	-3.421**	-2.605*	-5.342**
					(1.130)	(1.159)	(1.123)	(0.942)
Medium					-1.495	-1.396	-0.824	-1.054
					(1.161)	(1.173)	(1.132)	(0.910)
Age					-0.106	-0.111*	-0.134*	-0.258**
					(0.056)	(0.056)	(0.054)	(0.046)
Age square					0.001	0.001	0.001	0.002**
					(0.001)	(0.001)	(0.001)	(0.001)
Constant	-5.577**	-6.244**	-3.262**	-0.321	-0.690	-1.416	1.216	8.505**
	(0.690)	(0.711)	(0.663)	(0.669)	(1.790)	(1.811)	(1.726)	(1.627)
2-digit industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Endogeneity	.8975	.8418	.8389	.1288	.8722	.9298	.6251	.4253
Observations	4430	4430	4430	4430	4430	4430	4430	4430
Number of ciiu2	21	21	21	21	21	21	21	21

Robust standard errors in parentheses. *** significant at 1%; **significant at 5%; *significant at 10%
Note: ***Product innovator*** is defined based on real growth of sales due to new products. ***Process innovator*** is defined based on innovation output according to EDIT survey.