Quality of jobs and
innovation generated
employment outcomes

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THE EMPLOYMENT AND JOB QUALITY EFFECTS OF INNOVATION IN FRANCE, GERMANY AND SPAIN: EVIDENCE FROM FIRM-LEVEL DATA

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QuInnE - *Quality of jobs and Innovation generated Employment outcomes* -is an interdisciplinary project investigating how job quality and innovation mutually impact each other, and the effects this has on job creation and the quality of these job.

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Quinne project brings together a multidisciplinary team of experts from nine partner institutions across seven European countries.

Project partners:

CEPREMAP (Centre Pour la Recherche Economique et ses Applications), France

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Abstract: Empirical studies focusing on the impact of innovation on employment and job quality are scarce and limited, especially at the firm level. Innovation is a complex phenomenon that is often cited as a solution to create jobs and improve their quality as well as a source of unemployment (especially for low qualified workers) and job quality deterioration. Based on a comparative study of France, Germany and Spain, this paper evaluates the impact of innovation on employment and job quality at the firm level. Its contribution is twofold: first, it uses databases including a rich set of innovation variables (CIS for France, IAB panel for Germany and ESEE for Spain) , which allows distinguishing between different kinds of innovation in a comparative perspective (product, process, organizational, following the definitions of the Oslo manual); second, it analyzes the effect of innovation on a variety of employment variables including job quality variables (employment variation, types of contracts, wages, etc.). Using a difference-in-differences method, we find a general positive impact of innovation variables on employment, which is more pronounced for product innovation. Our results also support the presence of a skilled-biased effect of product innovation on employment and wages (especially for France) at the firm level.

Executive summary

Europe 2020 strategy puts the emphasis on five main targets among which rising employment, boosting innovation through R&D as well as fighting against poverty and social exclusion. These goals are presented as interrelated and mutually reinforcing. In the framework of the *Quinne* project (*Quality of jobs and Innovation generated Employment outcomes*), this working paper brings empirical evidence on the links between innovation, employment and job quality outcomes as well as on the potential differentiated effects of innovation on different social groups. Innovation is a complex phenomenon that is often cited as a solution to create jobs and improve their quality but can also be a source of unemployment (especially for low qualified workers) and job quality deterioration. Empirical studies focusing on the impact of innovation on employment and job quality are scarce and limited, especially at the firm level.
Based on a comparative study of France, Germany and Spain, three European countries with different innovation and employment profiles (Erhel and Guergoat-Larivière, 2016), this paper evaluates the impact of innovation on employment and job quality at the firm level. It uses an innovative difference-in-differences methodology that deals with selection bias and unobserved heterogeneity. It is based on European and national databases including a rich set of innovation variables, in order to distinguish between different types of innovation in a comparative perspective (product innovation, product innovation new to the market, process innovation and organizational innovation, in accordance to the Oslo manual typology). Contrary to most studies on the impact of innovation at the firm level, it analyzes not only the effect of innovation on total employment but also on a variety of employment variables including job quality variables (types of contracts, wages, working hours etc.) and explores the possible differentiated effects of innovation on employment and job quality for different social groups (low/high educated workers, women/men…).

Our results show that technological innovation (i.e. product and/or process innovation) has a clear positive impact on employment at the firm level in the three countries. This positive effect holds true in the case of product innovation in all three countries but also in the case of process innovation (France, Spain) and organizational innovation (France, Germany) which is less expected from a theoretical point of view that usually considers these two last types of innovation as “labor saving”.

In terms of job quality (in France and Germany), it seems that product innovation generates higher wages and employment stability (open-ended contacts in France), suggesting that firms would therefore share the benefits of product innovation with their employees. However, results are more mixed for process and organizational innovation. In France, process innovation impacts negatively the synthetic index of job quality and organizational innovation has a negative impact on wages. In Germany, process and organizational innovations increase part-time employment, which can be associated with a “labor saving” process encouraged through the use of short-time working during the crisis. Organizational innovation also seems to increase the number of low-paid workers.

Another important contribution of this working paper is to show the impact of innovation on the structure of the workforce at firm level. Our results support the hypothesis of skilled-biased effects of innovation: technological and organizational innovation seems to be more favorable to high-skilled workers while it has no significant and sometimes negative impact on low-skilled workers. However, some specific effects appear across countries for some types of innovation (product, process, new to the market product innovation). Results on technological innovation are in line with the literature on learning economy and ICT use, which claims that new technology adoption, coming from product innovation, requires higher skills.

From a policy perspective, our results generally support the idea of a virtuous circle between innovation and employment but also underline the mixed effects of certain types of innovation on job quality and on employment distribution across occupations. For instance, organizational innovation (and to a lesser extent process innovation) can be related to different goals, such as upgrading quality or reducing labor cost, that do not lead to the same outcomes in terms of employment and job quality.

This study also points out that these effects are not identical in all countries: for instance, while organizational innovation has rather no effect on employment in Spain, it increases the number of jobs in the company in both France and Germany, but has different effects on wages in the two countries. Such differences may be related to national or lower-level (branch, industry, sector) institutional settings and their interactions with firms' decisions.

Introduction

Since the launch of the Lisbon Strategy and through the most recent Europe 2020 Strategy, the EU has put forward the hypothesis of a positive relationship between innovation and job quality: according to this view, a growth strategy based on innovation would be a driver of better jobs in Europe (which in return could favour the development of new innovations at the workplace). However, the academic literature linking innovation and job quality remains scarce, especially at the micro level. The QuInnE project (Quality of jobs and Innovation generated Employment outcomes), which started in 2015 in the framework of Horizon 2020, addresses this gap by bringing together quantitative and case study analyses for the EU and more specifically for seven countries (France, Germany, Hungary, the Netherlands, Spain, Sweden, the UK).

This working paper belongs to QuInnE empirical analyses and focuses on the impact technological and organizational innovation may have on employment and job quality. Different hypotheses can be made in that respect. The first one is related to the leading role played by technological change in the determination of productivity, which is in turn one of the key determinants of job quality. The second mechanism is associated to the impact that technological change has on the structure of production and employment, and the implications of such changes on job quality. The third mechanism refers to the direct effect that the adoption of different technologies or new work organization may have on the working environment and the conditions of work, and the subsequent implications for job quality.

Aiming to take advantage of the availability of more detailed databases on a national basis, this study tries to identify not only correlations but also causal relationships. The objective is to analyse the behaviour of innovating (*versus* non-innovating) firms in terms of job creation and job quality, trying to control for selection bias (innovation is not random) using applied micro-econometric techniques (a difference-in-differences approach). It is based on several databases: IAB panel for Germany, Survey on Business Strategy (*Encuesta de Estrategias Empresariales*, ESEE) for Spain, and for France a matched dataset constructed using the French part of the Community Innovation Survey (CIS) and administrative data on employment (*Déclaration Annuelle des Données Sociales* - DADS).

Innovation is defined in accordance to the Oslo manual (OECD, 2005; see box below), on which innovation surveys are based. The Oslo manual distinguishes four types of innovation: product, process, organizational and marketing. Product and process innovations belong to the broader category of technological innovation, whereas marketing and organizational innovations are included in the non-technological category. Marketing innovations are not considered in this working paper as their potential impact on employment and job quality is more limited. As innovation novelty also matters for employment effects, we also consider a subcategory of product innovation, which consists of innovations that are not only new to the firm, but also new to the market on which the firm and its competitors are operating. As far as employment is concerned, the working paper considers both the total number of jobs in the firm and some job quality outcomes (employment by type of contract, by occupations or qualifications, wage levels, number of hours worked). In comparison to QuInnE general job quality framework, which includes six dimensions, job quality is more narrowly defined (working conditions and participation/collective presentation are absent) as a consequence of important constraints of data availability. Some indicators of wage inequalities (by gender, by occupations) are also introduced when available.

In addition to testing the general relationship between innovation and employment levels as well as job quality, the working paper develops some comparative results about the relationship between innovation and job quality in different national contexts. Indeed, the three countries analysed in this paper belong to different regimes of innovation and job quality (Erhel and Guergoat-Larivière 2016): Germany belongs to European innovation leaders with a rather good job quality on average, Spain is characterised by lower job quality and low innovation, and France stands in an intermediary position (rather high innovation but lower job quality than Germany, see quinne.eu).

The first section of the paper recalls the expected relationships between innovation on the one hand and employment and job quality on the other. The second section presents the databases used at the firm-level for France, Germany and Spain as well as definitions of the different types of innovation and discusses the comparability of data. The third section shows descriptive statistics (structural characteristics, employment and job quality outcomes) for innovating and non-innovating firms in the three countries. The fourth section presents the methodology that combines propensity score matching and a difference-in-difference approach in order to correct for selection bias and unobserved heterogeneity. The last section displays the results of this method for the three countries and shows how different types of innovation may impact employment and job quality outcomes in French, German and Spanish firms.

Box 1- Types of innovation according to the Oslo manual

The Oslo Manual distinguishes four types of innovation within two categories of technological and non-technological innovations.

- Within the category of **technological innovation**:

-A **product innovation** is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.

-A **process innovation** is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.

- Within the category of **non-technological innovation**:

-A **marketing innovation** is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

-An **organizational** innovation is the implementation of a new organizational method in the firm's business practices, workplace organization or external relations.

- The Oslo manual also allows defining **a degree of novelty for innovations**.

The minimum entry level for an innovation is that it must be **new to the firm**. Innovations are said "**new to the market**" when the firm is the first to introduce the innovation on its market. The market is simply defined as the firm and its competitors and it can include a geographic region or product line. The geographical scope of new to the market is thus subject to the firm's own view of its operating market and thus may include both domestic and international firms. In this paper, innovations that are new to the market will sometimes be named as 'radical'.

Source: OECD (2005) Oslo Manual Guidelines for collecting and interpreting data on innovation

1-The employment impact of innovation at the firm level: existing evidence and further questions

The economic literature has extensively investigated the links between innovation and employment, both at the macroeconomic and sector or firm level. In this working paper, we focus on firm level evidence, addressing two main issues: the impact of innovation on employment and job quality, and the effect of innovation on employment by skill. Our literature review includes international literature with a specific focus on the three countries on which our empirical analyses have been conducted.

-*Innovation and employment*

According to standard economic theory, technological innovation is likely to have ambiguous effects on total employment at the firm level (Van Reenen, 1997; Van Roy *et al*, 2015). Two types of innovation are generally considered: product innovation (inducing a change in the production technology but also in the demand function) and process innovation (i.e. changes in the production function). Process innovation may decrease the level of employment through a direct labour saving effect: i.e. the required level of employment for a given output decreases when an innovation is implemented. However compensation mechanisms might mitigate or even overcome that negative impact: i.e. such process innovations also reduce the effective cost of labour and may lead firms to increase output and thereby leading to employment growth. The size of these compensation effects depends on the institutional and economic context (degree of competition on the goods market, demand elasticities, wage adjustments mechanisms, etc.). Product innovation leads to the opening of new markets or to an increase in the range or quality of products, which should have a job creation effect. However, even in that case, some contradictory mechanisms can be at play. Indeed, some old products might be displaced by the new ones, reducing the positive effect on employment. In the end, economic theory suggests ambiguous effects of innovation at the firm level, although they are more likely to be positive in the case of product innovation.

Empirical analysis at the micro level of the links between innovation and employment has been developing since the 1990s (for a detailed review, see Van Roy *et al*, 2015, Vivarelli, 2014).
Following several studies based on cross-section data (and therefore unable to control for firms' unobserved heterogeneity), most recent papers use panel data to deal with unobserved heterogeneity and endogeneity issues. Van Reenen (1997) uses a British panel of 589 firms in the manufacturing sector over the period 1945-1983, and finds a positive effect of technological innovation (defined quite narrowly using an experts' database) on employment at the firm level. That effect is persistent over several years, and is larger for product innovation. Greenan and Guellec (2000) also find a positive impact of both types of technological innovation on employment changes at the firm level using a sample of 15 186 French manufacturing firms from 1986 to 1990. However, at the sectoral level, the effect of process innovation becomes negative, which might be explained by the existence of substitution or effects where innovating firms gain market share at the expense of non-innovators. On the basis of a panel of 575 Italian manufacturing firms, Piva and Vivarelli (2005) also find a positive effect of technological

innovation on employment –even when they control for a potential business stealing effect by introducing a sales variable. For German manufacturing firms observed over the period 1982-2002, Lachenmaier and Rottman (2011) confirm a positive effect, which appears even higher for process than for product innovation. Furthermore, their results show a time-lag between an innovation and its effect on employment, which stresses the need to use panel data when investigating innovation related outcomes. In an earlier study, Peters (2004) also obtained a positive impact of product innovation on employment using CIS 2001 data, and more heterogeneous effects for process innovation (negative in the manufacturing sector but not in the service sector). For Spain Alonso-Borrego and Collado (2002) as well as Llorca and Gil (2002) and more recently Heijs *et al*. (2015) using longitudinal data of Spanish manufacturing firms from the Survey on Business Strategies, conclude that technologically innovative firms tend to create more – and to destroy less – employment than non-innovative firms. This effect is stronger in firms with process innovations.

In the three countries we are focusing on, the only study that goes beyond global employment effect and considers some dimension of job quality (in the present case the type of employment contract) is based on Spanish firm data (from CIS). Giuliodori and Stucchi (2012) analyze the relationship between innovation and temporary and permanent jobs before and after a change in the employment protection legislation (EPL) in Spain that took place in 1997 (a reduction in unfair dismissal compensation). The authors find that: (a) product and process innovation create jobs, (b) before the change in the EPL innovations had no effect on the number of permanent workers and all the increase in employment was explained by the increase in the number of temporary workers, (c) after the change in the EPL, innovations increased the number of both temporary and permanent employees.

On the whole, such national studies support the hypothesis of a positive employment effect of innovation at the firm level, and highlight some differences when disentangling between product and process innovation. However, these differences are not clear cut, and empirical results do not clearly validate the idea that process innovation would be less favorable on employment.

A few studies are also available on European databases, using different sources and definitions of innovation (based on patents in Van Roy *et al*, 2015; on R&D expenditures in Piva and Vivarelli, 2017; on sales growth declared by firms in the Community Innovation Survey in Harrison *et al*, 2014 –with a focus on Spain, France, Germany and the UK). They generally take a broader perspective than the previously mentioned national studies and include services as well as manufacturing firms. The results confirm a positive effect of innovation on employment, as well as some differences between process and product innovation when the distinction is available (Harrison *et al*, 2014). Indeed, the former type of innovation (process only) is found to have a negative impact on employment in the manufacturing sector. Differences by sectors are also found in these studies and show the importance of studying services and manufacturing together and separately. As far as cross-country heterogeneity is concerned, Harrison *et al* (2014) find very similar results for the four countries they analyze.

In the present working paper, we build on these results and disaggregate our analyses by types of innovation –following the Oslo manual typology- as well as by sectors when the information is available (manufacturing, retail and services). We also consider three countries that belong to different clusters of innovation according to comparative studies, even if existing micro studies obtain similar results across countries. Besides we will adopt a job quality perspective as much as possible given data constraints, and go beyond employment effects by considering also the types of labour contracts (permanent *vs* temporary), wages and working time.

-Innovation and employment by skills

Another important issue raised by the economic literature on the impact of innovation concerns the diversity of employment effects by skills. Indeed, the hypothesis of skill biased technological change assumes that innovation would be favorable to higher-skilled employment and destroy low-skilled jobs. Many empirical studies have provided support for such a hypothesis on national sector and firm level data. For the US, Autor *et al* (1998) related the employment shift in favour of skilled labour to firms' investments in computers and R&D in both manufacturing and non-manufacturing sectors. As far as European countries are concerned, Machin (1996) also found a positive relationship between the use of computers and skilled labour on firm data for the UK. For France Mairesse *et al* (2001) confirm that positive relationship exists between the use of Information and Communication Technology (ICT) and skilled labour in cross section, even if only the negative relationship between ICT and low qualified workers is robust in a time series perspective (from 1986 to 1994). For Germany, Falk and Seim (1999) show that firms devoting more resources to ICT employed more educated workers, even if the magnitude of the relationship was small. Machin and Van Reenen (1998) take a cross-national perspective based on a panel at the manufacturing sector level for seven countries (including France and Germany) and show that the relative demand for skilled workers is positively linked to R&D expenditures. Although it focuses on a restrictive definition of innovation (R&D, and more specifically computers, ICT), that literature shows the importance of decomposing the global impact of innovation on employment by skills.

In that perspective, our analysis will also take into account a more recent literature on jobs polarization, although the relationship with innovation at the firm level is less direct. The jobs' polarization hypothesis has recently been put forward in the economic literature and in the political debate, following several empirical studies (Autor, 2015; Goos *et al*, 2014; Eurofound, 2015). Jobs' polarization describes the process by which low qualified and highly qualified jobs are simultaneously created in most economies, while middle occupation jobs are disappearing. However, the level of analysis when considering polarization differs from previous studies mentioned above: analyses of job polarization are generally conducted on the basis of aggregate employment data (decomposed by occupations or wage levels)[1]. Besides, the links between polarization and technological change or innovation rely on the hypothesis of routine task replacement under technological change (Autor, 2010) that would affect more particularly job opportunities in middle-skilled clerical, administrative, production, and

[1] Although one recent paper confirms the existence of polarization in France on the basis of firm data (Harrigan *et al*, 2016), it does so without making a direct link with innovation.

operative occupations. Such a hypothesis is more specific than the general concept of innovation and it is not the exclusive factor to explain polarization: some labour supply or labour market regulation changes are also considered in that literature (Autor, 2010).

-*Our research questions*

The present paper will contribute to the literature by answering the following questions:
-what are the employment and job quality effects of innovation? Do they differ by category of innovation (product, process, organizational)?
-what are the effects of innovation on employment and wages by occupations? Do we observe a skill biased technological change as in most firm level empirical studies (i.e. job creation at the upper skill levels and some negative impact for low skilled jobs), or some polarization trend (i.e. job creation at the lower and upper skill levels and destruction in the middle)?
-do these impacts vary across countries which are characterized by different innovation and labour market regimes?
We will do so by taking a difference in difference approach that enables correcting for problems of endogeneity and unobserved heterogeneity (and therefore identifies causal effects), and will be applied to three national datasets.

2-Data bases

As mentioned before, different types of innovation can be identified. Databases used in this comparative analysis of French, German and Spanish cases all distinguish between technological and non-technological innovations. Technological innovations can be either product innovations or process innovations while non-technological innovations considered here are organizational innovations. Among product innovations, we can distinguish innovations that are "new to the market" namely new or significantly improved products firms introduced onto their market before their competitors (this information is not available for Spain). This subcategory can be seen as a proxy for more radical product innovations.

France

We use three different databases at the firm level: the Community Innovation Survey (CIS 2012), *Déclarations Annuelles de Données Sociales* (DADS) and fiscal data (FARE-FICUS). The Community Innovation Survey has been designed at the European level to collect data on activities in enterprises following the Oslo manual and its typology of innovation (see box 2). It is conducted every two years in every EU member state: the last available surveys are 2012 and 2014, and the first edition dates back to 1993. In France the sample includes about 23 000 enterprises in the private sector. DADS are administrative data on employment, collected every year on the basis of firms' compulsory declarations. They include information collected at the establishment level in the private sector about employment, by occupation and gender, as well as about working hours and the types of contracts (fixed-term or permanent) and their duration. FARE-FICUS include standard accounting data used by the administration to collect taxes on benefits etc. These three data bases can be merged at the enterprise level. Table A1.1 in appendix presents the variables used in our analyses.

The general framework for analysis is the following. To analyze the impact of innovation, we consider firms that are in CIS 2012 (= we know if they are innovating or not between 2010 and 2012), for which we have information about employment, job quality and different controls (rate of return, productivity, etc.) in 2009 and 2013. That is how we can analyze the impact of innovation on employment and job quality.

Matching CIS (17851 firms) with DADS and FARE, we finally get a sample of 14204 firms.

Box 2: definition of innovation according to CIS 2012 (source: CIS questionnaire)

"This survey collects information on your enterprise's innovations and innovation activities during the three years 2010 to 2012 inclusive.

An innovation is the introduction of a new or significantly improved product, process, organizational method, or marketing method by your enterprise.

An innovation must have characteristics or intended uses that are new or which provide a significant improvement over what was previously used or sold by your enterprise. However, an innovation can fail or take time to prove itself.

An innovation need only be new or significantly improved for your enterprise. It could have been originally developed or used by other enterprises."

Germany

The following firm-level analyses focusing on Germany are based on the data from the Institute for Employment Research (IAB) Establishment Panel which is a representative employer survey on occupational measures and employment. Annually, approximately 16.000 establishments from all industries and all establishment sizes are surveyed nationwide. The IAB Establishment Panel was first conducted in 1993 in Western-Germany and 1996 in East Germany. The study is carried out annually ever since, offering extensive and unique longitudinal data at the firm-level in Germany. The sampling is based on the data from the Federal Employment Agency (*Bundesamt für Arbeit*) which contains roughly two million employers, whereas the population of the IAB Establishment Panel consists of all establishments with at least one employee who are subject to mandatory social insurance contributions. The sample is drawn disproportionately and is stratified according to establishment size, industry and federal state. The survey is carried out through computer assisted personal interviews with representatives of the establishments (for more information see Fischer *et al.*, 2008).

Box 3: Definition of innovation according to IAB (source IAB 2013 questionnaire)

- In the last business year of 2012, did your establishment improve or further develop a product or service which had already been part of your portfolio?
- In the last business year of 2012, did your establishment start to offer a product/service that had been available on the market before?
- Have you started to offer a completely now product or service in the last business year of 2012 for which a new market had to be created?
- Did you develop or implement procedures in the last business year of 2012 which have noticeably improved production processes or services?

The general framework for the statistical analysis follows the overall comparative structure of this paper. For a better temporal comparability with French data, the IAB panel is delimited to the years 2009 to 2013, whereas innovation is captured in the years 2010, 2011 and 2012. This means that only firms for which we have balanced data over 5 years can be analyzed in the following. Through panel attrition and item or unit non-response the overall sample size consists of 9.416 firms.

Spain

The database used for the Spanish case is the Survey on Business Strategy (*Encuesta de Estrategias Empresariales*, ESEE). The ESEE is an annual survey run by the public *Sociedad Estatal de Participaciones Industriales* Foundation, which is part of the Spanish Ministry of Industry and represents the umbrella entity for all the State's participations in industrial firms. The survey was developed to study the strategic behavior of Spanish manufacturing firms and annual and running continuously since 1990. Our analysis focuses on the period 2002-2010, which is the period when the database has the highest-quality information (with no discontinuities and comprising all our variables of interest).

The ESEE consists of a panel of manufacturing firms, with a sample averaging 1857 firms and with an average response rate of 91%. The universe of the survey is manufacturing firms - Divisions 10 to 32 of NACE-2009 excluding 19 (Manufacture of coke and refined petroleum products) - with 10 or more employees. All firms over 200 employees are included in the sample, while smaller firms are selected by stratified sampling. Attrition is minimized by maintaining close contact with firms, and compensated, when it happens, by adding new firms meeting the criteria used in the first round of the survey: all new firms with more than 200 employees and 5% of new firms from 10-200 employees.

Apart from information on relevant markets, accounting and foreign trade, the survey has extensive and detailed information on the firms and their innovation activities and more basic information regarding employment. Some of the relevant variables (such as the number of high- and medium-educated workers) are only available every 4 years. Our analysis uses two intervals of time, 2002-2006 and 2006-2010, which include 1,603 firms and 2,298 firm-year and 4,596 firm-year observations, respectively. It contains information on product, process and organizational innovation (in the latter case, only for the interval 2006-2010, see Box 4 for further details). The variables related to employment and job quality available in this database are total employment, permanent and temporary employment, number of workers by educational attainment (allowing distinguishing between engineers and workers with a long university degree -which we label as high-educated workers-, technical engineers, workers with a short university degree and assistants with a relevant degree -medium-educated workers- and the rest of the firm workforce), expenditure per worker on external training and hourly labour costs.

Box 4: Definition of innovation according to ESEE (2010 questionnaire)

- State if, in 2010, the firm obtained any product innovations (new products or modification of existing products that are so important that are different from those produced earlier).
- State if, in 2010, the firm introduced any relevant change in the process of production or distribution (process innovation) referring to new machines and equipment, new techniques or methods or new software linked to production processes.
- State if, in 2010, the firm introduced new organization methods related to new economic practices of organizing work (either in the routines or in the distribution of responsibilities) or new methods of managing external relations with other firms or public institutions (providers, customers, etc.).

The databases used in the three countries enable us to have a good comparability of innovation definitions and concepts, as they all use the typology of the Oslo manual and distinguish between product, process and organizational innovation. For the French and German cases we have additional information about the novelty of product innovation ("new to the market" or only to the firm). As far as employment is concerned, despite some country specificities, we have the same basic information about employment levels in the firm and some decomposition by gender, occupations or skill levels, the type of contract and wages or hourly labour costs. The nature of the surveys is different, as Spanish and German analysis rely on a panel whereas for France CIS is a cross section survey. But it provides information on a period of three years and using our administrative data we can compare firms at two points in time. The periods finally covered in France and Germany are therefore the same. In the case of Spain it remains different to get better quality of data, and the scope of the survey is also different since only manufacturing sector is included.

3- Descriptive statistics

3.1 France

-Types of innovation and characteristics of innovating firms in France

In the French sample, based on CIS data matched with administrative data, we only consider firms where innovation activities were not abandoned over the 2010-2012 period. Considering only firms where innovation activities were successful, about 40% of firms have developed a *technological* innovation between 2010 and 2012. About 30% have introduced a significantly improved *product* and about the same proportion (29%) has introduced a significantly improved *process*. These figures show that a significant proportion of firms that introduced a technological innovation between 2010 and 2012 innovated both in terms of product and process. Among product innovations, about two thirds are "new to the market" which corresponds to about 21% of all firms in our sample.

Moving to non-technological innovation, we can observe that 37% of firms have introduced an organizational innovation.

Table 1. Share of innovating firms by type of innovation (between 2010 and 2012)

Type of innovation	Share of innovating firms
Product or process innovation (technological innovation)	40,8%
Product innovation	30,5%
Product innovation new to the market	21,4%
Process innovation	29%
Organizational innovation	37,1%

Source: CIS 2012-FARE 2009 2013-DADS 2009 2013, matched data, authors' calculations, 14.204 firms

Table 2: Characteristics of innovating and non-innovating firms with the regards to the type of innovation (technological, product, process, new to the market, organizational) - France

	Total	Technological innovation		Product innovation		Process innovation		New to the market product innovation		Organizational innovation	
		YES	*NO*	*YES*	*NO*	*YES*	*NO*	*YES*	*NO*	*YES*	*NO*
Industry											
Manufacturing	57,5%	62,9%	53,8%	62,8%	55,2%	63,8%	54,9%	62,9%	56,0%	56,6%	58,0%
Retail	14,5%	9,7%	17,8%	8,3%	17,2%	9,7%	16,4%	8,0%	16,3%	13,6%	15,0%
Other services	28,0%	27,4%	28,5%	29,0%	27,6%	26,5%	28,6%	29,1%	27,7%	29,7%	27,0%
Size (nb of employees)											
< 20	37,1%	27,4%	43,9%	24,7%	42,6%	27,6%	41,0%	23,5%	40,9%	29,4%	41,7%
20 to 49	31,1%	27,4%	33,6%	26,7%	33,0%	26,6%	32,9%	26,0%	32,4%	29,7%	31,8%
50 to 499	26,1%	34,8%	20,0%	36,7%	21,4%	34,6%	22,6%	36,8%	23,2%	31,6%	22,8%
500 to 999	3,4%	5,9%	1,6%	6,5%	2,0%	6,1%	2,2%	7,4%	2,3%	5,1%	2,3%
> 1000	2,4%	4,5%	0,9%	5,4%	1,1%	5,1%	1,3%	6,4%	1,3%	4,2%	1,3%
Part of a group											
In a group	46,0%	56,2%	39,1%	58,8%	40,4%	56,6%	41,7%	61,3%	41,9%	53,9%	41,4%
Not in a group	54,0%	43,8%	60,9%	41,2%	59,6%	43,4%	58,3%	38,7%	58,1%	46,1%	58,6%
Age (mean)	27,9	28,64	27,39	28,62	27,58	29,02	27,44	28,47	17,74	28,19	27,73
Rate of return (mean)	-0,199	0,412	-0,62	0,575	-0,539	0,530	-0,497	0,784	-0,467	0,215	-0,46
Productivity (mean)	66,35	72,76	61,93	75,84	62,19	70,39	64,70	78,93	62,93	69,80	64,32
Nb. Obs.	14204	5792	8412	4327	9877	4118	10086	3039	11165	5265	8939

Source: CIS 2012-FARE 2009 2013-DADS 2009 2013, matched data, authors' calculations

Focusing on technological innovation, we observe that innovating firms have specific characteristics: 63% of the firms are in the manufacturing sector while only 10% are in the retail sector. Among non-innovating firms, only 54% of the firms are in the manufacturing and 18% in the retail sector. The proportion of firms in the service sector is similar among innovating and non-innovating firms. Technological innovations thus seem to be more concentrated in the manufacturing sector while it is limited in the retail sector. This holds true when we look at subcategories of technological innovation (product, process or new to the market product innovations). Conversely, we can observe that the distribution across sectors of firms which have implemented an organizational innovation is very similar to the overall distribution in the sample (about 57% in manufacturing, 14% in retail and 29% in other services).

The effect of firm's size also appears clearly. Innovating firms are much more likely to be large firms (from 50 to 499, from 500 to 999 or above 1000 employees) and much less likely to be small firms (<20 or from 20 to 49 employees). For instance, among technological innovating firms, 4,5% have more than 1000 employees while this proportion is reduced to 0,9% for non-innovating firms. This size effect is reinforced for new to the market product innovations: 6,4% of these firms have more 1000 employees. Among firms implementing organizational innovations, we can also notice an overrepresentation of big firms, in the same proportion as for technological innovating firms (4,2% of them have more than 1000 employees).

Innovating firms are also more frequently part of a group. While about 46% of firms in our sample are part of a group, this is the case for 56% of technological innovating firms and only for 39% of non-innovating firms. This effect is less marked for firms that implement organizational innovations (54% among innovating ones and 41% among non-innovating ones) while it is stronger for firms which have introduced a product innovation new to the market (61% of these firms are in a group).

Innovating firms are slightly older on average than non-innovating ones. The difference is more marked for firms that have introduced an innovation of product that is new to the market. On average, rate of return and productivity seem to be higher in innovating than in non-innovating firms, especially in the case of product innovation and even more if the product is new to the market.

-Employment and job quality in innovating firms (compared to non-innovating firms) in France

On the basis of our matched sample of firms we can compare innovating and non-innovating firms according to a number of indicators of employment and job quality. These indicators are summarized in Tables 3 and 4 for 2009. While the econometric part (section 5.1) will use *differences in the number* of employees, descriptive statistics rather show shares of different types of workers in innovating and non-innovating firms in order to reduce the strong 'size effect' noticed in the previous section.

Tables 3 and 4 show that innovating firms have higher total workforce than non-innovating ones (whatever the type of innovation: product, product new to the market, process or organizational innovation). Shares of open-ended and temporary contracts are similar in the total sample and in subsamples of innovating and non-innovating firms, for all kinds of innovation. The average number of hours worked per employee is also very similar in all subsamples though slightly higher in firms that developed a product innovation new to the market. In terms of wages, some differences are noticeable: average hourly gross wage and average gross wage are higher in innovating firms and this is particularly true for firms innovating in products and even more when products are new to the market. Innovating firms also seem to have a different structure of their workforce in terms of skills[2]: they display lower shares of manual workers whereas they have higher shares of managers and professionals as well as technicians and associate professionals. They also have higher share of women workers.

[2] PCS in French data are not always easily comparable to European or other countries' classifications. In this paper, we will use the following terms:'managers and professionals' for French *cadres* which corresponds to ISCO 1-2, ‚Technicians and associate professionals' for French *professions intermediaires* which corresponds to ISCO 3-4 and ‚Manual workers' for French *ouvriers and employés* which corresponds to ISCO 4-9.

Table 3: Job quality and employment according to firms' innovation status (technological, product and process innovations)

	Total	Technological innovation		Product innovation		Process innovation	
		YES	*NO*	*YES*	*NO*	*YES*	*NO*
Total workforce	176,36	285,59	101,15	327,15	110,30	308,02	122,60
Share of open-ended contracts	95%	95%	95%	95%	95%	95%	95%
Share of temporary contracts	5%	5%	5%	5%	5%	5%	5%
Share of technicians and associate professionals	19%	21%	17%	22%	17%	21%	18%
Share of manual workers	63%	56%	68%	52%	68%	58%	65%
Share of managers and professionals	17%	22%	14%	25%	14%	20%	16%
Share of women	29%	30%	28%	31%	28%	30%	28%
Number of hours (annual)	1587,14	1587,68	1586,76	1591,75	1585,12	1586,37	1587,45
Synthetic index of JQ	0,02	0,04	0,00	0,06	0,00	0,03	0,01
Hourly gross wage in euros	18,60	19,77	17,79	20,43	17,80	19,41	18,27
Gross wage	29649	31541	28347	32682	28320	30935	29124
Gross wage for men	31937	34144	30412	35510	30368	33374	31348
Gross wage for women	26012	27183	25184	27849	25186	26817	25676
Gross wage for manual workers	22956	23356	22681	23686	22638	23287	22820
Gross wage for managers and professionals	51488	51545	51442	51801	51322	51432	51514
Gross wage for technicians and associate professionals	31706	31658	31744	31607	31756	31706	31706
Gender wage ratio (W/M)	0,86	0,83	0,87	0,81	0,87	0,83	0,86

Source: CIS-FARE-DADS matched data, authors' calculations. For number of hours, synthetic index, wages and gender wage ratios average values are displayed. Gross wages are annual.

Most of the differences observable in the structure of skills are reinforced for firms that innovate through a product innovation new to the market: these firms display even lower (resp. higher) shares of manual workers (resp. managers and professionals).

Decomposing gross wages by profession, we can observe that gross wages are generally higher in innovating firms for managers and professionals (except for organizational and process innovation) as well as for manual workers for all types of innovation. On the contrary, gross wages are slightly lower for technicians and associate professionals (except for product innovation new to the market).

Gender wage inequalities seem higher in innovating firms than in non-innovating ones: the ratio of women's gross wage on men's gross wage is indeed lower in innovating firms (e.g. 0,83 in technologically innovating firms and 0,84 in organizational innovating firms against 0,87 in non-innovating ones). The difference is even more marked in firms developing product innovations (0,81).

A synthetic index of job quality that includes some information about open-ended contracts, hours of work, hourly wages and gender wage gap is also calculated and seems to be higher in innovating firms than in non-innovating ones whatever the type of innovation considered (product, process, new to the market or organizational innovation).

Table 4: Job quality and employment according to firms' innovation status (new to the market product innovations and organizational innovations)

	New to the market product innovation		Organizational innovation	
	YES	*NO*	*YES*	*NO*
Total workforce	364,49	125,15	266,57	123,22
Share of open-ended contracts	95%	95%	95%	95%
Share of temporary contracts	5%	5%	5%	5%
Share of technicians and associate professionals	23%	18%	21%	18%
Share of manual workers	49%	67%	57%	66%
Share of managers and professionals	27%	14%	21%	15%
Share of women	31%	28%	30%	28%
Number of hours	1599,05	1583,89	1586,16	1587,72
Synthetic index of JQ	0,08	0,00	0,04	0,01
Hourly gross wage	21,03	17,94	19,48	18,08
Gross wage	33814	28515	31000	28853
Gross wage for men	36793	30612	33461	31037
Gross wage for women	28558	25303	26913	25472
Gross wage for manual workers	24094	22649	23438	22673
Gross wage for managers and professionals	52165	51265	51141	51719
Gross wage for technicians and associate professionals	31787	31682	31671	31729
Gender wage ratio (W/M)	0,81	0,87	0,84	0,87

Source: CIS-FARE-DADS matched data, authors' calculations. For number of hours, synthetic index, wages and gender wage ratios average values are displayed.

3.2 Germany

-Types of innovation and characteristics of innovating firms

Based on the IAB survey it is possible to distinguish five types of innovations relevant for this study. First, *product* innovation is conducted through three items in the questionnaire representing the improvement or further development of products or services, development of a new product or service which is new to the firm, but has been available on the market before and/or developing a new product which is new to the market. If one of the items is applicable for a firm in the years 2010 to 2012, it will be defined as a firm with a product innovation. This holds true for nearly 55% of the firms. Second, the most severe product innovation – *new to the market* innovation with approx. 12% of the firms - will also be analyzed separately in the following. Third, *process* innovations which have noticeably improved production processes or services in those three years will be analyzed. Fourth, *technological* innovation is conducted using the above described innovation of product or process innovation forms. There exists a high correlation between firms, which implement a product innovation and firms which carry out a process innovation, as seen inter alia in the overlapping shares of firms with both process and product innovation. Fifth, *organizational* innovation capturing changes in responsibility and decision-making structures, quality management, introducing team work, etc. is considered separately. This innovation type can be found in ca. 40% of the companies.

Table 5. Share of innovating firms by type of innovation (between 2010 and 2012) - Germany

Type of innovation	**Share of innovating firms**
Product innovation	54,75 %
Product innovation new to the market	11,47 %
Process innovation	20,09 %
Product or process innovation (technological innovation)	56,24 %
Organizational innovation	39,32 %

Source: IAB, 9 416 firms, weighted

Table 6 shows the relationship between firm size and innovation. Technological innovation can be detected in nearly 80% of large companies, whereas approx. 54% of the companies with less than 20 employees have conducted a technological innovation during the analyzed years. New to the market innovation is in the line with this finding – in comparison with ca. 10% of innovation is small companies, nearly 30% of large firms have brought out an innovation which is new to the market. The increase in the share of firms having implemented an organizational innovation is also in line with the higher number of employees in companies.

Table 6. Firm size of innovating and non-innovating firms with regards to the type of innovation (technological, new to the market, organizational) - Germany

Number of employees	Technological innovation (product and process)	New to the market product innovation	Organizational innovation
< 20 employees	53,89	10,28	34,75
20 to 49 employees	65,36	15,18	57,29
50 to 249 employees	71,13	19,85	68,24
> 250	79,60	29,46	80,43
Chi^2 *(Pr)*	420,8 (0.000)	304,6 (0.000)	1200 (0.000)

Source: IAB, 9 416 firms, weighted

The following table illustrates the share of innovating establishments according to their belonging to a group of firms. It can be stated, that technological, radical as well as organizational innovation are more frequent in firms with a group allocation.

Table 7. Group allocation of innovating and non-innovating firms with regards to the type of innovation (technological, new to the market, organizational) - Germany

Group allocation	Technological innovation (product and process)	New to the market product innovation	Organizational innovation
Firm in a group	65,97	15,19	50,49
Firm not in a group	54,01	10,62	36,76
Chi^2 *(Pr)*	118,3 (0.000)	115,6 (0.000)	1200 (0.000)

Source: IAB, 9 416 firms, weighted

Taking the founding year of the firms into account (Table 8), it can be said that the share of innovating firms by age is significantly connected with innovation – younger firms are in mean more prone to innovate than older establishments. Only organizational innovation is conducted more frequently in older firms founded before 1990s.

Table 8. Year of founding of innovating and non-innovating firms with regards to the type of innovation (technological, new to the market, organizational) - Germany

Year of founding	Technological innovation (product and process)	New to the market product innovation	Organizational innovation
Before 1990s	53,76	10,95	40,22
1990 to 2010	53,64	10,57	38,43
After 2010	62,46	13,13	38,94
Chi^2 (Pr)	17,3 (0.000)	6,3 (0.042)	38,4 (0.000)

Source: IAB, 9 416 firms, weighted

Table 9 shows the connection between industry sector and innovations. Technological innovation can be found predominantly in the firms from the manufacturing sector and services sector, whereas new to the market innovation is besides in the manufacturing sector more frequent in the retail sector. Regarding organizational innovation, it can also be said that the highest share of firms innovating by sector are those in manufacturing.

Table 9. Industry sector of innovating and non-innovating firms with regards to the type of innovation (technological, new to the market, organizational) - Germany

Industry sector	Technological innovation (product and process)	New to the market product innovation	Organizational innovation
Manufacturing	58,05	12,72	45,07
Construction	45,36	8,22	38,20
Retail	56,85	12,64	38,18
Other services	58,70	10,64	38,89
Chi^2 (Pr)	237,1 (0.000)	182,2 (0.000)	223,5 (0.000)

Source: IAB, 9 416 firms, weighted

The following table is a cross-tabulation of firm's turnover in quartiles and share of innovating establishments. The highest shares of companies having innovated in the considered three years can be detected in firms belonging to the last quartile of turnover i.e. economic power is significantly related with innovation. This holds true for all innovation forms.

Table 10. Turnover of innovating and non-innovating firms with regards to the type of innovation (technological, new to the market, organizational) - Germany

Turnover	**Technological innovation (product and process)**	**New to the market product innovation**	**Organizational innovation**
1st quartile	48,19	8,62	27,56
2nd quartile	57,77	12,98	45,92
3rd quartile	62,30	14,53	53,84
4th quartile	77,62	22,31	69,99
Chi^2 *(Pr)*	516,19 (0.000)	251,6 (0.000)	967,7 (0.000)

Source: IAB, 9 416 firms, weighted

-Employment and job quality in innovating firms

The next table (Table 11) gives an overview of the variables that are used from the German IAB data to capture job quality and employment.

Table 11. Job quality and employment according to firms' innovation status (new to the market product innovations and organizational innovations) - Germany

	Total	Technological innovation (product and process)		Innovation new to the market		Organizational innovation	
		YES	*NO*	*YES*	*NO*	*YES*	*NO*
Hours of work (week)	39,3	39,1	39,5	39,1	39,4	39,2	39,5
Gross wage (month)	458.678	637.366	117.208	1.143.667	339.826	762.443	132.637
Share of women in the workforce	0,435	0,435	0,435	0,414	0,439	0,420	0,450
Share of unskilled workers	0,149	0,147	0,154	0,149	0,150	0,154	0,142
Share of workers in skilled jobs	0,676	0,706	0,628	0,735	0,666	0,726	0,623
Share of part-time workers	0,258	0,247	0,274	0,215	0,265	0,236	0,281
Share of part-time female workers	0,765	0,77	0,760	0,776	0,763	0,765	0,765
Share of temporary contracts	0,053	0,057	0,047	0,067	0,051	0,063	0,043
Share of open-ended (permanent) contracts	0,947	0,943	0,953	0,933	0,949	0,937	0,957
Negative labour turnover (6 months)	5,488	6,805	3,304	11,155	4,474	8,204	2,593
Positive labour turnover (6 months)	5,784	7,238	3,444	12,366	4,642	8,546	2,879
Vacant positions	1,537	1,972	0,835	3,173	1,252	2,221	0,788
One-euro job holders	0,850	0,708	1,08	0,883	0,844	0,855	0,864
Number of workers with salary between 450 and 850 euro	1,837	2,126	1,371	2,560	1,707	2,468	1,167

Source: IAB, 9 416 firms, calculation of authors.

The weekly working hours amount to approximately 39 hours for all establishments, although they are slightly lower in innovating firms. Gross monthly wages are significantly higher in firms with innovation compared to non-innovating firms. There are no statistically significant bivariate differences in the share of women in the workforce and in the share of unskilled workers between firms according to their innovation status. On the other hand, the descriptive results show that the share of workforce in skilled jobs is indeed higher in innovating firms. The share of part-time workers is slightly lower in innovating firms, whereas the share of part-time workers differentiated by sex shows no significant differences in comparison.

Surprisingly, the share of temporary workers seems to be slightly higher in innovating firms through all innovation forms. This descriptive finding needs verification through the following multivariate analysis. In terms of the negative and positive labour turnover, innovative firms have significantly higher quantities in both variables. Furthermore, innovative firms have on average more vacant positions available than non-innovative firms. There are no statistical differences between the innovation in firms and the number of the so-called “one-euro jobbers”, i.e. unemployed persons receiving one-euro remuneration per hour worked in addition to the state benefits, used as an instrument to fight long-term unemployment. The number of workers with lower wages is significantly higher in firms with technological innovation and organizational innovation. Yet, these findings should be treated with cautiousness as the absolute numbers are correlated with firm size and can be compared more straightforwardly in the following analysis.

3.3 Spain

Tables 12 and 13 show the main descriptive statistics of the Spanish sample. It appears that process and organisational innovation are more frequent than product innovation. Besides, descriptive statistics indicate that the firms that introduce innovation, before doing so, are older, larger (a higher number of workers), have a higher productivity, exhibit higher profit margins, a higher proportion of high-educated workers, spend more on external training and present higher labour costs per worker. The proportion of temporary workers tends to be larger in the case of firms introducing product innovation than in the non-innovative firms and slightly lower in the case firms introducing either process or organizational innovations with respect to their counterparts not doing so. In any case, the existence and magnitude of these differences must be examined through the lens of the multivariate analysis.

Table 12. Share of innovating firms by type of innovation (between 2003 and 2005 and 2007 and 2009)

Type of innovation	Share of innovating firms
Technological innovation (product or process)	53,40%
Product innovation	29,80%
Process innovation	46%
Organizational innovation	35,10%

Source: ESEE

Table 13. Characteristics of innovating and non-innovating firms in 2006 (innovation observed in 2007, 2008 and 2009)

	Technological innovation		**Product innovation**		**Process innovation**		**Organizational innovation**	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Firm's age	29,345	25,157	31,168	26,066	29,359	25,692	28,790	26,973
Hourly productivity (Euros at 2010 prices)	34,188	28,207	33,943	30,743	34,752	28,373	35,833	29,480
Margin rate (over price)	0,099	0,086	0,094	0,094	0,101	0,086	0,101	0,090
No. of working hours per year	554 647	225 397	780 817	260 829	588 982	230 970	623 452	307 276
No. of workers	331,261	131,602	468,953	152,853	352,226	134,824	366,318	184,864
Proportion of permanent workers	0,834	0,846	0,837	0,840	0,832	0,848	0,835	0,842
Proportion of temporary workers	0,166	0,154	0,163	0,160	0,168	0,152	0,165	0,158
Proportion of high-educated workers	0,064	0,044	0,075	0,047	0,065	0,045	0,072	0,047
Proportion of medium-educated workers	0,083	0,052	0,093	0,060	0,084	0,055	0,086	0,061
Proportion of low-educated workers	0,853	0,903	0,831	0,893	0,851	0,899	0,842	0,891
Expenditure on external training per worker	117,485	62,169	155,888	67,946	126,371	59,682	148,464	65,409
Hourly labour costs (Euros at 2010 prices)	19,969	16,675	20,994	17,567	20,028	17,042	20,262	17,708
No. of firms	739	522	382	879	660	601	443	818

Source: ESEE

3.4. Descriptive statistics: comparative results

In the three countries, there is a positive correlation between firm’s size and the probability of innovation. The relationship with age is less clear cut: in the descriptive statistics, innovating firms are older in France and Spain but younger in Germany. Belonging to a group is positively correlated with innovation and so are the variables measuring firms’ performance (turnover, margin, productivity). In all countries, firms from the manufacturing sector are more likely to innovate. In France, firms from retail industry are less likely to innovate while in Germany they are relatively more likely to develop radical product innovation.

Looking at outcomes in terms of employment and job quality, we can observe in Germany and France that wages are higher in innovating firms while the number of hours worked is similar in both types of firms (data on wages are not available for Spain). The share of low skilled workers is smaller in innovating firms in France and Spain while it is similar in German innovating or non-innovating firms. Conversely, the share of high skilled is higher in innovating firms in Spain and France. In Germany, the share of workers in skilled jobs is higher in innovating firms. Finally, the share of employees on temporary contracts is similar in France in innovating and non-innovating firms while it is higher in innovating firms in Germany as well as in firms developing product innovation in Spain (the reverse is true in Spain for firms developing process or organizational innovation). In Germany, the share of part-time workers seems to correlate negatively with innovation.

4-Empirical strategy: a Difference in Difference approach to correct selection bias

Because firms that innovate do not have similar characteristics to other firms, we use an empirical methodology that allows us to take these differences into account. We use a propensity score matching model that was initially developed by Rosenbaum & Rubin (1983) to assess the effects of medical treatments. This method consists of considering innovation (I) as a treatment and constructing, for each firm that innovated between 2010 and 2012, an identical counterfactual that did not innovate. The effect of innovation on our different indicators of job quality is measured through the outcome variable (in our case we use different measures of employment and job quality). Thus, each firm is characterized by two potential results: y_0 if I=0 and y_1 if I=1. However, the effect of innovation on job quality is individual. Consequently, its distribution is not identifiable because y_0 and y_1 are never observed simultaneously; only the achieved result can be observed.

Let Y_i be the vector of result variables. For each firm, only the couple (Y, I) is observed. Nevertheless, if the latent outcome variables are independent of assignation to the treatment ($(y_0, y_1) \perp I$) – in other words, if the treatment is randomly assigned, – then the average effect on the treated firms (i.e., firms with innovation) can be identified: $E[(y_0, y_1)/I = 1]$. However, this property of independence is seldom confirmed. A solution would also consist of constructing a control group so that the distribution of a set of observable characteristics (i.e., a set of control variables, noted as *X)* is identical to the characteristic set of firms that innovated. In this way, we are able to reduce the selection bias. The identification condition also becomes less restrictive, and the independence property has to be checked ($(y_0, y_1) \perp I / X$). If numerous control variables are taken into account, it is subsequently problematic to find a counterfactual for each treated firm. According to Rosenbaum & Rubin (1983), conditional independence to the set of control variables is equal to the independence relative to the propensity score $P(X)$, which is a one-dimensional summary of matching variables and estimates the probability of being assigned to the treatment conditionally on these variables: $(y_0, y_1) \perp I / X$. The literature defines numerous propensity score matching methodologies. For instance, Caliendo & Kopeining (2005) recommend implementing several estimators. In this paper we use radius matching with a caliper of 0.001. Using panel data allows controlling for individual and unobservable fixed effects that simultaneously affect the treatment and the outcome variables. We are able to match the differences between firms using a difference-in-differences selection model because we observe firms over time (Heckman et al. 1997, 1998). This methodology allows taking into account both observable and unobservable characteristics of firms that innovated when evaluating the causal effect of innovation on job quality. It consists of observing the variation in the outcome variable between two dates (first difference) and comparing this variation between the treated and untreated firms (second difference). The formula for the treatment effect on the treated firms is as follows:

$$\Delta = \frac{1}{N_1}\sum_{\iota \in I_1}\left\{\left(\Psi_{\tau,\iota} - \Psi_{\tau',\iota}\right) - \sum_{\varphi \in I_0} M^{\iota}\left[\frac{\left(\Pi(\Xi_{\varphi}) - \Pi(\Xi_{\iota})\right)}{\sum_{\iota \in I_0}\left(\Pi(\Xi_{\varphi}) - \Pi(\Xi_{\iota})\right)}\right]\left(\Psi_{\tau,\varphi} - \Psi_{\tau',\varphi}\right)\right\}$$

where N_1 is the number of firms that innovate. I_1 represents the whole sample of firms that are involved in this mechanism, and I_0 is the sample of firms that are not. P(X) is the estimated propensity score, and Y stands for the outcome indicators of employment and job quality. $M^i[]$ represents the average value of the outcome variable among the population of firms *j* that belong to the control group and are selected among firms *i*. *t* and *t'* represent the two periods before (2009) and after (2013) the treatment assignation. This estimator is intended to satisfy the common trend assumption that we will simultaneously find treated and untreated firms for each value of the matching variable.

Our empirical strategy follows two steps. In the first step, we run a logit model in order to estimate the propensity score. From the determinants of innovation, we retain two categories of control variables: firm's characteristics (size, age, industry and part of a group) and indicators of economic performance (e.g. economic rate of return and labour productivity for France). All control variables are in year 2009, i.e. before firms decide to innovate or not. In addition, we consider the distribution of quantitative variables (by quartile) as dummy variables. To check whether logit models provide a good specification of innovation, we implement a balancing test that analyses standardized differences. It computes the mean of each control variable for the treated and the untreated firms and thus the reduction in selection bias associated with the difference in average differences before and after matching. In the second step, we estimate the average effect of the treatment (ATT) on the difference in employment and job quality variation for the treated and the control groups using the radius matching estimator. For France and Germany, the time period considered is 2009-2013 and innovation is observed between 2010 and 2012 (either in the CIS for 2012 or in the IAB establishment panel for 2010, 2011 and 2012).

In the case of Spain, we follow a similar strategy, with the difference that we consider two periods, 2002-2006 and 2006-2010. In the same fashion, we consider that a firm innovates during the period 2002-2006 if it introduces an innovation in 2003, 2004 or 2005 and we proceed in the same way with the second interval (an innovative firm in the interval 2006-2010 is that that introduces an innovation in 2007, 2008 or 2009). In order to increase the statistical power of our estimation, we pool both differences in the DID-PSM, but we stratify by time interval, that is, we impose that the change in a firm in 2002-2006 can be only matched with a firm in the same period, in order to take into account that the second period might have been particularly different because of the beginning of the Great Recession in Spain. In practical terms, we compute the ATT for the first and the second period and we calculate the average ATT weighting by the number of firms in each period, using bootstrap procedures (500 replications).

5. Econometric results

As explained above, our empirical strategy is based on comparison between innovative and non-innovative firms. In our datasets, we have information about innovation annually (Spain and Germany) or over a three-year basis (France). To make the analysis more comparable across countries all national analyses consider a three-year period. We compare the variations in terms of employment and job quality outcomes before and after innovation, between innovating and non-innovating firms. In our model we assume that, on average and with equal characteristics, we can isolate the impact of innovation during a given period of observation on firms' employment and job quality outcomes. To correct for unobserved heterogeneity and selection bias in innovative behavior, we use Propensity Score Matching estimation with innovation occurrence as treatment for a sub-population. Because innovation is not randomly distributed but correlated with structural effects (see section on descriptive results) this method leads to select a set of control variables. These controls allow us to compare effect of treatment on firms with similar structural characteristics and to avoid selection bias. Thereby the results are in two parts, first the results of a logit model explaining innovation by a series of control variables and second the results of the difference in difference analysis showing the effects of innovation on dependent variables of employment performance.

5.1 Results for France

-The determinants of innovation (first step)

The logit regressions (computed for the five types of innovation defined in Box 1, sections 2 and 3) include some firms' structural characteristics which are correlated with innovation, such as industry, firm size, age of the firm, or belonging to a group, as well as two indicators of economic performance (productivity and rate of return) (Table 14). For continuous variables (age, productivity, rate of return) we have included the corresponding quartiles.

Table 14. The determinants of innovation in France

Dependent variable (CIS 2012)	**Technological innovation**	**Product innovation**	**Process innovation**	**Product innovation new to the market**	**Organizational innovation**
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Sector (ref = Industry)					
Retail	-0.911 (0.059)***	-1.034 (0.068)***	-0.752 (0.064)***	-0.975 (0.078)***	-0.133 (0.055)*
Other services	-0.295 (0.044)***	-0.186 (0.046)***	-0.262 (0.047)***	-0.194 (0.051)***	0.081 (0.043)*
Size of firm (ref = less than 20 employees)					
20-49 employees	0.197 (0.047)***	0.268 (0.052)***	0.122 (0.051)**	0.259 (0.060)***	0.243 (0.046)***
50-499 employees	0.833 (0.052)***	0.888 (0.056)***	0.639 (0.056)***	0.796 (0.062)***	0.540 (0.052)***
500-999 employees	1.502 (0.113)***	1.466 (.108)***	1.158 (0.105)***	1.429 (0.110)***	0.906 (0.103)***
1000 employees and more	1.774 (0.139)***	1.935 (0.132)***	1.539 (0.124)***	1.849 (0.127)***	1.304 (0.124)***
Classes by quartile of rate of return (ref = class1)					
Class 2 rate of return	-0.064 (0.055)	-0.073 (0.059)	0.042 (0.059)	-0.187 (0.066)***	-0.113 (0.055)**
Class 3 rate of return	-0.105 (0.058)*	-0.138 (0.062)**	-0.006 (0.062)	-0.204 (0.069)***	-0.067 (0.057)
Class 4 rate of return	-0.177 (0.060)***	-0.180 (0.064)***	-0.081 (0.064)	-0.230 (0.071)***	-0.194 (0.059)***
Classes by quartile of productivity (ref = class1)					
Class 2 productivity	0.030 (0.056)	0.058 (0.061)	0.012 (0.060)	0.139 (0.070)**	0.152 (0.056)***
Class 3 productivity	0.379 (0.059)***	0.464 (0.063)***	0.162 (0.062)***	0.465 (0.071)***	0.286 (0.058)***
Class 4 productivity	0.560 (0.062)***	0.672 (0.066)***	0.303 (0.066)***	0.762 (0.074)***	0.439 (0.062)***
Classes by quartile of age (ref = class1)					
Class 2 age	-0.161 (0.051)***	-0.181 (0.055)***	-0.136 (0.055)**	-0.253 (0.060)***	-0.084 (0.050)
Class 3 age	-0.198 (0.054)***	-0.219 (0.058)***	-0.192 (0.058)***	-0.276 (0.064)***	-0.159 (0.054)***
Class 4 age	-0.303 (0.055)***	-0.372 (0.058)***	-0.196 (0.058)***	-0.429 (0.064)***	-0.210 (0.054)***
Group (ref.= not in a group)					
In a group	0.286 (0.042)***	0.299 (0.045)***	0.258 (0.045)***	0.330 (0.050)***	0.232 (0.042)***
Constant term	-0.651 (0.060)***	-1.234 (0.065)***	-1.125 (0.065)***	-1.688 (0.074)***	-0.937 (0.060)***
Number of obs	*13256*	*13256*	*13256*	*13256*	*13256*
LR chi2(18)	*1292.66*	*1347.3*	*788.03*	*1089.96*	*524.79*
Prob> chi2	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Pseudo R2	*0.0717*	*0.0815*	*0.0489*	*0.0777*	*0.0299*
Log likelihood	*-8365.9206*	*-7587.2395*	*-7665.2812*	*-6468.3064*	*-8521.9671*
*** sig 1%, ** sig 5%, * sig 10%					

Source: CIS 2012-FARE 2009 2013-DADS 2009 2013, matched data, authors' calculations

As in the descriptive analysis, the results show that all kind of innovations occur more in larger firms. This finding can be explained by the existence of important fixed costs of innovation and also by more employees dedicated to innovative work in larger firms. Being in a group also increases the probability to innovate. In terms of industry, technological innovation appears less probable in retail and other services, compared to manufacturing. However, in the case of organizational innovation the probability to innovate increases for the "other services" sector. The effect of age (the older the firm, the less innovative it is) seems to confirm a Schumpeterian effect, the new firms come to compete with the oldest, by introducing new products or processes. As far as economic performance indicators are concerned productivity level (measured in 2009, as an ex ante variable) is found to increase all types of innovation, whereas the rate of return has a negative or non-significant effect.

-The effects of innovation on employment job quality (second step)

In a second step, we compare the variations between 2009 and 2013 of a series of employment and job quality indicators for innovating (treated) and non-innovating firms (controls). We also decompose employment and job quality effects (in particular wages) by occupational groups and by gender, thus capturing some trends in inequalities by gender and occupations that are related to innovation. If significant the sign of the difference is presented in table 15[3].

In terms of employment effects, we find a positive impact of innovation on total workforce, whatever the type of innovation considered. There is no difference between men and women for technological innovation, except in the case of radical innovation that increases men's employment only (the effect on women's workforce variation is non-significant). On the contrary organizational innovation increases female workforce, while its effect on male workforce variation is non-significant. Decomposing by occupations shows differences by skill: the effect of innovation is always positive for managers and technicians and associate professionals, but it is more heterogeneous for manual workers. Indeed, process innovation increases their employment level, while product and new to the market innovation reduces it, and organizational innovation has no significant effect. Although the effects are heterogeneous by types of innovation, they seem to confirm some trends towards skill-biased technological change – that is, an upgrading in skill (at least in the case of product and new to the market innovations). Given the positive impact on technicians and associate professionals the hypothesis of skill polarization stemming from innovation is not validated in our data.

In terms of job quality, the analysis includes indicators of the type of contract (permanent vs fixed-term), of wages (gross wage, hourly wage), of working hours (average annual level by employee). Although all types of innovations (except new to the market) increase the number of employees on fixed-term contracts, only technological innovation (total, product, process, new to the market) has a positive impact on the variation of permanent contracts employees, whereas the difference is non-significant for organizational innovation. According to these

[3] Detailed results (coefficients, T stat and standard error) are presented in appendix.

results, technological innovation (and especially our proxy for "radical" innovation) would be more favorable to employment stability (at least in terms of labour contracts). This confirms some results obtained in the literature when considering the relationship between innovation and employment stability in the other direction: for instance, Zhou et al. (2011) find a negative impact of temporary employment on firms' probability to implement a radical innovation. As far as wages are concerned, technological innovation has a positive impact on the variation of hourly wage, as well as product and new to the market innovation, but a non-significant effect in the case of process and organizational innovation. Considering gross wages also reveal some specificity of organizational innovation that decreases their variation, whereas the effect is non-significant for other types of innovation. Organizational innovation would therefore be less favorable than technological innovation in terms of wage trends at the firm level. Finally, the analysis does not find any significant impact of innovation on working hours. For the dimensions of job quality considered here, the effects are more favorable in the case of technological innovation, compared to organizational.

The analysis also includes some indicators of **wage inequalities that may be considered as part of job quality.** In particular, we consider gender (men-women) and occupational (high skilled-manual workers) pay gaps, as well as gross pay variations by gender and occupations. Organizational innovation reduces gender pay gap as well as occupational pay gap variations, whereas other forms of innovation have a non-significant effect on these indicators. The reduction of gender pay gap is explained through a decrease in the variation of men's gross pay, and the reduced occupational pay gap corresponds to a decrease in higher skilled pay variation. Other results show a negative impact of technological innovation on the variation of low skilled pay, which is also observed for technicians and associate professionals in the case of new to the market innovation. Thus, in general, technological innovation seems to be less favorable to wage development for the low skilled, confirming again some skilled biased technological change. Organizational innovation would favor a decrease in pay inequalities.

To account for several dimensions of job quality simultaneously (and for potential compensation effects between the different dimensions), we introduce a synthetic index of job quality, including four variables: permanent contracts employees, hourly wage, average working hours and gender pay gap. The results show a difference between product and process innovation in terms of global job quality impact: the effects of product innovation and its subcomponent radical innovation are positive, while the impact of process innovation on the job quality index is negative. The effect is non-significant for organizational innovation.

Finally, all these estimations have also been run by industry, comparing manufacturing and services. The results show some heterogeneity, mainly in terms of the significance of the effects rather than the signs. In general, the effects are more significant for services than for manufacturing. For instance, the positive impact of organizational innovation on employment appears driven by the services sector.

Table 15- Impact of innovation on employment and job quality, France

Dependent variables	Technological (product or process)	Product	Process	Product new to the market	Organizational
Variation of total workforce	+	+	+	+	+
Workforce variation for men	+	+	+	+	ns
Workforce variation for women	+	+	+	ns	+
Workforce variation for managers and professionals	+	+	+	+	+
Workforce variation for technicians and associate professionals	+	+	+	+	+
Workforce variation for manual workers	Ns	-	+	-	ns
Variation of open ended (permanent) contract employees	+	+	+	+	ns
Variation of fixed-term contract employees	+	+	+	ns	+
Variation of gross pay	Ns	ns	ns	ns	-
Variation of hourly wage (gross)	+	+	ns	+	ns
Variation of the average annual hours worked per employee	Ns	ns	ns	ns	ns
Variation of gross pay (pay, salary, earning, wage) for men	Ns	ns	ns	+	-
Variation of gross pay (pay, salary, earning, wage) for women	Ns	ns	ns	ns	ns
Variation of gross pay for managers and professionals	Ns	ns	ns	ns	-
Variation of gross pay for manual workers	-	-	-	-	ns
Variation of gross pay for technicians and associate professionals	Ns	ns	ns	-	ns
Variation of gender pay gap (men-women)	Ns	ns	ns	ns	-
Variation of occupational group pay gap (highest - lowest)	Ns	ns	ns	ns	-
Variation of synthetic Job quality index	Ns	+	-	+	ns

Source: CIS 2012-FARE 2009 2013-DADS 2009 2013, matched data, authors' calculations Results from difference in difference model, psmatch 2
Ns: non significant. + positive and significant at 10% -negative and significant at 10%

5.2 Germany

The determinants of innovation (first step)

Table 16 shows the first step towards the difference-in-difference analysis and estimates the control variables for comparing firms as similar as possible to each other, with the only difference being the innovation activity of the firm.

The chosen control variables are dummy variables capturing the affiliation of a firm, the industry sector of a company can be assigned to, the size of a firm, the four quartiles of firm turnover, the year of founding and a control for organizational innovation.

The control variables show the same tendencies on all innovation forms (technological, new to the market and organizational innovation). The inclusion of organizational innovation as an explanatory variable does not change the robustness of control variables on innovation.

As the descriptive results show, belonging to a group of firms has a positive effect on innovation compared to the reference group of firms without an affiliation. The industry variable underlines the above discussed bivariate results – in comparison to the manufacturing sector all other sectors are less innovative (see negative logit coefficients). Firm size has a positive effect on all innovation types, which also holds true for the productivity of firms. All these coefficients are statistically significant. The last control variable is the year of founding. As seen in the descriptive results, younger firms are more innovative than firms founded before the 1990s. The difference between the first category of firms founded during 1990 to 2010 show in comparison to the reference group no statistically significant results.

Table 16. Explaining innovation in 2010 to 2012 (logit-coefficients), Germany

Dependent variable (IAB 2010 - 2012)	**Technological innovation**	**Technological innovation Control: Organizational innovation**	**Product innovation new to the market**	**Organisationnal innovation**
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Part of an enterprise group (ref = no)				
Enterprise group	0,484** (0,082)	0,436** (0,085)	0,289** (0,086)	0,293** (0,078)
Industry (ref = Manufacturing)				
Construction	-0,953** (0,092)	-0,882** (0,096)	-1,140** (0,162)	-0,523** (0,094)
Retail	-0,405** (0,070)	-0,298** (0,073)	-0,484** (0,086)	-0,498** (0,069)
Other services	-0,330** (0,081)	-0,273** (0,085)	-0,480** (0,104)	-0,286** (0,082)
Size of firm (ref = very small firm, less than 20 employees)				
Small (20 to 49 employees)	0,344** (0,097)	0,167+ (0,102)	0,265* (0,131)	0,637** (0,094)
Medium (50 to 249 employees)	0,417** (0,126)	0,219+ (0,131)	0,311* (0,158)	0,736** (0,122)
Large (more than 250 employees)	0,888** (0,187)	0,586** (0,194)	0,885** (0,187)	1,352** (0,179)
Classes by quartile of productivity (ref = class1)				
Class 2 productivity	0,267** (0,075)	0,133** (0,078)	0,302* (0,128)	0,557** (0,079)
Class 3 productivity	0,411** (0,100)	0,176** (0,105)	0,540** (0,153)	0,931** (0,102)
Class 4 productivity	0,859** (0,145)	0,571** (0,152)	0,731** (0,192)	1,241** (0,143)
Year of founding (ref = before 1990s)				
1990 - 2010	0,073 (0,064)	0,049 (0,085)	0,144+ (0,085)	0,115+ (0,065)
after 2010	0,279** (0,074)	0,247** (0,077)	0,382** (0,096)	0,200** (0,074)
Organizational innovation (ref = no)		1,213** (0,061)		
Constant term	0,086**	-0,246**	-2,244**	-0,759**
Number of obs	*6348*	*6348*	*6348*	*6348*
LR chi2(12)	*699,29*	*1104,17*	*384,06*	*1184,38*
Prob> chi2	*0.0000*	*0.0000*	*0.0000*	*0.0000*
Pseudo R2	*0.0840*	*0.1329*	*0.0699*	*0.1358*
Log likelihood	*-3828,72*	*-3602,64*	*-2556,02*	*-3767,3592*

** sig 1%, * sig 5%, + sig 10%

Source: IAB, 6 348 firms, logit-coefficients, calculation of authors.

The effects of innovation on employment and job quality (second step)

The following table is a summary of all results from the second-step propensity score matching of seventeen variables capturing the difference in employment and job quality related outcomes in firms between 2009 and 2013. All variables are analyzed separately for different innovation forms, whereby the above discussed control variables are held constant through all models. In this way we can conclude if the occurrence of a specific innovation has a sole effect on our outcome variables.

In terms of employment effects, technological innovation (product or process), product innovation and organizational innovation have a positive influence on the total number of workers in a firm. The effect of organizational innovation is significant only at the 10% level, whereas new to the market innovations do not show significant results.

Table 17. Summary of econometric results, Germany

	Product or process	Product	Process	New to the market	Organiza-tional
Variation of total workforce	+	+	ns	ns	+
Workforce variation for women	+	+	ns	ns	+
Workforce variation for men	+	+	ns	ns	ns
Variation of part-time workers	ns	ns	+	ns	+
Variation of part-time female workers	ns	ns	ns	ns	+
Variation of unskilled workers	ns	+	-	ns	-
Variation of workers in skilled jobs	+	+	ns	ns	+
Variation of managers and owners	ns	ns	ns	ns	ns
Variation of fixed-term contract employees	+	+	-	ns	ns
Variation of open ended (permanent) contract employees	+	+	+	+	+
Variation of the average annual hours worked per employee (week)	ns	ns	ns	ns	ns
Variation of gross wages (month)	+	+	+	ns	+
Variation negative in labour turnover	ns	-	-	ns	ns
Variation positive in labour turnover	+	+	ns	ns	-
Variation of vacant positions	ns	ns	ns	ns	ns
Variation of workers with salary between 450 and 850 euro	ns	+	+	ns	ns
Variation of one-euro job holders	ns	ns	ns	ns	+

Source: IAB, 6 347 firms, calculation of authors.

Results from difference in difference model, psmatch 2.

Ns: non significant; + positive and significant at 10%; - negative and significant at 10%.

The same positive effects can be found on the workforce of women and men underlying the results described in the literature review about positive effects of innovation on employment. This holds above all true for product innovation where the most robust results are estimated. The number of part-time workers is influenced only by organizational innovation stressing the possibility, that through organizational restructuring (at least in the beginning) more part-time jobs are being created. Both process and organizational innovation have a negative effect on the number of unskilled workers in a firm, whereas product innovation influences this outcome variable in a positive way (only significant on 10% significance level). On the contrary technological (product or process), product and organizational innovation show a positive effect on the workforce with specific qualifications in skilled jobs, which indicates a shift in the employment structure of a firm to a more skilled workforce through innovations. Innovations seem to have no significant influence on the quantity of managers and owners.

In terms of job quality, the overall positive effect of innovations on the quantity of labour can be seen also in the positive variation of fixed-term and permanent contracts. Whereas especially the variation in permanent contracts is positively connected with technological, new to the firm and organizational innovation, the average hours worked in a week are not shaped by innovation. As seen in the descriptive results, the variation in the working hours between innovating and non-innovating firms is rather marginal, furthermore working hours are highly regulated. Nearly all innovation forms have a positive influence on the average gross monthly wages in firms. Unfortunately, it is not possible to differentiate between the wages of different qualifications and positions to distinguish if this positive effect holds true for all employees or varies across them. Product and process innovations show a decreasing effect on negative labour turnover i.e. there seems to be less workers leaving or being quit in firms that have conducted a product or process innovation. Technological innovation and product innovation viewed on its one has a positive effect on workers' inflow. These findings support the above stated positive effect of innovations on employment. Concerning the outcome variable of workers with lower pay, product and process innovation shows a positive effect of innovations on these jobs. Only organizational innovation has a positive effect on the amount of "one-euro jobbers", other innovation forms show no statistically significant results for this variable.

All in all, the German analysis shows positive effects of different innovation forms on employment, the number of permanent contracts, the qualifications of employees, average wages and workers inflow. On the other hand, the number of part-time workers and fixed-term workers, as well as workers with relatively low wages seems to increase in line with innovative changes in a firm.

5.3 Spain

The determinants of innovation (first step)

The results of the first-step *probit* selection equations for the Spanish case (Table 18) suggest that, overall, innovation is positively correlated with firm's size and productivity, with the exception of organizational innovation, which seems immune to the latter variable. The age of the firm and the margin rate do not have a statistically significant impact on innovation. Productivity has no impact on the likelihood of product innovation in the period of time and firm age appears to positively affect the probability of introducing an innovating product in the first period of analysis.

Table 18. The determinants of innovation in Spain (2002-2010): coefficients of a *probit* model

	Technological innovation		Product innovation		Process innovation		Organizational innovation
	2002-2006	2006-2010	2002-2006	2006-2010	2002-2006	2006-2010	2006-2010
Firm size 20-49	0.284**	**0.224	0.556***	0.366***	0.159	0.218**	0.206*
	(0.123)	(0.104)	(0.147)	(0.123)	(0.127)	(0.105)	(0.113)
Firm size 50-499	0.454***	0.646***	0.767***	0.739***	0.451***	0.582***	0.554***
	(0.125)	(0.102)	(0.148)	(0.117)	(0.128)	(0.102)	(0.108)
Firm size 500-999	0.437**	0.680***	0.895***	0.963***	0.382**	0.674***	0.831***
	(0.183)	(0.180)	(0.200)	(0.181)	(0.185)	(0.176)	(0.176)
Firm size 1000 and over	1.496***	1.281***	1.483***	1.655***	1.121***	1.209***	0.790***
	(0.298)	(0.271)	(0.251)	(0.240)	(0.250)	(0.251)	(0.220)
2nd quartile of productivity	0.220*	0.311***	0.117	0.342***	0.177	0.309***	0.151
	(0.120)	(0.106)	(0.133)	(0.118)	(0.124)	(0.106)	(0.111)
3rd quartile of productivity	0.450***	0.429***	0.153	0.347***	0.402***	0.417***	0.161
	(0.134)	(0.116)	(0.145)	(0.127)	(0.136)	(0.116)	(0.120)
4th quartile of productivity	0.743***	0.460***	0.296*	0.418***	0.619***	0.457***	0.269
	(0.153)	(0.133)	(0.163)	(0.142)	(0.155)	(0.132)	(0.135)
2nd quartile of age	0.058	0.081	0.102	0.141	-0.081	-0.029	-0.162
	(0.113)	(0.103)	(0.124)	(0.110)	(0.115)	(0.102)	(0.104)
3rd quartile of age	0.142	-0.058	0.216*	-0.002	-0.004	-0.099	-0.208
	(0.114)	(0.104)	(0.122)	(0.112)	(0.115)	(0.103)	(0.106)
4th quartile of age	0.055	-0.041	0.168	-0.007	-0.117	-0.085	-0.172
	(0.121)	(0.111)	(0.127)	(0.116)	(0.121)	(0.109)	(0.111)
2nd quartile of margin rate	-0.042	-0.004	-0.062	0.046	-0.034	-0.055	-0.015
	(0.121)	(0.108)	(0.130)	(0.114)	(0.123)	(0.107)	(0.110)
3rd quartile of margin rate	0.057	-0.068	0.022	0.033	0.055	-0.067	0.092
	(0.126)	(0.113)	(0.134)	(0.120)	(0.127)	(0.112)	(0.114)
4th quartile of margin rate	-0.136	-0.047	0.024	-0.224*	-0.008	0.007	-0.076
	(0.139)	(0.123)	(0.147)	(0.131)	(0.141)	(0.122)	(0.125)
Constant term	-0.817***	-0.442***	-1.454***	-1.354***	-0.871***	-0.532***	-0.774***
	(0.135)	(0.113)	(0.160)	(0.134)	(0.139)	(0.114)	(0.120)
Pseudo R^2	0.085	0.070	0.074	0.088	0.069	0.063	0.044
No. of observations	1,037	1,261	1,037	1,261	1,037	1,261	1,261

Notes: *** significant at 1% level; ** significant at 5% level; * significant level. Standard errors between parentheses. The reference category is a firm of less than 20 employees, in the 1st quartile of productivity in the1st quartile of age and in the 1st quartile of margin rate. Source: Authors' analysis from ESEE.

The effects of innovation on employment and job quality (second step)

The results obtained for the Spanish case (Table 19 and Table A5 in appendix) suggest an overall lack of effect of innovation on job quality. In line with previous literature for this country, technological innovation has a positive effect on employment levels (when using a specification in logs, the most common in previous research). All the coefficients are significant at least at the 10% significance level. Also, the effect of process innovation is larger than the effect of product innovation, a finding also reported by previous literature. Organizational innovation, the impact of which, to our knowledge, has not been studied before, seems to have a null effect on employment. Nevertheless, further research is needed as long as the sample available for examining this variable is reduced.

Table 19. The effects of innovation in Spain (2002-2010): summary results of the Propensity Score Matching-Differences-in-Differences

	Technological innovation	Product innovation	Process innovation	Organizational innovation
No. of workers	ns	ns	Ns	ns
No. of workers (in logs)	+	+	+	ns
No. of permanent workers	ns	ns	Ns	ns
No. of workers with high education	ns	ns	Ns	ns
No. of workers with high or medium education	+	ns	ns	+
Expenditure on external training per worker	ns	ns	ns	ns
Hourly labour cost	ns	ns	ns	ns

Source : Authors' analysis from ESEE.

Regarding job quality, the only significant effects concern high or medium educated workforce, with a positive coefficient for higher education in the case of process innovation, as well as for medium and high education in the case of both technological and organizational education. Therefore, innovation would be associated with some trend towards upgrading of the skill structure. However, we find no impact of innovation on hourly labour costs (as a proxy for wages), the spending on external training per worker or the number of permanent workers. In order to assess the stability of our overall results of positive effects of innovation – with exception of organizational innovation – on employment and lack of relevant impacts on job quality, we implement other approaches also used in this literature, such as within-group estimator using the year-by-year sample (allowing for lags of innovation variables), a dynamic random-effects estimator and a Blundell-Bond-type model in order to control for unobservable heterogeneity in a model including a lag of the dependent variable). Overall, we find that technological innovation has a positive effect on employment and it is neutral with relation to job quality. These results are available from the authors upon request. Nevertheless, considering the size of the final sample of firms, further studies on this topic using different databases are encouraged and could be useful.

5.4 Comparison across the three countries

In the three countries, we find a positive effect of technological innovation (product and process innovation) on employment at the firm level, which is consistent with existing literature. Our results also find a positive effect for organizational innovation in France and Germany, which was not considered in previous studies.
As mentioned earlier, we go further than most studies by also considering employment structure as well as job quality effects. In terms of employment by gender, innovation increases employment for both men and women in France and Germany (the gender decomposition is not available for Spain). However, in the French case, new to the market product innovation (i.e. more radical innovation) is found to increase men's employment only.

When decomposing by skill (defined on the basis of education or occupations as a proxy for skill), we find evidence of upskilling in relationship with technological change: the proportion of higher-skilled workers increases following innovation, whereas there is generally no effect or a negative effect on lower skilled categories.[4] Medium skill or medium level occupation employment does not decrease following innovation – which contradicts the hypothesis of polarization at the firm level.

Job quality effects are more heterogeneous across countries and vary with the type of innovation considered. In general, the effects are more positive for technological innovation than for organizational, and within technological innovation product innovation seems to be more favorable to job quality than process innovation. In France as well as Germany we find a positive effect on wages, but the results differ for the types of contracts. In France, technological innovation increases the number of permanent[5] contracts, whereas in Germany it tends to increase fixed-term employment and lower paid jobs. Organizational innovation is also associated with more one-euro jobbers in Germany, but seems to reduce wage inequalities (by gender and occupations) in France. Such country differences might be related to institutions and labour market regulation, but also to specific firms' human resource practices, such as the importance of internal labour markets in large and innovative French firms. In Spain, no specific job quality effects are found at the firm level.

Conclusion

This working paper follows a number of studies on the impact of innovation on employment. . However, it offers several, significant contributions. First it adopts a comparative perspective using firm level data from three European countries with different innovation and employment profiles (Erhel and Guergoat-Larivière, 2016). Second, it uses original data to study the effect of different types of innovation (technological but also organizational) on employment as well as job quality outcomes (wages, type of contracts etc.) in addition to decomposition of

[4] Except in the case of product innovation for Germany.
[5] As well as fixed-term contracts in the case of technological, product and process innovation (but not radical product innovation).

employment by occupation. Third, this paper uses an innovative methodology that enhances the robustness of results by dealing with selection bias and unobserved heterogeneity.

Our results show that *technological* innovation has a clear positive impact on employment at the firm level in the three countries. This positive effect holds true in the case of product innovation in all three countries but also in the case of process innovation (France, Spain) and organizational innovation (France, Germany) which is less expected from a theoretical point of view that considers these two last types of innovation as “labor saving”.

In terms of job quality[6], it seems that product innovation generates higher wages (in France and Germany) and employment stability (open-ended contacts in France). However, results are more mixed for process and organizational innovation. Process innovation impacts negatively the synthetic index of job quality in France and organizational innovation has a negative impact on wages. In Germany, process and organizational innovations increase part-time employment, which can be associated with a “labor saving” process encouraged through the use of short-time working over the global economic crisis. Organizational innovation also seems to increase the number of low-paid workers.

One major contribution of this working paper is to show the impact of innovation on the structure of the workforce at firm level. Our results support the hypothesis of skilled-biased effects of innovation: technological and organizational innovation seems to be more favorable to high-skilled workers while it has no significant and sometimes negative impact on low-skilled workers. However, some specific effects appear across countries for some types of innovation (product, process, new to the market product innovation). Results on technological innovation are in line with the literature on learning economy and ICT use, which claims that new technology adoption, coming from product innovation, requires higher skills (Machin and Van Reenen, 1998, Mairesse *et al* , 2001).

From a policy perspective, our results generally support the idea of a virtuous circle between innovation and employment but also underline the mixed effects of certain types of innovation on job quality and on employment distribution across occupations. For instance, organizational innovation (and to a lesser extent process innovation) can be related to different goals, such as upgrading quality or reducing labor cost, that do not lead to the same outcomes in terms of employment and job quality.
This study also points out that these effects are not identical in all countries: for instance while organizational innovation has rather no effect on employment in Spain, it increases the number of jobs in the company in both France and Germany, but has opposite effects on wages in the two countries. Such differences may be related to national or lower-level (branch, industrial, sector) institutional settings and their interactions with firms’ decisions.

[6] Note that the Spanish data do not include many variables on job quality and no significant results appear so comments are focused on France and Germany.

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Appendix 1

Table A1.1 Main variables used for France

Innovation (CIS)	Source	Availability	Type of innovation
Introduction of product innovation	CIS	2004 to 2012	Product
Introduction of process innovation	CIS	2004 to 2012	Process
Innovations of products new to the market	CIS	2004 to 2012	Product
Organizational innovation	CIS	2010 to 2012	Organizational

Employment and job quality	Source	Availability
Number of employees at the end of the year	DADS	2004 to 2013
Number of employees at the end of the year by occupation	DADS	2004 to 2013
Number of employees at the end of the year by sex	DADS	2004 to 2013
Number of employees on permanent contracts at the end of the year	DADS	2009 to 2013
Number of employees on fixed-term contracts at the end of the year	DADS	2009 to 2013
Total payroll (gross)	DADS	2004 to 2013
Total payroll (net)	DADS	2004 to 2013
Total payroll by occupation	DADS	2009 to 2013
Total payroll by sex	DADS	2009 to 2013
Total number of hours worked (workplace level)	DADS	2004 to 2013

Other firm level data	Source	Availability
Fiscal and financial data	FARE-FICUS	2004-2013

Table A1.2 Variables used for Germany

Innovation (IAB)	Availability	Type of innovation
Introduction of product *or* service innovation	1993; 1994; 1998; 2001; 2004; 2007 to 2014	Product
Innovations new to the market	1993; 1994; 1998; 2001; 2004; 2007 to 2014	Product
Innovations new to the firm only	1993; 1994; 1998; 2001; 2004; 2007 to 2014	Product
Percentage of turnover related to improved products (in the last year)	1998; 2001; 2004	Product
Percentage of turnover related to completely new products (in the last year)	1998; 2001; 2004	Product
Production process innovation (have noticeably improved production processes or services)	2007 to 2014	Process

Production process innovation and distribution channels and/or innovation in customer relations in the last 2 years	1995; 1998; 2000; 2001; 2004; 2007; 2010; 2012; 2014	Process
Sum of all *investments* (in the previous year)	1993 to 2014	
Share of *expansion investments* in all investments (%)	1997 to 2014	
Areas of investment (Real estate, EDP, Production facilities, transportation)	1993 to 2014	
Research and Development department (y/n); number of employees	1998; 2004; 2007; 2009; 2011; 2013	Product & process
Organizational innovation in the last 2 years: quality management; team work; employee responsibilities; restructuring; introduction of units	1995; 1998; 2000; 2001; 2004; 2007; 2010; 2012; 2014	Organizational

Employment	**Availiability**
Number of employees on *30th June*	1996 to 2014
Workers flows - inflows (vacancies to be filled immediately)	1993 to 1998; 2000 to 2014
Workers flows - outflows	1993 to 2014
Workers flows - outflows only women	1997 to 2014
Workers flows (inflows) by *qualification needed*	1993 to 1998; 2000 to 2014
Workers flows (outflows) by reason for the termination of contract	1993 to 2014
Expected ratio of workers inflows and outflows for the next year	1993 to 2014

Job quality	**Availability**
Number of employees on 30 June by unskilled jobs, skilled jobs, directors/managers, apprentices	1993 to 2014
Number employees on 30 June by sex	1993 to 2014
Number of employees on permanent contracts on 30 June	1996 to 2014
Number of employees on permanent contracts on 30 June by sex	1996 to 2014
Number of employees on fixed-term contracts on 30 June	1993 to 1994; 1996 to 2014
Number of employees on fixed-term contracts on 30 June by sex	1993 to 1994; 1996 to 2014
Number of temporary agency workers on 30 June	1993 to 1998; 2002; 2004 to 2014
Number of freelancers under contract for services on 30 June	1993 to 1998; 2002 to 2014
Number of "One-euro-job" holders on 30 June	2005 to 2014
Number of interns on 30 June	1994 to 1998; 2002 to 2014
Total amount of gross pay effected in the month of June 2014	1993 to 2014
Number of employees with a gross monthly salary between 451 EUR and 850 EUR on 30 June	2003 to 2014
Proportions of working hours per week	1996 to 1999; 2001 to 2003; 2006; 2008; 2010; 2012; 2014

Number of employees in *part-time* equivalent (full-time computable with v25fri; v28ges; v28voll; v26tz)	1993 to 2014
Number of employees in *part-time* equivalent by sex (full-time computable with v25fri; v28ges; v28voll; v26tz)	1993 to 2014

Table A1.3 Variables used for Spain

Innovation	**Availability**
Introduction of product innovation	2002-2010
Introduction of process innovation	2002-2010
Organisational innovation	2007-2010

Employment and job quality	**Availability**
Number of employees at the end of the year	2002-2010
Number of employees on permanent contracts at the end of the year	2002-2010
Number of employees on fixed-term contracts at the end of the year	2002-2010
Number of high-educated employees contracts at the end of the year	2006-2010
Number of medium-educated employees contracts at the end of the year	2006-2010
Expenditure on external training per worker	2002-2010
Hourly labour costs (Euros at 2010 prices)	2002-2010

Appendix 2-Detailed results for France

Table A2.1: impact of innovation on employment and job quality, all industries

	Technological innovation (product and/or process)	Product	Process	Product new to the market	Organisational
Total workforce	9,65 (2,43)***	10,64 (2,74)***	19,73 (3,13)***	7,40 (3,78) **	4,92 (2,59) *
Managers and professionals	6,5 (1,22)***	9,04 (1,41)***	8,06 (1,64)***	12,42 (2,19) ***	3,70 (1,34) ***
Technicians and associate professionals	5,2 (0,93)***	5,18 (1,37)***	6,16 (1,16)***	2,77 (1,48)*	3,13 (0,96) ***
Manual workers	-2,05 (1,47)	-2,74 (1,58)*	5,56 (1,79)***	-7,83 (1,92)***	-1,88 (1,51)
Men	6,17 (1,76)***	7,17 (1,97)***	12,83 (2,29)***	5,79 (2,70) **	3 (1,87)
Women	3,48 (0,84)***	3,47 (0,97)***	6,9 (1,04)***	1,61 (1,31)	1,91 (0,90) **
Open ended (permanent) contract employees	10,11 (1,77)***	9,09 (2,03)***	16,38 (2,27)***	9,66 (2,71) ***	1,67 (1,86)
Fixed-term contract employees	0,97 (0,31)***	0,9 (0,37)**	1,06 (0,36)***	0,25 (0,46)	0,85 (0,32) ***
Gross pay	38,46 (106,4)	95,44 (112,28)	-76,05 (107,11)	186,29 (124)	-275,45 (99,44) ***
Hourly wage (gross)	0,15 (0,042)***	0,18 (0,045)***	0,049 (0,042)	0,24 (0,05) ***	-0,06 (0,04)
Average annual hours worked per employee	-2,18 (5,05)	1,31 (4,4)	-6,82 (4,99)	3,73 (5,55)	-2,81 (4,66)
Gross pay for men	42,91 (139,14)	101,54 (145,06)	-64,99 (138,28)	277,61 (159,18)*	-479,44 (131,30)***
Gross pay for women	-55,58 (144,52)	-7,15 (143)	-31,01 (140,95)	117,63 (164,45)	-99,1 (134,85)
Gross pay managers and profs	235,44 (359,57)	121,5 (347,14)	239,20 (351,74)	82,68 (354,17)	-595,68 (327,33) *
Gross pay for technicians and associate professionals	-153,5 (218,53)	-267,11 (215,41)	-38,77 (215,39)	-428,04 (229,95)*	-149,61 (194,52)
Gross pay for manual workers	-291,01 (120,73)**	-285,28 (132,07)**	-53,64 (121,91)	-370,58 (149,71) **	-83,03 (114,8)
Gender pay gap (men-women)	71,31 (177,11)	184,95 (186,82)	31,04 (172,44)	135,35 (200,77)	-329,36 (165) **
Occupational group pay gap (managers and professionals – manual workers)	333,02 (388,27)	120,31 (375,97)	65,71 (365,06)	307,87 (394,65)	-670,91 (354,50) *
Synthetic index	0,1 (1)	0,01135 (1,1)	-0,01395 (1,4)	0,027 (0,01)***	-0,0004 (0,01)

Results from difference in difference model, psmatch 2, Number of observations: 13256.
Standard errors in parentheses, *** sig 1%, ** sig 5%, * sig 10%

Appendix 3. Detailed results for Germany

Table A3.1. Impact of product or process innovation on employment and job quality

Treatment variable	Product or process innovation (IAB 2010-2012)		
	Difference (effect of treatment after matching)	*S.E.*	*T-stat*
Variation of total workforce	**9,435****	3,512	2,69
Workforce variation for women	**5,164****	1,188	3,35
Workforce variation for men	**4,235+**	2,6071	1,64
Variation of part-time workers	**0,898**	1,199	0,75
Variation of part-time female workers	**0,018**	0,917	0,02
Variation of unskilled workers	**1,241**	1,298	0,96
Variation of workers in skilled jobs	**7,810***	3,110	2,51
Variation of managers and owners	**0,017**	0,024	0,72
Variation of fixed-term contract employees	**2,191***	1,023	2,14
Variation of open ended (permanent) contract employees	**3,170****	1,175	2,7
Variation of the average annual hours worked per employee (week)	**-0,563**	1,144	-0,49
Variation of gross wages (month)	**85847,656***	36149,800	2,37
Variation in negative labour turnover	**-0,020**	0,556	-0,04
Variation positive labour turnover	**1,806***	0,749	2,41
Variation of vacant positions	**0,050**	0,360	0,14
Variation of workers with salary between 450 and 850 euro	**0,224**	0,294	0,76
Variation of one-euro job holders	**-0,050**	0,201	-0,25

** sig 1%, * sig 5%, + sig 10%

Source: IAB, 6 348 firms, calculation of authors.

Table A3.2. Impact of product innovation on employment and job quality

Treatment variable	Product innovation (IAB 2010-2012)		
	Difference (effect of treatment after matching)	*S.E.*	*T-stat*
Variation of total workforce	**21,987****	3,646	6,03
Workforce variation for women	**5,019****	1,186	4,23
Workforce variation for men	**16,881****	2,737	6,17
Variation of part-time workers	**0,851**	1,085	0,78
Variation of part-time female workers	**0,455**	0,858	0,53
Variation of workers with no specific qualification	**2,260+**	1,271	1,78
Variation of workers in skilled jobs	**19,592****	3,264	6,00
Variation of managers and owners	**0,013**	0,023	0,57
Variation of fixed-term contract employees	**2,908****	1,017	2,86
Variation of open ended (permanent) contract employees	**15,464****	2,473	6,25
Variation of the average annual hours worked per employee (week)	**-0,534**	1,050	-0,51
Variation of gross wages (month)	**90947,502***	37135,007	2,45
Variation in negative labour turnover	**-3,767****	0,586	-6,43
Variation positive labour turnover	**2,093****	0,725	2,89
Variation of vacant positions	**0,121**	0,354	0,34
Variation of workers with salary between 450 and 850 euro	**0,833****	0,264	3,15
Variation of one-euro job holders	**-0,036**	0,189	-0,19

** sig 1%, * sig 5%, + sig 10%

Source: IAB, 6 348 firms, calculation of authors.

Table A3.3. Impact of process innovation on employment and job quality

Treatment variable	Process innovation (IAB 2010-2012)		
	Difference (effect of treatment after matching)	*S.E.*	*T-stat*
Variation of total workforce	**3,062**	6,946	0,44
Workforce variation for women	**1,563**	2,086	0,75
Workforce variation for men	**1,498**	5,206	0,29
Variation of part-time workers	**2,161**+	1,124	1,92
Variation of part-time female workers	**0,527**	0,868	0,61
Variation of workers with no specific qualification	**-4,800****	1,614	-2,97
Variation of workers in skilled jobs	**7,625**	6,424	1,19
Variation of managers and owners	**0,030**	0,024	1,26
Variation of fixed-term contract employees	**-3,118**+	1,614	-1,93
Variation of open ended (permanent) contract employees	**3,369**	4,784	0,70
Variation of the average annual hours worked per employee (week)	**0,040**	0,754	0,05
Variation of gross wages (month)	**141917,294**+	76931,785	1,84
Variation in negative labour turnover	**-1,670***	0,840	-1,99
Variation positive labour turnover	**0,776**	1,075	0,72
Variation of vacant positions	**0,475**	0,616	0,77
Variation of workers with salary between 450 and 850 euro	**0,725****	0,241	3,01
Variation of one-euro job holders	**-0,079**	0,160	-0,49

** sig 1%, * sig 5%, + sig 10%
Source: IAB, 6 348 firms, calculation of authors.

Table A3.4. Impact of new to the market innovation on employment and job quality

Treatment variable	New to the market innovation (IAB 2010-2012)		
	Difference (effect of treatment after matching)	*S.E.*	*T-stat*
Variation of total workforce	**9,283**	8,446	1,10
Workforce variation for women	**4,433**	2,938	1,51
Workforce variation for men	**4,823**	6,152	0,78
Variation of part-time workers	**1,127**	1,491	0,76
Variation of part-time female workers	**0,006**	1,076	0,01
Variation of workers with no specific qualification	**0,241**	3,355	0,07
Variation of workers in skilled jobs	**8,573**	7,359	1,17
Variation of managers and owners	**0,035**	0,029	1,21
Variation of fixed-term contract employees	**1,200**	3,172	0,38
Variation of open ended (permanent) contract employees	**17,488***	8,663	2,02
Variation of the average annual hours worked per employee (week)	**-0,326**	0,886	-0,37
Variation of gross wages (month)	**145909,75**	119493,027	1,22
Variation in negative labour turnover	**-0,046**	1,134	-0,04
Variation positive labour turnover	**0,763**	1,279	0,60
Variation of vacant positions	**-0,055**	0,885	-0,06
Variation of workers with salary between 450 and 850 euro	**0,010**	0,293	0,04
Variation of one-euro job holders	**0,261**	0,191	1,36

** sig 1%, * sig 5%, + sig 10%

Source: IAB, 6 348 firms, calculation of authors.

Table A3.5. Impact of organizational innovation on employment and job quality

Treatment variable	Organizational innovation (IAB 2010-2012)		
	Difference (effect of treatment after matching)	*S.E.*	*T-stat*
Variation of total workforce	**7,625**+	4,151	1,84
Workforce variation for women	**4,734****	1,300	3,64
Workforce variation for men	**2,595**	3,077	0,84
Variation of part-time workers	**3,483****	0,804	4,33
Variation of part-time female workers	**2,079****	0,616	3,38
Variation of workers with no specific qualification	**-3,865****	1,403	-2,76
Variation of workers in skilled jobs	**11,183****	3,704	3,02
Variation of managers and owners	**0,030**	0,021	1,42
Variation of fixed-term contract employees	**1,296**	1,143	1,13
Variation of open ended (permanent) contract employees	**4,966**+	2,738	1,81
Variation of the average annual hours worked per employee (week)	**-0,631**	0,983	-0,64
Variation of gross wages (month)	**82391,290**+	43231,249	1,91
Variation in negative labour turnover	**-0,504**	0,556	-0,91
Variation positive labour turnover	**-1,453**+	0,759	-1,91
Variation of vacant positions	**-0,606**	0,387	-1,56
Variation of workers with salary between 450 and 850 euro	**0,200**	0,219	0,92
Variation of one-euro job holders	**0,377**+	0,227	1,66

** sig 1%, * sig 5%, + sig 10%
Source: IAB, 6 348 firms, calculation of authors.

Appendix 4. Detailed results for Spain

Table A4.1. The effects of innovation in Spain (2002-2010): detailed results of the Propensity Score Matching-Differences-in-Differences

	Technological innovation	Product innovation	Process innovation	Organizational innovation
No. of workers	6,059 (5,548)	-11,942 (12,352)	11,944 (7,183)	12,677 (17,278)
No. of workers (in logs)	0,045*** (0,017)	0,032* (0,017)	0,066*** (0,017)	0,032 (0,026)
No. of permanent workers	5,853 (5,513)	3,178 (9,873)	11,231 (7,079)	18,823 (15,222)
No. of workers with high education	4,222 (2,242)	1,304 (3,573)	4,788* (2,651)	8,952 (6,920)
No. of workers with high or medium education	6,455* (3,530)	4,802 (6,486)	8,591 (5,362)	19,313** (9,517)
Expenditure on external training per worker	-12,046 (15,798)	-11,360 (18,257)	-5,390 (14,878)	-31,428 (22,843)
Hourly labour cost	-0,039 (0,206)	-0,234 (0,186)	-0,047 (0,163)	0,035 (0,215)
Observations used	2,298	2,298	2,298	1,261

Notes : (1) The PSM is a radius matching with caliper 0.001, no replacement and limited to the common support. It is carried out separately for each period (2002-2006 and 2006-2010), in order to ensure that firms are only matched with firms in the same time interval; then, we compute the average results using a weighted average (the number of firms each period) and bootstrap techniques (with 500 replications).
(2) The PSM relies on a probit that includes the following variables: firm's size (<20; 20-50; 50-500; 500-1000; +1000), firm's age (in quartiles), firm's productivity (in quartiles) and firm's margin (in quartiles) at the beginning of each period. The reference categories are firms with less than 20 workers and in the first quartile of age, productivity and margin at the beginning of each period.
(3) Organizational innovation only includes results for the second interval (2006-2010), as the variable of interest is only available since 2007.
(4) Standard errors are showed in brackets below coefficients

Source : Authors' analysis from ESEE.