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# Firm's innovation strategies and employment: New evidence from Uruguay.

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## Abstract

A large and rich body of literature has shown that the relationship between innovation and employment is complex and dynamic in nature. From a firm's level analysis, recent researches have shown heterogeneous empirical patterns for developed and developing countries. This paper contributes by inquiry in the role of innovation strategies as determinants of the firm's employment growth in a Latin American small middle-income country. Adapting econometric structural models currently in vogue, we discuss the effects of three innovation strategies (Make, Buy, Make&Buy) on the firm's workforce growth. In line with the literature, we identify a significant positive relation between product innovation associated with Make and Make&Buy strategies, however, on the contrary to most recent research we find a positive and significant effects of process innovation associated to Buy strategies. Considering technological, sectoral and firm characteristics, our findings show a clear positive effect of any innovation strategy in the growth of the firm's workforce. Meanwhile, no innovative strategies negatively affect workforce growth. Our findings contribute by deepening the understanding of the firm level determinants of employment in developing countries. We analyze our result in the light of a recent but extensive evidence on the relationship between innovation and employment at firm's level in Uruguay. In particular, we discuss the traditional explanation on the firm's technological behavior in Latin America, to discuss the effects on employment of integrative innovation strategies in Uruguay.

**JEL Codification**: O33, D22, J23

**Key words**: innovation strategies, employment, Latin America, Uruguay

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## Resumen

Una amplia y rica literatura ha mostrado que la relación entre innovación y empleo es de naturaleza compleja y dinámica. Investigaciones recientes han mostrado patrones empíricos heterogéneos a nivel de la firma, tanto para países desarrollados como en desarrollo. Este estudio analiza el rol de las estrategias de innovación como determinante del crecimiento del empleo a nivel de la firma en un país latinoamericano de ingresos medios. Se discute el efecto de cuatro estrategias de innovación (*Make, Buy, Make&Buy*) sobre el crecimiento del empleo, adaptando modelos econométricos estructurales largamente utilizados en investigaciones previas. En línea con la literatura, se identifican relaciones positivas y significativas entre innovación en productos, asociada con la estrategia *Make&Buy*. No obstante, a diferencia de lo encontrado en las investigaciones recientes, se encuentra un efecto positivo y significativo de la innovación en procesos, asociada con la estrategia Buy. Tomando en consideración las características tecnológicas y sectoriales de las firmas, los resultados encontrados muestran un efecto positivo claro de las estrategias de innovación sobre el crecimiento del empleo en las mismas. Adicionalmente, la ausencia de estrategias de innovación afecta negativamente el crecimiento del empleo. Estos hallazgos van en la dirección de mejorar la comprensión de los determinantes del empleo a nivel de la firma en los países en desarrollo. Para eso discutimos los resultados a la luz de una reciente, pero extensa acumulación de estudios sobre innovación y empleo a nivel de firma para Uruguay. En particular, se discute la explicación tradicional sobre el comportamiento tecnológico de la firma en América Latina.

Palabras clave: estrategias de innovación, empleo, América Latina, Uruguay.

Código JEL: O33, D22, J23

## 1. Introduction

Innovation is a process of creative destruction, where new things and ways to do things replace older one, affecting the resources and capabilities related to the development, production and commercialization of such things (Schumpeter 1942). It triggers structural changes that involve reallocation processes of resources that are observable at different analytical levels. The destructive and creative effects of this process has gained particular attention related to the potential effects on employment and skills demand (Dachs et al. 2017; Catela et al. 2015).

Facing the global crisis of 2008 and the diffusion of ICT innovations, research on the effects of innovation in employment has dramatically grown (Frey 2019; Acemoglu and Restrepo 2018; Autor 2015). However, the relationship between technical change and employment is a classic topic that has received attention from diverse research streams, based on different theoretical basis and at different aggregation levels (Dosi and Mohnen 2019; Calvino and Virgillito, 2018; Vivarelli 2014; Freeman et al. 1992). This wide and large body of literature has demonstrated that there is a complex, no linear relationship between innovation and employment which effects are neither homogenous nor immediate (Herstad and Sandven 2019; Kancs and Siliverstovs 2019; Piva and Vivarelli 2018).

Empirical research has been mostly based on the study of the theoretically expected effects of different types of innovation outcomes in employment (for literature revision see: Calvino and Virgillito 2018; Vivarelli 2014). Following the main distinction between product and process innovation, these works have identified labor saving and creating effects of innovation outcomes. In stylized facts, it is expected that process innovations lead to efficiency gains (labor productivity) savings employments. Conversely, if the firm is able to establish lower prices creating a demand increase, process innovation may positively affect employment (Coad and Rao 2011). On other hand, product innovation may trigger compensation effects due the market expansion of the firm, which in turn create new employment demand. However, product innovation can also present negative externalities that can reduce employment. Rather than create new markets, product innovation can displace old products either from the innovative firm (cannibalization effect) or from its competitors (business stealing effect) (Vivarelli 1995 and 2013).

Based on these concepts, the debate on the effects of innovation in employment at firm level has gained great attention (Barbieri et al., 2019; Bianchini and Pellegrino 2019; Cirera and Sabetti 2019; Herstad and Sandven 2019; Hou et al. 2019; Harrison et al. 2014; Giuliodori and Stucchi 2012; Lachenmaier and Rottmann 2011; Coad and Rao, 2011; Bogliacini and Pianta 2010; Jamandreu 2003; Pianta 2003). These works have contributed to identify and understand some general patterns among heterogeneous findings from developed economies. In a general manner, product innovation shows positive effects on employment growth, in particular when considering big firms acting in high-tech sectors. On the other hand, process innovation shows neutral or negative effects on employment (Calvino and Virgillito 2018; Vivarelli 2014). Moreover, recent researches shed light on heterogeneous effects according to macroeconomics cycle, market structure and sectoral composition of the economies (Díaz et al. 2020; Lim and Lee 2019; Dachs et al. 2017). Regarding developing economies, results show a similar landscape, with an intensive positive relation between product innovation and employment and mainly neutral effect of process innovation on employment (Baensch et al. 2019; Cirera and Sabetti 2019; Crespi et al, 2019; Pereira and Tascir 2019; Mitra 2019; Castillo et al. 2014).

Despite this large and rich body of literature, there is relatively few empirical works analyzing the firms' behavior determining innovation outcomes that canalize the effects of innovation in employment (Barbieri et al. 2019; Triguero et al. 2020; Zuniga and Crespi 2013; Evangelista and Savona 2003). Following these authors, we pose that innovation outcomes are observable mechanisms related to no-observable deliberate actions of the firm –i.e. strategies-, acting in a high uncertainty context. The literature on the topic has usually associated innovation strategy to product or process innovation (Peters 2004; Pianta 2001). However, there is a critical conceptual difference between these concepts. Innovation strategies refers to deliberate actions to achieve performance's improvements in a more or less open way (Triguero et al. 2020; Criscuolo et al. 2018), which are partially observable through the innovation activities that the firm conduct (Breemersch et al 2019; Barletta et al. 2016). These activities, which include R&D, technology acquisition and collaboration, are the main determinants of the type of innovation outcomes (Cohen 2010).

Following Penrosean contributions, the firm is conceived as an agent that embrace a set of resources, organizing it to transform technical innovations in production practices to improve firm performance (Lazonick 2016; Dodgson 2017). To achieve the aimed improvements, a critical decision refers to what extent the firm focuses its innovation strategy in internal activities (Make), in external knowledge acquisition (Buy) or both (Make&Buy) (Cassiman and Veugelers, 2000). We analyze the effects of these strategies on the growth of the workforce and skills' demand of the firm.

We consider the effects these strategies on employment regarding the situation of no innovative firms. Evidence on the firm's innovation behavior in Latin America has widely show that firms face several barriers to innovate and even do not perceive the potential benefits of innovation regarding their regular market position (Grazzi and Pitrobielli 2016).

Based on previous contributions from Latin America, we test the effects of different types of innovation on firm's employment. In doing so, we adapt the estimation method developed by Harrison et al. (2008 and 2014) and early adapted by Zuniga and Crespi (2013), using instrumental variables to test the effects of innovation strategies on the growth of the workforce and the skills' demands in a panel data set containing 4,126 observations from Uruguayan firms during 2007-2015. Relatedly, in line with the literature (Bogliaccino and Pianta 2010) we test likely heterogeneous effects of innovation strategies according the technology intensity of the sector and the size of the firm.

This article contributes with the ongoing debate on the effects of innovation on employment. In particular, it improves previous conceptualization on the relationship between innovation strategies and the type of innovation outcomes.

The results show consistent differences between innovative and no innovative strategies. Firms that conducted any type of innovation strategies show a positive and significant impact of them on workforce growth. In line with previous empirical findings, we corroborate a positive impact on workforce growth of the Make, Buy and Make&Buy strategies (Zuniga y Crespi 2013, Aboal et al. 2011a and 2011b) These findings have been also corroborated according skilled and unskilled workers and considering the sectoral technology intensity. However, unlike previous research, our findings reveal strongest effects of the integrative strategy: Make&Buy.

Moreover, when comparing the evidence for the Uruguayan case in the backdrop of the Latin American extant literature, we corroborate the singular positive effect of the strategy Buy, strongly associated to process innovation. It allows us to discuss the relevance of innovation strategy as a firm's growth firm strategy in a developing context.

## 2. Innovation strategies and types of innovation

The innovation strategy of the firm refers to a deliberate effort of the firms that rationalize their objectives and how to intend to pursue them (Nelson 1991). Some of them are more explicit while others are part of the tacit organizational knowledge. We pose that innovation strategies are observable through the mix of knowledge and practices adopted by the firm via internal and external searching activities and trial and error practices to improve firm's performance, e.g. productive improvements, market advantages (Criscuolo et al., 2018; Veugelers and Cassiman, 2006). Innovation strategies usually imply a bundle of heterogeneous innovation activities, which have quite different effects on the innovation capabilities of the firms' workforce.

Firms conducting innovation strategies based on internal activities oriented to create knowledge, mostly R&D, likely obtain productivity gains (Crepon et al 1998; Ortega-Argilés et al. 2011) and potential market advantages (Hall and Vopel 1996) through product innovation. Job creating effects attributable to innovation strategies based on R&D has been mostly identified in big and micro firms from technologically dynamic sectors (Calvino and Virgillito 2018).

Relatedly, since the seminal contributions of Cohen and Levinthal (1989 and 1990) it is largely recognized that R&D also affects positively the firms' absorptive capacities and interactive learning. In this regard, recent empirical researches has shed light on the heterogeneous effects of the openness degree of the innovation strategy on the firm on employment and skills' demand (Bello-Pintado and Bianchi 2020; Triguero et al. 2019).

Moreover, innovation strategies include diverse activities beyond R&D – i.e. external technology acquisition; training, design –, oriented by standardized search for improvements (routines) (Barletta at al. 2016), that critically affect the performance of the firm (Som et al. 2015; Vega-Jurado et al. 2009).

These type of innovation has historically predominated in Latin American firms (Katz 2004) usually determining process innovation outcomes (Crespi et al. 2019), oriented to efficiency gains and enhancing competitiveness that allow the firm maintain the market position (Cassoni and Ramada-Sarasola 2015). These activities, rather than R&D, are in core of the firms' innovation patterns identified in Latin American economies, which are characterized by a high proportion of small and median firms acting in traditional branches in both, service and manufacturing (Dutrenit et al. 2019; Barletta et al. 2016).

Sectoral dynamics affects firms' innovation strategy through technological and institutional microeconomic factors related to the technological cycles, knowledge basis and appropriability conditions (Dachs et al. 2017; Bogliacino and Pianta 2010). In this regard, the literature on service innovation (Aboal et al. 2015) has shown that innovation on this sector is less standardized and strongly based on customer interaction rather than R&D. These activities contribute to create new service products, but especially in customized improvements of old services. Therefore, as Dachs et al. (2017), point out, customization would imply lesser cannibalization and business stealing effects than in manufacturing, but low intensive market creation effects on employment. However, empirical research has identified heterogeneous effects due to the technological intensity of the sector both in service and manufacturing (Yang and Lin 2008; Evangelista and Savona 2003; Piva and Vivarelli 2002).

Moreover, firms' strategies and their effects on employment are determined by sectoral variables related to the global organization of production and the national productive specialization (Breemersch et al. 2019; Dachs et al. 2017; Giuliodori and Stucchi 2012). Despite the agricultural and extractive sectors, Latin American economies are concentrated in manufacturing of commodities and traditional services, with critical productivity gaps respect dynamic economies (Catela et al. 2015; Grazzi and Pietrobielli 2016) and a small critical mass of innovative firms (Yoguel and Robert 2010; Berrutti and Bianchi 2019). In this context, Latin American firms have usually been dependent of foreign knowledge, being the acquisition of knowledge embodied in machinery and equipment oriented to process innovation outcomes the most usual innovation activity in the region (IDB 2010; Katz 2004).

Evidence show that embodied technological acquisition involves knowledge search and adoption practices, that require qualitative and quantitatively different workforce than R&D based strategies (Bello-Pintado and Bianchi 2020; Barbieri et al. 2009; Conte and Vivarelli 2007). In this regard, in developed countries, the acquisition of capital goods for innovate has been associated to process innovation outcomes with potential negative effects on workforce (Barbieri et al. 2019). However, the dynamic of displacement and compensation mechanisms observed in developed countries is not necessarily expected in developing ones. In economics structures based on low productivity traditional activities the compensation mechanisms based on market creation are questionable (Crespi et al. 2019) But, in other way, displacement mechanisms associated to labor saving efficiency gains due process innovation, can be compensated by productivity gains and enhancing competitiveness effects that allow firms survive (Cirera and Sabetti 2019; Pereira and Tascir 2019; Mitra and Jha 2016).

In order to capture the effects of different innovation strategies in employment through the firm's innovation activities, Zuniga and Crespi (2013) use the stylized typology coined by Cassiman and Veuguelers (2006). They distinguished three types of strategies: (i) Make: internal technology development based on R&D activities; (ii) Buy: external knowledge acquisition through embodied or disembodied knowledge; and (iii) Make & Buy: mix strategies (Cassiman and Veugelers, 2000; Veugelers and Cassiman, 1999).

Finally, we should recognize the inherent limitation of the firm's level analysis of the relation between innovation and development. It is well known that firm's innovation outcomes (product or process) result from a complex process affected by institutional, macroeconomic and technological factors that are usually exogenous of the firm's behavior. Moreover, the mechanisms operating between innovation outcomes and employment described above strongly depend on demand features, market structure and competition (Breemersch et al. 2019; Kancs and Siliverstovs 2019). In this regard, recognized the limitations associated with the firm level analysis to capture the displacement and compensation effects (Barbieri et al. 2019), we pose that innovation strategies determine innovation outcomes and ultimately affect innovation effects in the firm's workforce quantity and quality.

## 3. Empirical background and hypotheses statements

Empirical researches have consistently corroborated heterogeneous effects of innovation on employment at firm's level. Growing evidence makes possibly to identify some general patterns but also shows non-conclusive evidence on the effects of innovation outcomes on firm's employment growth and on the mechanisms operating between them (Calvino and Virgillito 2018; Vivarelli 2014).

Considering European cases, Harrison et al. (2014) find a positive effect of product innovation (new product sales) on employment in both manufacturing and services in France, Germany, Spain and the UK. However, even compensated by old product market expansion, they find that process innovation shows negative impact on firm's workforce. Very similar general results, using the same empirical strategy, have obtained by Hou et al. (2019) for France, Germany, The Netherlands and China. These results are partially aligned with evidence from Italy showed a robust effect of the R&D investment in manufacturing firm's employment but do not significant effect of innovation investment in external acquisitions on employment (Barbieri et al. 2019; Piva and Vivarelli 2005). However, previous findings from Germany and Spain had shown a positive impact of product innovation but also a positive, even higher, effect of process innovation outcomes (Giuliodori and Stucchi 2012; Lachenmaier and Rottmann 2011).

In addition, except for Germany (Lachenmaier and Rottmann 2011), empirical evidence from Europe show heterogeneous effects according technology intensity of the sector and the firm's size. Considering manufacturing firms, Barbieri et al. (2019) and Pellegrino et al. (2018) find evidence of positive effects of R&D expenditures on firm's workforce in Italy and Spain, but only for high-tech firms, and negative effects of embodied technological acquisition in the small and medium firms. In addition, Bianchini and Pellegrino (2019) identified a dynamic positive effect of persistence in product innovation outcomes in Spain manufacturing firms, being it stronger for SMEs than for big firms. On the contrary, they do not find significant effects of process innovation outcomes on workforce growth. Regarding the service sector, Evangelista and Savona (2003) find a positive effect of gross innovation investment in firm's employment, in particular of R&D investment. However, they find this result for small firms acting in knowledge intensive business service (KIBS), while, on the contrary, they found a negative effect of gross innovation investment in big firm's employment, particularly in capital intensive and financial sectors.

There is few but growing evidence from non-western central countries. Researches from Asian emergent countries corroborate the results from developed economies: product innovation outcomes are consistently associated to workforce growth while process innovation shows mainly no significant effects (Hou et al. 2019; Lim and Lee 2019; Yang and Lin 2008). Moreover, Yang and Lin (2008) show that these effects have skill biased effects, favoring highly skilled workforce growth. Similar results have been obtained using a pooled database of firms from Africa, Eastern Europe, Central Asia and Middle-East (Cirera and Sabetti 2019). However, these authors call the attention on the intensity of the product innovation effects on employment according the income level of the country, suggesting than firms in lower income countries will obtain more intensive effects of product innovation.

### 3.1 The Uruguayan case in the Latin American context

The study on the linkages between technical change and employment has a long tradition from varied theoretical and methodological approach in Latin American studies (Haddad, and Hewings 1999; Robert et al. 2010). Moreover, as part of the growing interest on the topic worldwide, it has recently gained growing attention in Latin America.

As usual in Latin American economies, heterogeneity prevails. However, regarding the evidence on the effects of product and process innovation, findings from this region also show some rough general patterns in line with the compensation and displacement effects stated in the literature and the evidence from developed and emergent countries. Against this backdrop, evidence from Uruguay show results that are non-totally convergent with the regional findings. (**Table 1**).

Based in the approach of Harrison et al. (2008 and 2014) a number of studies have corroborated positive effects of product innovation on firm employment in manufacturing firms in Argentina, Chile, Colombia, Costa Rica and Uruguay (Crespi et al. 2019; Pereira and Tascir 2019; Mejia and Arias-Granada 2014; Zuniga and Crespi 2013; Crespi and Tascir 2011; Benavente and Lauterbach 2006) and in service firms in Colombia and Uruguay (Mejia and Arias-Granada 2014; Aboal et al. 2011b).

On another hand, several studies (Pereira and Tascir 2019; Mejia and Arias-Granada 2014; Benavente and Lauterbach 2006) did not found significant effects of process innovation in firm employment, but negative effects of this type of innovation outcome has been observed for Chile (Crespi and Tacsir 2011) and positive effects in Argentina and Costa Rica (Castillo et al. 2014; Crespi and Tacsir 2011).

More recent multi-country evidence in the topic shows similar findings but suggesting singular results for the Uruguayan case. Using OLS estimators, Crespi et al. (2019) find consistent evidence of a positive effect of product innovation in firm's employment in Argentina, Chile, Costa Rica and Uruguay. Moreover, this finding is corroborated for the four countries through IV estimation models.

In the same vein, using both OLS and IV estimates, they mostly find non-significant evidence of impacts of process innovation outcomes on firm's employment. Exceptions that they observe to this results are negative significant effects of process innovation on firms' employment for the whole manufacturing sample in Chile and Uruguay, in particular in small manufacturing firms in Uruguay. However, when using IV estimators, this results is only observed for the whole sample of manufacturing firms in Uruguay, and with particular effects on high tech firms.

These authors argue that divergences can be attributable to non-relevant effects of process innovation on productivity that in turn do not trigger labor saving effects in or, in the contrary as is usually attributed to product innovation, process innovation can be showing expansion market effects that overcompensate displacement effects.

On another hand, when analyzing the effects of innovation in skill composition of the workforce in Argentina and Uruguay, Crespi et al. (2019) find positive effects of product innovation on skilled and unskilled employment in Argentina and Uruguay. Moreover, they find weak but significant negative effects of process innovation on unskilled employment in Argentina.

Another recent research, analyzing product and process innovation for aggregated data from 14 Latin American countries, have corroborated a positive relationship between product innovation and employment and non-significant effects of process innovation. In addition, analyzing the relative weight of regulation in favor of labor reward, they also show that more labor friendly regulation (which includes Uruguay) reduce the effects of product innovation on employment (Baensch et al. 2019).

From the perspective of the innovation strategies, some of the main references for our research found positive effects of all innovation strategies (Make, Buy, and Make&Buy) for manufacturing and services firms from Argentina, Chile and Uruguay. Finding also stronger effects in big firms and high-tech sectors. Previous research focused on the Uruguayan case, also following similar approaches, had obtained similar results. (Peluffo and Silva 2017, Aboal et al. 2011a, 2011b). However, Aboal et al. (2011a and 2011b) did not find effects of the Make strategy in services except by SMES and KIBS firms.

***Table 1**: Previous research on relationship innovation and employment for Uruguay*

| Work | Period | Method | Results |
|---|---|---|---|
| Crespi et al. (2019) | 1998-2009 | Harrison model; MCO-VI | (+) total employment on product innov. in the whole sample, small, low-tech and high-tech firms; (+) skilled/unskilled employment on product innov. in the whole sample; (-) total employment on process innov. in the whole sample and high-tech firms; (-) unskilled employment on process innov. in the whole sample. |
| Peluffo and Silva (2017) | 2000-2012 | VI-GMM | (+) Product innov; (+) productivity enhancing innov; (+) Skilled employment on Innov. outcomes. |
| Zuniga and Crespi (2013) | 1998-2009 | Harrison model adapted; VI | (+) Innov. strategies; (+) Small firms; low-tech*;* high-tech; (+) skilled/unskilled employment on Innov. Strategies. |
| Aboal et al. (2011a) | 2004-2009 | Harrison model; MCO-VI | (+) total, skilled/unskilled employment on buy*;* make and buy in the whole sample, small and kibs firms; (+) employment on make strategy in small firms; (-) unskilled employment on make strategy. |
| Aboal et al. (2011b) | 1998-2009 | Harrison model; MCO-VI | (+) total, skilled/unskilled employment on innov. strategies in the whole sample, small, and kibs, high-tech and low-tech firms; (+) unskilled employment on buy and make and buy strategies in low-tech firms. |

*Source*: Authors.

*Note*: It is worth noticing that other quoted research (Aboal et al. 2015 and Crespi and Tascir 2011) also include results from Uruguayan firms, but they are replicated in articles included in this table (Aboal et al. 2011; Crespi et al. 2019).

Summing up, according with previous research evidence, we expect a positive relationship between firm innovative strategies and the growth of the firm workforce and we do not expect to observe negative effects of innovation activities in firm's employment.

*H1: Innovative strategies show a positive effect on the firm's workforce growth in Uruguay.*

However, considering the prevalence of heterogeneous effects of innovation types and strategies, the extant evidence show that the firm's growth is strongly associated with innovation based on R&D activities (product innovation), which in turn are a critical determinant of internal capabilities. Therefore, we expect a stronger effect of the strategies that include Make activities, i.e. Make and Make&Buy.

*H2 Firms that conduct Make or Make&Buy innovative strategies show more intensive, positive, effects in workforce growth that those that conduct only Buy strategies.*

We test H1 and H2 for the whole sample and also for different subsamples that allow us to capture potential disparate effects according to sectoral technology intensity and the size of the firms.

Finally, considering the effect of innovation in the firms' employment composition, in line with prevalence evidence from both regional and international previous research, we expect a stronger effects of innovation strategies on the growth of the skilled firm's workforce. Therefore, we pose that:

*H3: Firms that conduct innovative strategies show a bigger growth of skilled workforce than unskilled one.*

## 4. Methodology

In order to test our hypotheses, we adapt the model developed by Harrison et al. (2008 and 2014), following Zuniga and Crespi (2013) to integrate the analysis of innovative strategies. The multiproduct model of Harrison et al. (2008, 2014) allows differentiating effects of innovation on employment, distinguishing according the innovation outcome: process or product innovation. Moreover, the approach based on innovative strategies (Zuniga and Crespi 2013) allows analyzing the effects of the innovation strategies on the innovation outcomes, considered as mechanisms that affect the workforce growth.

The model of Harrison et al. (2008, 2014) is based on a labor demand function, where the rate of growth of the firm's workforce is affected by the type of innovation. According to the literature, efficiency gains in the production of old products and the efficiency changes associated to process innovation negatively affect the workforce growth. On the contrary, the growth rate in the production of old products will positively affects employment due market expansion effect. In the same vein, a positive effect of the rate of growth of the new products production is expected. Relatedly, the production expansion due to new products also positively affects workforce' growth.

The equation 1 from Harrison et al. (2008, 2014) shows the relationship between the workforce growth, efficiency gains due process innovation and the growth of sales of new and old products.

$$wg = \alpha_0 + \alpha_1 \, process + old + \beta new + \mu \qquad (1)$$

Where: *wg* is the workforce growth rate; *process* is a dummy variable indicating process innovation; *old* is the nominal growth rate of the sales due to old products; *new* is the nominal growth rate of the sales due to new products; $\alpha_o$ is the average parameter of efficiency growth in the production of old products; $\alpha_1$ is the average parameter of efficiency growth in the production of old products due to process innovation; $\beta$ is the relative efficiency parameter between new and old products production; $\mu$ are unobservable factors -i.e. productivity shocks and changes in the products prices-.

Zuniga and Crespi (2013) adapted a reduced form of the model of Harrison et al. (2008, 2014), where they substitute the innovation outcomes (product or process) by innovation strategies. Moreover, aiming to capture the net effect of the innovation strategies on workforce (*wg_net*), these authors substitute the dependent variable of equation (1) by the difference between *wg*, the growth rate due to old products (*old*) and the sectorial price growth index ($\pi$).

$$wg\_net = \alpha_0 + \alpha_m make + \alpha_b buy + \alpha_{m\&b} m\&b + \mu \qquad (2)$$

The innovation strategies are three excludent dummy variables, where: make captures if the firm conducts internal R&D; buy captures if the firm acquires external – embodied and disembodied – knowledge; m&b captures if the firm conducts both.

In order to control endogeneity problems, Zuniga and Crespi (2013) use a structural model approach in two steps. It allows testing orthogonality between innovation strategies and the error term in equation 2. Since innovation strategies depend on firm's growth, which in turn is also affecting the error term of equation 2, these variables are potentially endogenous.

Using instrumental variables, the first step of the model includes two equations where innovation strategies predict product (3) or process (4) innovations.

$$new = \gamma_0 + \gamma_m make + \gamma_b buy + \gamma_{m\&b} m\&b + e \qquad (3)$$

$$process = \delta_o + \delta_m make + \delta_b buy + \delta_{m\&b} m\&b + e \qquad (4)$$

Since we have more instrumental (*make; buy; m&b*) than endogenous (*new; process*) variables, we could test instrument validity using the Sargan's test. Not rejecting the null hypothesis implies that the innovation strategies are orthogonal regarding the error term (Hou et al. 2019).

Finally, in the second step, the effect of innovation strategies in workforce is estimated incorporating predicted values from (3) and (4) in equation (1).

In order to test our hypotheses, we split the data-base and, using the same econometric approach, we capture the effects of innovation strategies on the growth of the workforce according the most relevant features highlighted in the literature.

### 4.1 Data and variables

We use three waves (2007-2015) of the Uruguayan Innovation Survey (UIS). UIS, based on the Oslo Manual (OECD 2005), is representative of firms with more than five employees acting in the manufacturing industry and selected services activities1. Regarding our empirical strategy, our final data set is an unbalanced panel including 4,126 observations from firms that were surveyed in at least two consecutive waves. 50.5% of observations belong to manufacturing sector while the rest of them act in service.

**Table** *2* resumes the main variables used in the analysis. We concisely report the construction method of dependent and explicative variables base on the questionnaire survey.

***Table 2:*** *Variable names and description.*

| **Dependent variable** | | |
|---|---|---|
| *wg_net* | Net workforce growth rate | Average annual net workforce growth rate, calculated by *wg* – (*old* – *π*). Average annual net workforce growth rate of skilled (*skilled_gnet*) and unskilled (*unskilled_gnet*) labor is defined analogously. |
| *new* | Sales growth rate of new products | Average annual sales growth rate of new products, computed as *new* = *innsales**(1+*sales*), where *innsales* is the share of sales due to product innovations. |
| *process* | Process innovation only | =1 if firm introduce process innovation only or organizational change innovation only. |
| *wg* | Workforce growth rate | Average annual workforce growth, calculated by $(\ln(workforce_t)-\ln(workforce_{t-1}))/3$ |
| *skilled_wg* | Growth rate of skilled labor | Average annual workforce growth, calculated by $(\ln(skilled\_workforce_t)-\ln(skilled\_workforce_{t-1}))/3$ |

[1] ISIC classification Rev. 3: Manufacturing includes division from 15 to 37; Selected services include the divisions: 40, 41, 50, 51, 55, 60 to 67, 71-74, 85, 90 and 92.

| | | |
|---|---|---|
| *unskilled_wg* | Growth rate of unskilled labor | Average annual workforce growth, calculated by (ln(un*skilled_workforce*$_t$)-ln(*unskilled_workforce*$_{t-1}$))/3 |
| *old* | Sales growth rate of old products | *old = sales - new* |
| *Sales* | Average annual sales growth rate | Average annual sales growth rate calculated by (ln(*sales*$_t$)-ln(*sales*$_{t-1}$))/3 |
| $\pi$ | Prices growth rate | Average annual Index of prices growth rate. The Index is computed based on GDP deflator (implicit price deflator) for manufacture and service sector. |
| | **Variables of interest** | |
| *make* | Make dummy | =1 if firm conducted internal R&D. |
| *buy* | Buy dummy | =1 if firm reports external R&D, acquisition of capital goods, hardware and software or technology transfer, consultancy, training, engineering and industrial design, organization and management design. |
| *m&b* | Make and Buy dummy | =1 if firm reports both activities |
| | **Control variables** | |
| *i.year* | Wave dummy | A set of UIS wave dummy variables. |
| *i.isic* | Industrial dummy | A set of industrial dummy variables. |
| | | |
| | **Sub sample variables** | |
| *small* | Small firm | =1 if firm has up to 50 employees at the end of the survey wave. |
| *htech* | High-technology-intensive | =1 if firm belongs a sector activity classified as high technology according to the OECD (2011) classification. |
| *kibs* | Knowledge-intensive business services | =0 for nonclassified firms; =1 for traditional services firms (include the ISICs divisions: 40, 55, 60, 61, 63, 71, 85); =2 for kibs firms (include the ISICs divisions: 64, 72 to 74), adapted from Aboal et al. 2011a. |

*Source*: Authors.

## 5. Results

Descriptive statistics present the heterogeneous innovation strategies conducted by the Uruguayan firms, showing a similar share of product and process innovative firms (See Table A3 and

Table **A4**, appendix). In line with regional patterns, no-innovative firms predominate, in both manufacturing and service sectors, and there is noticeable differences between innovative and no-innovative firms. The former are bigger and show a greater participation of skilled employees in the workforce than the latter. In addition, the average growth of the workforce is negative or close to zero in the whole manufacturing sample, but it turns positive when considering only innovative firms. On the other hand, relatedly to structural tendencies in the world economy, the service sector is growing, showing a positive average growth of the workforce. On other hand, within innovative firms, descriptive results show the association between the strategy buy and process innovation outcomes, but product innovators follow both make and buy strategies (See Table A1 and Table A2, appendix).

Regarding econometric estimates, our results corroborate the positive and significant effect of innovative strategies on the growth of firm's workforce, i.e. *H1* can be accepted. Table 3 presents the estimates of equation 2, showing positive and strong effects of all innovation strategies on firms' workforce growth. This result is consistent considering both size and sector of the firm. In line with the studies on innovation strategies and employment in Latin America, the estimated coefficients are noteworthy high (Zuniga and Crespi 2013; Aboal et al. 2011a and 2011b) but, unlike these previous research, our results reveal stronger effects of integrative *Make&Buy* strategies. Within manufacturing sector, there are not relevant differences in the intensity of the effects in small and big firms. On the contrary, small service's firms show more intensive effects than big ones.

***Table 3:*** *Innovation strategies in manufacturing and service firms (2010-2015).*

| **Sector** | **Manufacturing firms** | | **Service firms** | |
|---|---|---|---|---|
| | **Total** | **Small** | **Total** | **Small** |
| Regression | MCO | MCO | MCO | MCO |
| Dependent Var. | *wg_net* | *wg_net* | *wg_net* | *wg_net* |
| Constant | -0.038*** | 0.001 | 0.017 | 0.033 |
| | (0.013) | (0.017) | (0.042) | (0.049) |
| make (*dummy*) | 0.337*** | 0.288** | 0.321** | 0.506** |
| | (0.090) | (0.114) | (0.134) | (0.245) |
| buy (*dummy*) | 0.236*** | 0.247*** | 0.272*** | 0.330*** |
| | (0.021) | (0.032) | (0.025) | (0.043) |
| mnb (*dummy*) | 0.360*** | 0.412*** | 0.518*** | 0.586*** |
| | (0.030) | (0.060) | (0.045) | (0.075) |
| $R^2$ | 0.241 | 0.282 | 0.263 | 0.322 |
| Standard error | 0.284 | 0.259 | 0.299 | 0.270 |
| n | 1,336 | 746 | 1,299 | 705 |
| Sargan | 0.908 | 0.407 | 1.072 | 0.875 |
| p-value | 0.635 | 0.816 | 0.585 | 0.646 |

*Source*: Authors based on UIS.
*Notes*: **1-** Standard errors in parentheses. **2-** All regressions include industrial dummy variables (2 digits) and year dummy variables. **3-** * p<0.1, ** p<0.05, *** p<0.01.

Moreover, instrumental variables estimates of equation 1 corroborate previous results (See Table A5 and Table A6, appendix). Considering sector and size of the firm, there are consistent positive effects of all innovation strategies in product innovation outcomes. On the contrary, there is no significant relationship between any innovation strategy and process innovation (See Table A5 and Table A6, appendix). Validity of the instrumental variables is confirmed since results do not reject Sargan's null hypothesis.

These results give us to reject H2, in spite of international evidence the effect of innovation in workforce' growth do not show relevant differences between innovation strategies. According to the literature, we split the sample in order to inquire about specific effects considering labor demand determinants (size and sector of the firm) and labor composition (skills), which allows testing *H3*.

In doing so, we use a sectoral taxonomy currently use in the field (Dachs et al. 2017), which distinguishes four sectors: Low-tech manufacturing, high-tech manufacturing, traditional services and KIBS (Table 4). Results are similar to observed in whole sample, rejecting a linear relationship between some innovation strategy and the sectoral intensity of technology. However, high-tech manufacturing firms show more intensive effects of the strategy *Make,* which, in contrary show low significance regarding KIBS's firms.

***Table 4: Innovation strategies manufacturing and service firms according to sectoral technology intensity (2010-2015).***

| | **Manufacturing firms** | | **Service firms** | |
|---|---|---|---|---|
| | **High-tech** | **Low-tech** | **KIBS** | **Traditional services** |
| Regression | MCO | MCO | MCO | MCO |
| Dependent Var. | *wg_net* | *wg_net* | *wg_net* | *wg_net* |
| Constant | 0.001 | -0.049*** | -0.053 | 0.019 |
| | (0.028) | (0.014) | (0.046) | (0.044) |
| make (*dummy*) | 0.518** | 0.303*** | 0.386* | 0.293 |
| | (0.202) | (0.097) | (0.203) | (0.181) |
| buy (*dummy*) | 0.193*** | 0.246*** | 0.255*** | 0.264*** |
| | (0.043) | (0.024) | (0.037) | (0.035) |
| mnb (*dummy*) | 0.339*** | 0.367*** | 0.486*** | 0.490*** |
| | (0.047) | (0.039) | (0.054) | (0.082) |
| $R^2$ | 0.218 | 0.249 | 0.281 | 0.225 |
| Standard error | 0.289 | 0.282 | 0.296 | 0.290 |
| n | 288 | 1,048 | 560 | 624 |
| Sargan | 1.933 | 0.426 | 0.347 | 1.273 |
| p-value | 0.164 | 0.808 | 0.841 | 0.529 |

*Source*: Authors based on UIS.
*Notes*: **1-** Standard errors in parentheses. **2-** All regressions include industrial dummy variables (2 digits) and year dummy variables. **3-** * p<0.1, ** p<0.05, *** p<0.01.

These results are also corroborated when considering the quality of labor demand (see *Table A7* and Table A8, appendix). Considering size of the firm and sectoral technological intensity, the positive effects of innovation in workforce' growth is confirmed for both skilled and unskilled workforces. Moreover, while in manufacturing firms, the intensity of the effect of each strategy are always stronger for skilled workforce, this result is not observed for service firms. Therefore, we can only partially confirm H3.

## 6. Main findings and conclusions

The main finding of this research is the consistently and robustly identification of a positive and significant relationship between all innovation strategies and workforce growth (Table 5). This finding, even expectable, is critical to inform the current debate on employment and technical change. In particular, to differentiate micro effects at firm level, mostly associated to the firm's dynamics than macro effects where, as the Uruguay case show, a general falling of employment is observed (OPP 2019).

In addition, results corroborate that Make&Buy is the strategy that shows more intensive effects on workforce growth, rather than only Make, as have shown previous research (Aboal et al. 2011a and 2011b). However, it is possible to observe that the strategy Make shows the most intensive effects when considering manufacturing firms acting in high-tech sectors.

Even though it is possible to identify different intensities in the relationship between firm strategies and workforce' growth according firms' size and sectoral technology intensity, evidence seems favor the interpretation of a big and positive effect of innovation on employment rather than highlight heterogeneity (Table 5).

***Table 5**: Innovation strategies and workforce growth.*

| | | Manufacturing firms | | | | Selected Services firms | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Strategy** | **Total** | **Small** | **High-Tech** | **Low-Tech** | **Total** | **Small** | **KIBS** | **Trad.** |
| Total workforce growth | M | (+)*** | (+)** | (+)** | (+)*** | (+)** | (+)** | (+)* | (+) |
| | B | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** |
| | M&B | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** |
| Skilled workforce growth | M | (+)*** | (+)*** | (+)** | (+)*** | (+)** | (+) | (+)* | (+)* |
| | B | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** |
| | M&B | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** |
| Unskilled workforce growth | M | (+)*** | (+)** | (+)** | (+)*** | (+)** | (+)*** | (+) | (+) |
| | B | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** |
| | M&B | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** | (+)*** |

*Source*: Authors based on UIS.
*Note*: **1-** *** p<0.01, ** p<0.05, * p<0.1.

Our results show that innovative firms have a higher probability to increase their workforce, due the different innovation activities that they have conducted. The disparate effects of different strategies are observed according sector and size, but the most salient results is the positive influence of innovation in firm's employment.

In the light of these results, further research should inquire deeply on a potential displacement effect from no innovative firms to innovative ones. Moreover, an accurate measure of innovation strategies, opposing market technology purchase vs R&D based activities only, should improve the conclusion that, on the contrary to the international evidence, in small developing countries, technology acquisition associated to enhancing competitive process are strongly associated to firms' growth.

Finally, in line with recent contribution (Dosi and Mohnen 2019), when considering the growing and varied production on the topic worldwide, the micro effect should be framed into the global trade demand changes.

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## Appendix

***Table A1**: Innovation Strategies in manufacturing firms. Period 2007-2015.*

| Share of firms follow each type of strategy by type of firm (%) | Buy | Make | Make/Buy |
|---|---|---|---|
| **Non innovators** | 1 | 0 | 0 |
| **Process only innovators** | 82 | 2 | 15 |
| **Product innovators** | 47 | 5 | 48 |
| **All firms** | 29 | 2 | 15 |

*Source*: Authors based on UIS.
*Notes*: *Buy strategy:* The firm acquired external R&D, capital goods, hardware and software or technology transfer, consultancy, training, engineering and industrial design, organization and management design. *Make strategy:* the firm reports internal R&D. *Non innovators:* firms that not obtain process or product innovations. *Process only innovators. Firms that obtain process only innovations.* Product innovators: firms that have introduced product innovations.

***Table A2**: Innovation Strategies in service firms. Period 2007-2015.*

| Share of firms follow each type of strategy by type of firm (%) | Buy | Make | Make/Buy |
|---|---|---|---|
| **Non innovators** | 1 | 0 | 0 |
| **Process only innovators** | 86 | 3 | 12 |
| **Product innovators** | 56 | 4 | 40 |
| **All firms** | 28 | 1 | 10 |

*Source*: Authors based on UIS.
*Notes*: *Buy strategy:* The firm acquired external R&D, capital goods, hardware and software or technology transfer, consultancy, training, engineering and industrial design, organization and management design. *Make strategy:* the firm reports internal R&D. *Non innovators:* firms that not obtain process or product innovations. *Process only innovators. Firms that obtain process only innovations.* Product innovators: firms that have introduced product innovations.

***Table A3**: Descriptive statistics for manufacturing firms (2007-2015).*

| | Mean | Median | sd | Min | Max |
|---|---|---|---|---|---|
| **Type of firm** | | | | | |
| Non-innovators | 0,56 | | | | |
| Process only innovators | 0,20 | | | | |
| Product innovators | 0,23 | | | | |
| **Number of employees** | | | | | |
| Non-innovators | 62,08 | 23 | 113,45 | 3 | 1.104 |
| Process only innovators | 139,32 | 65 | 208,03 | 3 | 2.316 |
| Product innovators | 148,61 | 73,50 | 252,28 | 5 | 2.465 |
| All firms | 98,03 | 39 | 180,41 | 3 | 2.465 |
| **Share of skilled workforce** | | | | | |
| Non-innovators | 0,09 | 0,03 | 0,15 | - | 1,00 |
| Process only innovators | 0,12 | 0,07 | 0,13 | - | 1,00 |
| Product innovators | 0,15 | 0,10 | 0,16 | - | 1,00 |
| All firms | 0,11 | 0,06 | 0,15 | - | 1,00 |
| **Workforce growth (average annual rate)** | | | | | |
| Non-innovators | (0,02) | (0,01) | 0,10 | (0,35) | 0,30 |
| Process only innovators | 0,01 | 0,02 | 0,09 | (0,26) | 0,24 |
| Product innovators | 0,01 | 0,01 | 0,08 | (0,33) | 0,26 |
| All firms | (0,01) | - | 0,10 | (0,35) | 0,30 |
| **Skilled workforce growth (average annual rate)** | | | | | |
| Non-innovators | (0,09) | (0,03) | 0,49 | (1,65) | 1,44 |
| Process only innovators | 0,00 | 0,00 | 0,37 | (1,42) | 1,38 |
| Product innovators | 0,03 | 0,02 | 0,34 | (1,15) | 1,44 |
| All firms | (0,05) | (0,01) | 0,44 | (1,65) | 1,44 |
| **Unskilled workforce growth (average annual rate)** | | | | | |
| Non-innovators | (0,02) | 0,00 | 0,12 | (0,50) | 0,69 |
| Process only innovators | 0,01 | 0,02 | 0,11 | (0,43) | 0,46 |
| Product innovators | 0,01 | 0,02 | 0,11 | (0,48) | 0,61 |
| All firms | 0,00 | 0,00 | 0,12 | (0,50) | 0,69 |
| **Sales growth (nominal) (average annual rate)** | | | | | |
| Non-innovators | 0,06 | 0,07 | 0,15 | (0,53) | 0,69 |
| Process only innovators | 0,10 | 0,10 | 0,13 | (0,54) | 0,59 |
| Product innovators | 0,09 | 0,10 | 0,11 | (0,37) | 0,52 |
| All firms | 0,08 | 0,08 | 0,14 | (0,54) | 0,69 |
| **Prices growth** | | | | | |
| Non-innovators | 0,09 | 0,08 | 0,06 | (0,11) | 0,24 |
| Process only innovators | 0,08 | 0,08 | 0,06 | (0,11) | 0,24 |
| Product innovators | 0,09 | 0,09 | 0,06 | (0,25) | 0,21 |
| All firms | 0,09 | 0,08 | 0,06 | (0,25) | 0,24 |

*Source*: Authors based on UIS.

***Table A4**: Descriptive statistics for service firms. (2007-2015).*

| | Mean | Median | sd | Min | Max |
|---|---|---|---|---|---|
| **Type of firm** | | | | | |
| Non-innovators | 0,61 | | | | |
| Process only innovators | 0,21 | | | | |
| Product innovators | 0,18 | | | | |
| **Number of employees** | | | | | |
| Non-innovators | 108,71 | 29 | 355,00 | 2 | 9.373 |
| Process only innovators | 286,32 | 79 | 794,79 | 5 | 9.973 |
| Product innovators | 290,54 | 77 | 736,81 | 5 | 7.470 |
| All firms | 178,14 | 42 | 559,08 | 2 | 9.973 |
| **Share of skilled workforce** | | | | | |
| Non-innovators | 0,19 | 0,05 | 0,27 | - | 1,00 |
| Process only innovators | 0,24 | 0,11 | 0,27 | - | 1,00 |
| Product innovators | 0,35 | 0,28 | 0,31 | - | 1,00 |
| All firms | 0,23 | 0,09 | 0,29 | - | 1,00 |
| **Workforce growth (average annual rate)** | | | | | |
| Non-innovators | 0,01 | 0,01 | 0,11 | (0,34) | 0,33 |
| Process only innovators | 0,02 | 0,03 | 0,11 | (0,33) | 0,32 |
| Product innovators | 0,04 | 0,04 | 0,09 | (0,31) | 0,33 |
| All firms | 0,01 | 0,02 | 0,11 | (0,34) | 0,33 |
| **Skilled workforce growth (average annual rate)** | | | | | |
| Non-innovators | (0,04) | 0,00 | 0,46 | (1,68) | 1,67 |
| Process only innovators | 0,03 | 0,02 | 0,41 | (1,63) | 1,64 |
| Product innovators | 0,04 | 0,05 | 0,39 | (1,59) | 1,46 |
| All firms | (0,01) | 0,00 | 0,44 | (1,68) | 1,67 |
| **Unskilled workforce growth (average annual rate)** | | | | | |
| Non-innovators | 0,01 | 0,01 | 0,19 | (1,10) | 0,83 |
| Process only innovators | 0,03 | 0,02 | 0,17 | (0,49) | 0,73 |
| Product innovators | 0,05 | 0,04 | 0,24 | (0,99) | 0,96 |
| All firms | 0,02 | 0,02 | 0,20 | (1,10) | 0,96 |
| **Sales growth (nominal) (average annual rate)** | | | | | |
| Non-innovators | 0,10 | 0,10 | 0,14 | (0,50) | 0,66 |
| Process only innovators | 0,12 | 0,13 | 0,13 | (0,54) | 0,55 |
| Product innovators | 0,13 | 0,13 | 0,14 | (0,48) | 0,60 |
| All firms | 0,11 | 0,11 | 0,14 | (0,54) | 0,66 |
| **Prices growth** | | | | | |
| Non-innovators | 0,10 | 0,11 | 0,05 | (0,13) | 0,58 |
| Process only innovators | 0,10 | 0,11 | 0,05 | (0,13) | 0,30 |
| Product innovators | 0,09 | 0,11 | 0,06 | (0,08) | 0,41 |
| All firms | 0,10 | 0,11 | 0,06 | (0,13) | 0,58 |

*Source*: Authors based on UIS.

***Table A5:***

| Sector | **Whole sample** | | **Small** | | **High-tech** | | **Low-tech** | |
|---|---|---|---|---|---|---|---|---|
| Regression | MCO | Probit | MCO | Probit | MCO | Probit | MCO | Probit |
| Var. Depend | new | process | new | process | new | process | new | process |
| Constant | -0.040*** | -9.579 | -0.015 | -11.036 | -0.057* | -10.633 | -0.042*** | -5.839 |
| | (0.015) | -248.683 | (0.018) | -305.361 | (0.033) | -633.753 | (0.015) | -97.943 |
| make (*dummy*) | 0.322*** | 8.925 | 0.279*** | 9.937 | 0.518*** | (a) | 0.286*** | 5.334 |
| | (0.052) | -248.683 | (0.063) | -305.361 | (0.143) | | (0.055) | -97.943 |
| buy (*dummy*) | 0.242*** | 9.818 | 0.261*** | 10.768 | 0.209*** | 10.713 | 0.249*** | 6.083 |
| | (0.016) | -248.683 | (0.020) | -305.360 | (0.041) | -633.753 | (0.018) | -97.943 |
| mnb (*dummy*) | 0.370*** | 8.886 | 0.411*** | 9.608 | 0.364*** | 9.519 | 0.371*** | 5.255 |
| | (0.022) | -248.683 | (0.033) | -305.360 | (0.042) | -633.753 | (0.026) | -97.943 |
| $R^2$ | 0.271 | | 0.343 | | 0.263 | | 0.274 | |
| Standard error | 0.253 | | 0.213 | | 0.279 | | 0.245 | |
| n | 1,336 | 1,330 | 746 | 721 | 288 | 278 | 1,048 | 1,044 |

*Source*: Authors based on UIS.
*Notes*: **1-** Standard errors in parentheses. **2-** All regressions include industrial dummy variables (2 digits) and year dummy variables. **3-** * p<0.1, ** p<0.05, *** p<0.01.

***Table A6:***

| Sector | **Whole sample** | | **Small** | | **KIBS** | | **Traditional services** | |
|---|---|---|---|---|---|---|---|---|
| Regression | MCO | Probit | MCO | Probit | MCO | Probit | MCO | Probit |
| Var. Depend | new | process | new | process | new | process | new | process |
| Constant | 0.002 | -6.240 | 0.003 | -10.689 | 0.097*** | -6.705 | -0.000 | -5.749 |
| | (0.109) | -88.013 | (0.112) | -603.384 | (0.037) | -153.042 | (0.110) | -124.146 |
| make (*dummy*) | 0.351*** | 5.890 | 0.555*** | 10.207 | 0.374*** | 5.285 | 0.370*** | 6.143 |
| | (0.071) | -88.014 | (0.093) | -603.384 | (0.096) | -153.044 | (0.111) | -124.147 |
| buy (*dummy*) | 0.265*** | 6.087 | 0.301*** | 10.587 | 0.242*** | 6.284 | 0.272*** | 6.024 |
| | (0.018) | -88.013 | (0.023) | -603.384 | (0.028) | -153.042 | (0.025) | -124.146 |
| mnb (*dummy*) | 0.507*** | 5.247 | 0.565*** | 9.411 | 0.448*** | 5.049 | 0.526*** | 5.669 |
| | (0.027) | -88.013 | (0.038) | -603.384 | (0.034) | -153.042 | (0.047) | -124.146 |
| $R^2$ | 0.304 | | 0.389 | | 0.319 | | 0.268 | |
| Standard error | 0.267 | | 0.223 | | 0.262 | | 0.267 | |
| n | 1,299 | 1,293 | 705 | 673 | 560 | 560 | 624 | 618 |

*Source*: Authors based on UIS.
*Notes*: **1-** Standard errors in parentheses. **2-** All regressions include industrial dummy variables (2 digits) and year dummy variables. **3-** * p<0.1, ** p<0.05, *** p<0.01.

***Table A7**: Innovation strategies and workforce composition. (2010-2015).*

| Sector | Manufacturing firms | | | | Service firms | | | |
|---|---|---|---|---|---|---|---|---|
| | Total | | Small | | Total | | Small | |
| Workforce composition | Skilled | Unskilled | Skilled | Unskilled | Skilled | Unskilled | Skilled | Unskilled |
| Regression | MCO | MCO | MCO | MCO | MCO | MCO | MCO | MCO |
| Dependent var. | *skilled_gnet* | *unskilled_gnet* | *skilled_gnet* | *unskilled_gnet* | *skilled_gnet* | *unskilled_gnet* | *skilled_gnet* | *unskilled_gnet* |
| Constant | -0.173*** | -0.030** | -0.156*** | 0.009 | -0.087 | 0.112* | -0.104 | 0.179*** |
| | (0.028) | (0.014) | (0.042) | (0.018) | (0.093) | (0.060) | (0.110) | (0.064) |
| make (*dummy*) | 0.420*** | 0.309*** | 0.381*** | 0.237** | 0.384** | 0.348** | 0.467 | 0.716*** |
| | (0.101) | (0.090) | (0.128) | (0.117) | (0.160) | (0.176) | (0.289) | (0.221) |
| buy (*dummy*) | 0.311*** | 0.233*** | 0.386*** | 0.239*** | 0.336*** | 0.263*** | 0.417*** | 0.334*** |
| | (0.035) | (0.022) | (0.058) | (0.034) | (0.038) | (0.027) | (0.070) | (0.045) |
| mnb (*dummy*) | 0.445*** | 0.345*** | 0.527*** | 0.379*** | 0.549*** | 0.522*** | 0.642*** | 0.629*** |
| | (0.042) | (0.031) | (0.088) | (0.065) | (0.056) | (0.049) | (0.112) | (0.081) |
| $R^2$ | 0.149 | 0.221 | 0.146 | 0.246 | 0.134 | 0.218 | 0.139 | 0.287 |
| Standard error | 0.512 | 0.293 | 0.566 | 0.272 | 0.522 | 0.341 | 0.573 | 0.309 |
| n | 1,336 | 1,325 | 746 | 736 | 1,299 | 1,268 | 705 | 681 |
| Sargan | 0.148 | 0.450 | 0.260 | 0.561 | 1.030 | 0.680 | 1.143 | 1.264 |
| p-value | 0.929 | 0.798 | 0.878 | 0.755 | 0.598 | 0.712 | 0.565 | 0.531 |

*Source*: Authors based on UIS.
*Notes*: **1-** Standard errors in parentheses. **2-** All regressions include industrial dummy variables (2 digits) and year dummy variables. **3-** * p<0.1, ** p<0.05, *** p<0.01.

***Table A8**: Innovation strategies and workforce composition. (2010-2015).*

| Sector | ***high-tech*** | | ***Low-tech*** | | **KIBS** | | **Traditional services** | |
|---|---|---|---|---|---|---|---|---|
| Workforce composition | Skilled | Unskilled | Skilled | Unskilled | Skilled | Unskilled | Skilled | Unskilled |
| Regression | MCO | MCO | MCO | MCO | MCO | MCO | MCO | MCO |
| Dependent Var. | *skilled_gnet* | *unskilled_gnet* | *skilled_gnet* | *unskilled_gnet* | *skilled_gnet* | *unskilled_gnet* | *skilled_gnet* | *unskilled_gnet* |
| Constant | -0.090* | 0.005 | -0.196*** | -0.040*** | -0.154* | -0.039 | -0.100 | 0.116* |
| | (0.054) | (0.028) | (0.030) | (0.014) | (0.086) | (0.051) | (0.089) | (0.061) |
| make (*dummy*) | 0.656** | 0.506** | 0.373*** | 0.272*** | 0.411* | 0.483 | 0.429* | 0.274 |
| | (0.283) | (0.213) | (0.105) | (0.096) | (0.236) | (0.323) | (0.221) | (0.182) |
| buy (*dummy*) | 0.282*** | 0.176*** | 0.319*** | 0.247*** | 0.305*** | 0.249*** | 0.310*** | 0.264*** |
| | (0.070) | (0.043) | (0.039) | (0.025) | (0.064) | (0.041) | (0.049) | (0.037) |
| mnb (*dummy*) | 0.459*** | 0.332*** | 0.437*** | 0.347*** | 0.570*** | 0.480*** | 0.399*** | 0.536*** |
| | (0.067) | (0.050) | (0.053) | (0.040) | (0.073) | (0.064) | (0.085) | (0.084) |
| $R^2$ | 0.179 | 0.203 | 0.150 | 0.227 | 0.144 | 0.214 | 0.116 | 0.209 |
| Standard error | 0.462 | 0.296 | 0.523 | 0.292 | 0.525 | 0.358 | 0.483 | 0.320 |
| n | 288 | 284 | 1,048 | 1,041 | 560 | 538 | 624 | 615 |
| Sargan | 0.207 | 0.224 | 0.138 | 0.429 | 0.229 | 3.989 | 3.878 | 1.559 |
| p-value | 0.902 | 0.894 | 0.933 | 0.807 | 0.892 | 0.136 | 0.144 | 0.459 |

*Source*: Authors based on UIS.
*Notes*: **1-** Standard errors in parentheses. **2-** All regressions include industrial dummy variables (2 digits) and year dummy variables. **3-** * p<0.1, ** p<0.05, *** p<0.01.