Impact of innovation on employment and skill upgrading of firms[1]

Jože P. Damijan

Institute for Economic Research, Ljubljana; Faculty of Economics, University of Ljubljana, and VIVES, KU Leuven

Metka Stare

Faculty of Social Sciences, University of Ljubljana

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Abstract

This paper adds to the literature by studying the impact of firms' own technology and non-technology innovations as well as of innovation spillovers from vertically linked manufacturing and services industries on firms' employment growth and skill upgrading. We exploit unique representative samples of micro data for Spain and Slovenia for the period 1996 -2008. Our results show a substantial heterogeneity of innovation effects on employment and skill composition of labor. This implies that, first, the effects depend a lot on the specific structure of each economy, whereby results can vary substantially across industries that generate spillovers and across firms that are potential beneficiaries of the spillovers. And second, innovations in service industries do not seem to have a different spillover effect on employment and skill structure when compared to innovations in manufacturing industries.

1. Introduction

In times of sluggish economic growth innovation is perceived as the key lever to re-introduce dynamism into economy that will eventually also revive employment growth. Yet, six years after the outbreak of the financial crisis it becomes evident that the rising unemployment is among the biggest victims of slow recovery in a large number of European economies. Not only people with lower levels of education are affected but also the demand for highly educated workforce declined. The remedies introduced under the austerity programmes to cope with the consequences of the crisis so far failed to boost economic activity and induce employment growth, particularly in countries that are most severely hit. Public policies are confronted with difficult task to mitigate the unemployment problem that will need to be addresses with different mechanisms.

In this setting, it is reasonable to take into account that service industries dominate the employment landscape in all European economies and also that the bulk of new jobs is created in the service sector. These facts are highly relevant when considering the impact of various types of innovation activities in services on jobs dynamic. Furthermore, due to the increasing interlinkages of services with manufacturing additional channel arises through which innovation in services may affect employment at the aggregate level. The competitiveness of manufacturing is increasingly based on intangibles, mix of products and services that transform manufacturing companies beyond simply »making things« (Sissions, 2011). They tend to introduce new business models, where services become an essential part of their value chain strategies (e.g. servitization). Service dominant logic is spreading all over the globe and across economic sectors, revealing the potential of service innovation to importantly complement technological innovations in revitalizing growth and in addressing societal challenges. As pointed out by Djellal and Gallouj (2008) the discussion on the relation between innovation and employment in the context of service economy needs to take account of both, innovation in services (be it technological or non-technological) and innovation by services, where services as inputs to other sectors may cause changes in employment. Besides the impact of innovation on the direction of employment change, the effect on skills‘ composition is of equal importance.

In both cases, innovation in services and innovation by services, the linkages between innovation and employment are very complex and difficult to asses due to deficient data for longer time series and also due to heterogeneity of services. The latter is manifested in the intensity of using labour, capital, technology, knowledge, skills, etc. that result in different pace, intensity and diverse innovation patterns. Some service industries innovate mainly via the adoption and application of new technology by providing new services and improving processes while other service industries are more prone to rely on non-technological types of innovation (Vence, Trigo, 2009). Case studies of innovation activity performed by service (and manufacturing) firms reveal that most firms combine different types of innovation, depending on their capabilities and strategies. Firm-level analyses confirm beneficial effects of combining technological (product and process) and non-technological innovation that bring competitive advantage for firms' current performance and for the generation of future innovations (Evangelista, Vezzani, 2010; Som et al., 2012).

In the last two decades the influence of innovation in services has been studied mostly from the perspective of economic growth and productivity gains. With some exemptions, the analyses of innovation impact largely overlooked the employment effects. Recently, we may observe an increased interest in the topic that could be attributed to improved knowledge on service innovation due to availability of data that capture different types of innovation. In addition, employment related issues are of high relevance for the governance of socio-economic consequences of the crisis. The impact of innovation on jobs takes effect directly and indirectly via firms‘ growth. However, final outcome depends on a larger set of determinants (compensation mechanisms) that pertain to competition, demand, labour market mechanisms, institutional framework, etc. (Evangelista, Savona, 2003; Harrison et al., 2008; Bogliacino, Pianta, 2010; Evangelista, Vezzani, 2012; Vivareli, 2012). Compensation mechanisms may mitigate or reinforce direct impact of innovation on jobs, depending on the interplay and strength of those mechanisms.

Upon this background the paper aims to complement still scarce research in this field by taking into account multidimensional effects of innovation in services. The objectives of this paper are twofold. First, we evaluate the impact of firms' own technology and non-technology innovations on employment and skills composition in manufacturing and in services firms. And second, we examine how innovation in services sector affects employment in vertically linked manufacturing and services firms via spillover effects. In both cases the implications for skills composition is assessed as well. We focus on two EU economies heavily affected by the crisis – Spain and Slovenia. We make use of two representative samples of micro (firm-level) data for both countries that include firm accounting data and data on innovation activity. These data are matched with the sectoral data on innovation, obtained from the Community Innovation Survey (CIS) and linked to micro data using the respective input-output tables for both countries. While micro data on firm innovation activities allow to account for firm own innovation, the latter enables us to assess the impact of innovation spillovers from vertically linked services sector on individual firm's employment growth and changes in skill composition.

To the best of our knowledge the latter innovation spillover effects were so far not explored and present the major contribution of this paper. Our main finding is that there is a substantial heterogeneity in the estimated innovation effects on employment and skill composition of labor. Results vary substantially across industries that generate spillovers and across firms that are potential beneficiaries of the spillovers. In addition, we find no differences in innovation spillover effects between service and manufacturing industries. This implies that innovation effects depend a lot on the specific structure of each economy and that no ad hoc generalizations can be made.

The structure of the paper is as follows. In next section, we discuss different approaches to analyzing the innovation & employment nexus from the perspective of services. We refer to studies analyzing impacts of technological and non-technological innovation on employment in services/manufacturing as well as to studies that examine the spillover effects of innovation in services on employment in firms using those services. Section 3 discusses methodology, empirical model and data set. In section 4, we present results for both countries. Last section concludes.

2. Conceptual framework

Debates on innovation and employment implications have a long history and addressed different perspectives, methodologies and levels of empirical analysis (Pianta, 2005). For long their focus was on technologist perspective that earned additional attention of researchers with the broad diffusion of information-communication technology (ICT). Studies addressing the link between technical change and employment were restrained to evaluating the impacts on manufacturing while service sector was fairly overlooked in spite of its dominant role in advanced economies (Bogliacino, Pianta, 2010). The underlying gap has several origins: underestimation of innovation in services in economic literature (Djellal and Gallouj, 2007); large heterogeneity of services that affects innovation patterns and makes it very difficult to deal with the effects of innovation on employment; the character of innovation in services where, apart from R&D and technical change, other types of innovation, such as organisational and marketing changes, play equally or more important role in innovation (Tether, Tajar, 2008); lack of comparable data sets on non-technological types of innovation which started to improve after the revision of Oslo Manual (2005) that introduced broader definition of innovation[2].

We refer to studies that focus on the relation between innovation and employment changes in services or in both sectors - manufacturing and services – in a comparative perspective. The investigation of the above relation is highly complex and multi-dimensional as reflected by scholars who addressed it. They distinguish several characteristics or combination thereof in examining the link between innovation and employment dynamic: (a) direct and indirect effects of innovation on employment; (b) effects of

[2] »An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method (significant changes in product design or packaging, product placement, product promotion or pricing) or a new organisational method (in business practices, knowledge management systems, workplace organisation or external relationships« (Oslo Manual, 2005). Since CIS3 the innovation surveys included the information on organisational and marketing innovations, but only for firms that introduced technological innovation (product and/or process). Data on firms that carry out only organisational and marketing innovations became available after new definition of innovation by Oslo Manual 2005 (CIS6 and CIS7). For a detailed review of the sectoral and innovation type coverage of various Community innovation surveys see Vergori, 2013.

technological (product, process) and non-technological (organisational) innovation; (c) taxonomies of services based on technological trajectories; (d) innovation strategies (cost competitiveness and technological competitiveness). In order to illustrate the diversity of approaches we reflect upon some studies that are of relevance for our analysis[3].

Early studies referred to information from individual countries only, however, they brought important insight into the relation between technological change and jobs dynamics in services. Based on Italian CIS2 data (1993-1995) Evangelista and Savona (2003) found that innovation in services has a direct negative effect on employment at the aggregate level. They argue that the result reflects the specialisation pattern of Italian service sector, where knowledge intensive services that generate new jobs are underdeveloped. Evidently, the impact of innovation differs between groups of services.sectors. The sectors intensively using ICT, such as finance-related services, reveal labour saving impact of innovation while the opposite is valid for sectors producing new ICT services (e.g. computing and software, R&D, engineering. Finally, the results of the above study reveal that positive impact of innovation on employment at the firm level is compatible with the jobs decline at the aggregate level for total service sector. They suggest that the net result to a large extent depends on the composition of the service sector (Evangelista and Savona, 2003). More generally, when taking into account also the external factors, such as weak demand and strong competition among firms, only the most innovative firms increase employment on account of those less innovative (market stealing effect) resulting in the loss of jobs at the aggegate level (Evangelista and Vezzani, 2012).

As far as the difference between product and process innovation is concerned Djellal and Gallouj (2007) observe that studies have generally claimed positive employment effects of product innovations in services owing to the broadening of services variety and to the openning up of new markets. To the contrary, process innovations seem more likely to downsize employment by improving the efficiency in services production and substituting labour with capital. These outcomes are similar to those found in manufacturing (Pianta, 2005). However, Harrison et al. (2008) find no evidence of displacement effects from either type of innovation in the service sector. They suggest that the results provide explanation for both the strong positive effect of product innovation on employment and the inconclusive effects of process innovation.

A broader perspective of studying implications of technological change on jobs creation/destruction in manufacturing and service industries is followed by Bogliacino, Pianta (2010). They reveal that firms aiming at developing new products and markets (technological competitiveness) display significant positive effect on job creation. To the contrary the strategy aiming at labour saving processes (cost competitiveness) has a negative effect on employment. The impact of two innovation strategies on employment

[3] See Djellal, Gallouj (2008) and Evangelista, Savona (2010) for a detailed overview and discussion of literature and approaches to analysing the nexus between innovation and employment in services.

is assessed for four groups of industries using a revised Pavitt taxonomy[4] . The study reveals important differences between four groups of industries in respect of employment changes that are not only the result of innovation patterns followed (technological vs. cost competitiveness), but also of changes in demand, wages, competition and firm dynamics. The analysis of data for the period 1994 - 2004 based on CIS2, 3 and 4 for eight European countries shows no major differences between services and manufacturing concerning the impact of innovation on employment. This challenges the views on special characteristics of innovation in services that are supposed to also cause variation in employment effects.

Most studies analysing the relation between innovation and employment have a clear focus on technological types of innovation. Arguments in favour of including organisational innovation into analysis to better understand growth and employment effects of innovation were the exception (Edquist et al., 2001). Pianta (2005) argues that organisational innovation is frequently an indispensable complement to the adoption of new technologies. Furthermore, organisational innovation is viewed as being more prominent in services than in manufacturing (Tether, Tajar, 2008). The observed gap finally led to the broader definition of innovation (Oslo Manual, 2005) that recognised non-technological innovation and enhanced data collection on various types of innovation undertaken by firms.

Using CIS4 data from six EU economies and distinguishing between direct and indirect impacts, Evangelista and Vezzani (2012) assert that all types of innovation (product, process and organisational) bear positive indirect effect on employment through increased sales of firms in both services and manufacturing. It is important to observe that their results illustrate direct employment gains even if firms introduce only organisational innovations. Nevertheless, the strongest job creation effects are revealed in firms that combine product, process and organisational innovation highlighting the complementary nature of innovation types. The latter is confirmed also by studies exploring the impact of various innovation types on firm sales and productivity (Evangelista, Vezzani, 2010; Som et al., 2012). From the perspective of sectoral patterns of employment effects, Evangelista and Vezzani (2012) could not find almost any difference between manufacturing and services. The only exemption being that the combination of process and organisational innovations exerts direct and statistically significant labour saving effect only in manufacturing. We suggest that the absence of such effect in services may originate from the fact that process & organisational innovations in services contribute to improvements in quality and this change may require additional employees with the requisite skills.

The most recent analysis based on cross-sectional CIS data from 20 European countries (Peters et al., 2013) brings new insight into the effects of product, process and

[4] Original Pavitt taxonomy (1984) includes only manufacturing while Bogliacino and Pianta (2010) revision adds service industries and groups all industries into four groups: science-based, specialised suppliers, scale and information intensive and supplier dominated activities that made it possible to capture the effect of technological change on employment in the sector that dominates employment.

organisational innovation in services on employment. The findings are aligned with the results of previous analyses and confirm that product innovation encourages employment in service firms in all countries of the sample and for all service industries. In addition and somewhat surprisingly, the estimations show that the employment effect is fairly similar in all countries and industries. Process innovation seems to have a neutral impact on employment in services, suggesting that positive compensation effects might override potential labor saving influence of process innovation. Most important difference indicated by the analysis refers to non significant employment impact of organisational innovations in European economies, with the exception of France and Luxembourg where this type of innovation displays significant and negative influence on employment (Peters et al., 2013).

Marketing innovation is also considered as an important element of non-technological innovation, the assessment of its impact on employment in services, however, is highly deficient. Empirical analysis of CIS 2008 data for sixteen European economies illustrates that those forms of non-technological innovation activities, which impact on external relations and sales channels, have a positive effect on the growth of firm sales in any sector (Som et al., 2012). Taking into account the results of the analysis by Evangelista and Vezzani (2012), we may infer that the sales growth may also result in employment increase, suggesting that marketing innovation may indirectly lead to job creation via growth of firms‘ sales. Nonetheless, the assumption deserves detailed empirical assessment and testing on the basis of longer data series to earn validity.

With broad dissemination of ICT, the interest in evaluating the impact of technological change and innovation on jobs has shifted from quantity dimension to analysing also the effect on the quality of the workforce. The evidence on the substitution of unskilled with skilled labour confirms the skill biased technological change hypothesis across different OECD countries, different economic sectors and different types of innovation (Vivarelli, 2012). Some scholars argue that there might also be other factors at work that increase the demand for skilled workforce and refer to organisational change. A number of studies indicate that efficient ICT deployment is associated with changes in different organisational dimensions that require skilled workers[5]. Estimations for Italian manufacturing firms show that the upskilling trend of employment appears to be mainly a function of organisational change that exerts significant impact, possibly combined with technological change (Piva et. al, 2005). The results tend to suggest that technological and non-technological innovations should be percieved as complements in assessing the effects on skills composition of the workforce.

Only few studies have empirically addressed the impact of technological innovation on skills composition in services and even fewer the effects of organisational change. In general, the introduction of ICT to services is assumed to increase demand for higher skills however this may hold true only for some services. Examples of country studies confirm such reasoning - the analysis of service firms in Germany found that firms with larger expenditures in ICT employ more educated workers, however the strenghth of this

[5] See Piva et. al. (2005) for a detailed survey of literature.

relation depends on the service sector (Falk, Seim, 1999). In Sweden the analysis revealed that innovation has a positive effect on employment and upskilling in knowledge-intensive services (Nählinder, Hommen, 2002). Large number of service industries use ICT mainly to rationalize the delivery processes and communications with suppliers/ customers that may reduce the number of employees, in particular those with lower skills. On a firm level, ICT induced innovation in Italian firms leads to the replacement of low-skilled employees with high-skilled employees in all service industries (Evangelista and Savona, 2003). At best, the above results are inconclusive and need to be supplemented with more recent empirical evidence of the influence of the technological and non-technological innovation in services on skills composition.

The discussions above suggest that positive effects of technological innovation on employment in services tend to prevail over the negative ones at the firm level and also that the positive effects are amplified with simultaneous adoption of organisational innovation. When the link between innovation in services and employment is analysed at the sectoral or macro level the results are inconclusive and much less clear, which causes difficulties in understanding the phenomenon.

Equally important dimension of the relation between innovation and employment occurs via the linkages of services with other sectors of economy. As a result, spillover effects of using inputs of innovative services arise on employment in manufacturing, services and other sectors. So far, the evidence on spillovers from service inputs is limited on the special role of knowledge intensive services[6] (KIS) in fostering the innovation capacity throughout the economy (Muller, Zenker, 2001; Gallouj, 2002) by generating new knowledge, processing and diffusing it within the innovation systems (Miles, 2007). Knowledge intensive services display high innovation intensity that surpasses the innovation intensity of manufacturing in most EU member states (Eurostat - CIS7, 2013). By introducing new or improved services, proceses and organisational & marketing innovations the suppliers of KIS augment better performance of their clients. Therefore, KIS are percieved as co-producers of innovation by interacting with their client firms and helping them to upgrade products, processes, organisational structures and business models (Den Hertog, 2010). A number of firm-level analyses confirm knowledge spillovers from KIS and their facilitating role for innovation, productivity and export performance of manufacturing firms (Wolfmayer, 2011; Doloreux, Shearmur, 2012; Foster et al., 2012).

Following the results of the above studies, one can imagine that KIS also generate employment spillovers in other sectors of the economy. To the best of our knowledge, the empirical evidence on the link between innovation generated by KIS and employment in firms using those services is largely missing even though the gap was observed already some time ago by Djellal and Gallouj (2008). They see large scope for research in this respect, but also point to other themes to be explored such as the relation between

[6] Throughout the paper we use the term knowledge intensive services (KIS) to denote market knowledge intensive services. For details on different sub-sectors of knowledge intensive services see EC (2012).

outsourced and in-house KIS activities. Since KIS display high innovation intensity, their use in client firms may have positive employment effects, however the latter may be impaired by the negative effects in case that client firms outsource KIS activities. While this question deserves empirical testing of data, we see the fundamental research challenge in exploring the spillover effects of inovative KIS inputs on employment in interlinked sectors. We turn to this challenge in the following sections.

3. Methodology, empirical model and data

In previous section, we presented literature on importance of different types of innovation for employment growth of service firms. In addition, we also suggested that technological and organisational innovations may likely impact the skills composition in service firms. Furthermore, we also claim that firms are not necessarily affected only by their own innovation activities, but may well be affected by innovation spillover effects by using inputs of vertically linked innovative service industries. These innovation spillovers are likely to have an impact on employment and skill composition of manufacturing and service firms. A good example of this is the whole range of innovation in the ICT sector in the previous two decades and its impact on productivity growth and employment in the rest of the economy.

3.1. Empirical approach

We study the above effects of innovation in services using a general framework, which accounts for the impact of firm own innovation as well as innovation spillovers from vertically linked manufacturing and services industries on individual firm's employment growth and changes in skill composition. We estimate the following model:

$$\Delta y_{ijt} = \alpha + \beta \cdot \mathbf{X}^k_{ijt-2} + \delta \cdot \mathbf{Z}^k_{mt-2} + \phi \mathbf{V}_{ijt-2} + \varphi \mathbf{T} + \gamma \mathbf{S} + u_{it} + \varepsilon_{ijt}, \quad (1)$$

where Δy_{ijt} denotes our dependent variable, which is either firm's *i* employment growth or indicator of increase in firm's *i* high-skilled labor share. This means that we estimate model (1) using one of the two alternate dependent variables: employment growth and high-skilled labor share. Among explanatory variables, there are three groups of variables. $\mathbf{X}^k_{ijt-2}$ denotes a vector of firm's own innovation of type *k*, which consists of technological (product or process) and non-technological (organizational or marketing) innovation. Innovation variables are lagged 2 years. Using two lags enables us also to account for long-run effects that innovation exerts on employment and skill composition. Second group of variables is contained in the vector $\mathbf{Z}^k_{mt-2}$, which denotes vertical innovation spillovers of type *k* stemming from different sectors *m* that are vertically linked to the industry *j* in which firm *i* is operating (where $j \neq m$). Here, *j* denotes Nace 2-digit industries and m stands for a broader sector, such as manufacturing, service or groups of services. Innovation spillover variable is described in greater detail below. Third group of explanatory variables is $\mathbf{V}_{ijt-2}$, which contains firm-level control variables, such as size, productivity and foreign trade participation (i.e. share of exports and imports in firm's total sales). Both innovation spillovers and firm control variables are lagged 2 years in order to control for long-run effects of these variables on our dependent variables. Our model includes also year and sector fixed effects by including the vectors **T** (year) and **S** (Nace 2-digit industries). Finally, our model includes also firm fixed effects u_{it} and the usual white noise error term e_{ijt}.

We explicitely account for potential vertical innovation spillovers of service industries where these serve as suppliers to industries in which particular firms operate. The rationale behind is that innovation by service industries can importantly affect performance of industries (and firms therein) that are more dependent on inputs from these particular service industries. The higher the share of innovative firms in upstream service industries and the higher the linkage between vertically linked industries, the higher is potential for downstream industries to benefit from innovation in upstream service industries. We account for these backward vertical innovation spillovers linkages $\mathbf{Z}_{mt}^{k}$ as the sum of the output of industries *m* purchased by firms in industry *j* weighted by the share of innovative firms total number of firms in industry *m* (sIN_{mt}^{k}). Innovation spillover variable is hence constructed using the following formula:

$$Z_{mt}^{k} = \sum_{m,j=1}^{n} \left(a_{mjt} * sIN_{mt}^{k} \right), \qquad m,j=1,...,n, \qquad (2)$$

where a_{mjt} ($0 \leq a_{mjt} \leq 1$) is the proportion of industry *m*'s output consumed by industry *j*. These direct input requirements are obtained in the form of corresponding technical coefficients from the country's input-output matrix. Share of innovative firms by industries is obtained from the CIS country surveys.

We estimate model (1) using OLS. WE prefer this approach over the fixed effects (FE) technique as our dependent variable is specified in first difference (growth rate), which means that the firm specific fixed effects were differenced out. In addition, most of the explanatory variables are sector specific and would hence be cancelled out with the FE transformation. We do, however, control for the possible remaining error due to firm fixed effects by including a set of firm specific control variables, such as size, productivity and foreign trade participation.

3.2. Data

Effects of innovation in services on employment and skill composition are estimated at the firm level. We estimate model (1) for two countries – Spain and Slovenia – using firm-level accounting data and data on innovation activity and combine these data with the aggregate sector-level data on innovation of vertically linked sectors. Different sources of data are used for each of the countries.

Spain

We make use of a representative sample of survey data for Spanish manufacturing firms for the period 1996-2008. The dataset from the Encuesta Sobre Estrategias Empresariales (ESEE) is an unbalanced sample of firms collected using direct interviews with a questionnaire. For firms with fewer than 200 employees, a random sample of survey participants was drawn ensuring the representativeness of the industrial and size categories. On the other hand, the total population of large firms, with at least 200 employees, was included in the survey. Our sample includes 34.748 firm-year observations, ranging from 1,373 to 2,154 firm observations per year between 1990 and 2008. For a more detailed description of the ESEE database see Damijan and Kostevc (2010). In addition to accounting data, the ESEE also provides information on the innovative activity of manufacturing firms, imports, exports and skill composition of employees. Unfortunately, the survey covers only technological innovation (product or process innovations). The data on skill composition (number of low- and high-skilled labor) is available only every four years (i.e. in 1990, 1994, 1998, 2002 and 2006).

To calculate vertical innovation spillover variables we use sector level data from the Community innovation survey (CIS) and combine it with the data from the input-output (IO) tables. CIS data aggregated to the 2-digit Nace Rev.1 is available from the Eurostat for every second year. Note that, CIS includes information on both technological (product, process) and non-technological (organizational, marketing) innovation, but the later is available only after 2004. IO tables are also available from the Eurostat, but only for every 5 years. In order to fill the gaps in the data we used the following approach. For the CIS data, we assumed that, according to the survey questionnaire[7], data at the end of the 2-year period applies for the whole period. More precisely, CIS data from the 2008 survey is used both for 2007 and 2008, and similarly for the other CIS waves. For the IO data we assume fixed IO coefficients in between two subsequent IO tables.[8]

Slovenia

As a source of micro data for Slovenia, we use firm accounting data from annual financial statements provided by AJPES for the period 1996-2008. We match these data with the CIS survey data for the same period, whereby the surveys are carried out on a preselected stratified sample of manufacturing and service firms. CIS data include information on both technological (product, process) and non-technological (organizational, marketing) innovation, but the later is available only after 2006. CIS is biannual and conducted every even year. The number of firms covered by the CIS constantly increased during the 1996-2008 period (from 1,400 firms in 1996 to 3,000 firms in 2008). The data on skill composition of employees is available from the labor force survey for every year, which is compulsory for all firms. These data are matched with the accounting and CIS data using unique firm identifiers.

[7] The actual questions posed in CIS for product innovations were: "During the three year period [...], did your enterprise introduce any technologically new or significantly improved products (goods or services) which were new to your firm?", and similar for other type of innovations.

[8] Another approaches, such as linear interpolation of IO coefficients in between two subsequent IO tables, are also possible. However, as changes in IO coefficients over the observed period are very small, we decided to use a more simple approach.

Data sources for aggregate CIS data and IO tables are the same as for the Spanish data (Eurostat). We also use a similar approach to fill the data gaps.

In both samples, all value data were deflated using NACE 2-digit industry producer price indices, while the capital stock variable was deflated using the consumer price index.

3.3. Descriptive statistics

Aggregate data for Spain and Slovenia seem to conform to the findings of Evangelista and Savona (2003) for Italy that employment growth in service sectors is negatively correlated to innovation. As revealed in Table 1, employment in service sector in both countries over the period 1996-2008 surpassed the expansion of employment in the whole economy by orders of magnitude despite lower measured innovation succes. There also seem to bi no significant deifferences between konwledge intensive ans less knowledge intensive service industries in terms of innovation intensity, whereby the former have expanded much faster.

[*Table 1 about here*]

Caution, however, is needed in interpreting the above aggregate figures. Notably, data on innovation activity is imperfect both due to the way how the data is compiled (surveys on samples of firms) as well as due to the coverage. CIS data is available since 2006, but only for technological innovation, while data on non-technological innovation is available only since 2004 (for Spain) or 2006 (for Slovenia). Hence, any comparisons over time of innovation data is cumbersome. And furthermore, there is no way to infer about causality when using such imperfect data sets.

[*Table 2 about here*]

This is why we refer to firm level data, which enables us to track the effects of innovation treatment on employment for the same firms over a long period. Table 2, which is constructed using firm-level data for the whole period, comes closer to disentangle the potential effects of innovation on employment and skill composition over time. Table 2 presents average changes in total employment and shares of low- and high-skilled labor over the period 1996-2008[9] for Spanish and Slovenian firms that received the innovation treatment and those who did not. Firms with no technological innovation in the period under investigation are shown to decrease number of employees on average between 9 (Spain) and 32 per cent (Slovenia), while firms that pursued product or process innovation increased employment on average by 70 (Spain) and 32 per cent (Slovenia). Furthermore, shares of high-skilled labor in firms with no innovation decreased, while it boomed in innovative firms.

At the same time, the evidence shows that, on average, innovative firms also increased the shares of low-skilled labor. This implies that innovation can boost demand for either high- or low-skilled labor and hence its effect on skill composition can turn out inconclu-

[9] Period 1994-2006 for Spain.

sive. The actual evolution of employment and skill composition depends on individual firm's characteristics as well as characteristics of sectors in which firm operates. In the next section we present results of estimating empirical model (1) that takes into account both, but also accounting for potential vertical innovation spillovers.

4. Results

This section presents the results of estimating model (1) on the impact of firm own innovation and innovation spillovers from vertically linked services sector on individual firm's employment growth and changes in skill composition in Spain and Slovenia. We first present results for the overall employment and then turn to results for skill composition.

4.1. Results for employment effects of innovation

Tables 3 and 4 present results for overall employment as a dependent variable. Results show two notable differences in terms of effects of innovation on employment between Spain and Slovenia.[10] First, for Spain (see Table 3) we find that firm's own process innovations positively affect future employment growth, while product innovations do not seem to have any impact on employment growth. The only difference is in specification (1), where both product and process innovation positively affect employment growth. This is somehow counterintuitive and in contrast to recent findings that product innovations are more likely to boost employment, while process innovations are more likely to have a labor-saving effect.

On the other hand, in the sample of Slovenian firms (see Table 4) firm's own innovation do not seem to have any impact of firm employment performance. Slovenian data is richer and allows for accounting for both technological and non-technological innovation, but neither of them seem to affect employment. Similar insignificant results were found by Damijan, Kostevc and Rojec (2011), who find that innovation does not affect firm productivity growth of Slovenian firms. In a later study, Damijan, Kostevc and Rojec (2012) show that some positive effects of innovation is present for poor performing firms, while high productivity firms experience a negative effect of innovation.

[*Table 3 about here*]

[*Table 4 about here*]

Second, results for both countries differ also in terms of the innovation spillover effects. In Spain, product innovation in vertically linked industries is positively affecting firms' future employment growth, while process innovation is shown to have a negative impact. In contrast, vertical spillovers from marketing and organisational innovation are insig-

[10] Note that for Spain our data consist only of manufacturing firms, while for Slovenia the data comprise both manufacturing and service firms.

nificant. When decomposing vertical innovation spillovers into those originating in manufacturing and those stemming from service industries, results in column 2 show that firms benefit form both sources of spillovers in terms of product innovation. Process innovation in vertically linked manufacturing industries still have a negative effects, while process innovation in service industries turn out to have a positive impact. Decomposing innovation spillovers from service sectors into knowledge intensive (KIS) and less knowledge intensive (LKIS), reveals that the whole effect is coming from the former. Interestingly, while vertical spillovers from marketing and organisational innovation are in general non-existent, they turn significant and positive for spillovers from KIS industries and negative and significant from LKIS industries. This shows huge heterogeneity of spillover effects and calls for cautious interpretation of any results obtained at a more aggregate level.

For Slovenia, results for spillovers from product and process innovations are reversed. Spillovers from process innovations positively affect firms' future employment growth, while spillovers from product and marketing and organisational innovation innovations have a significantly negative impact. This is seems to be a general pattern for both manufacturing and service firms. For manufacturing firms, these effects are mainly coming from vertically linked less knowledge intensive services industries (compare columns 2 and 3), while for service firms this is also true, but less pronounced.

The above results show that there is no general pattern in terms of employment effects of firm own innovation and innovation spillovers. The actual effects depend much on the specific structure of each economy.

4.2. Results for effects of innovation on skill composition

While above results show no general pattern in terms of employment effects of innovation spillovers across Spanish and Slovenian firms, the effects are more clear in terms of the skill composition. Table 5 shows that Spanish manufacturing firms are benefitting from own innovation as both product and process innovation positively affect firms' shares of high-skilled labor. The effects are biggest for process innovators only, followed by firms that are successful both in product and process innovations. For Slovenia (see Table 6), own innovation again does not seem to affect firm skill composition. There are even some negative effects recorded for a sample of service firms that engage in process innovations (see columns 4 and 5), suggesting that in service firms own process innovations decrease the share of high-skilled labor and increase demand for low-skilled labor.

[*Table 5 about here*]

[*Table 6 about here*]

In terms of the effects of innovation spillovers results are quite similar for both countries. In both countries, manufacturing firms experience positive effects of vertical spillovers from product and marketing and organizational innovations and negative spillovers effects from process innovations. The difference is that in Spain these significant spillovers stem from service industries, while in Slovenia they originate in manufacturing industries. Skill composition of service firms in Slovenia do not seem to be affected by vertical innovation spillovers.

Above results again demonstrate that no general pattern can be identified for the effects of innovation on skill composition. Results vary across industries and across firms. In each country, specific economic structure plays a decisive role in how firms can benefit from innovative activities of other firms. In any case, innovation in service industries do not seem to have a different impact on employment and skill structure as compared to innovation in manufacturing industries.

5. Concluding remarks

This paper aims to contribute to still scarce research in the field of effects of innovation on employment and skills composition. The contribution of the paper lies in taking into account multidimensional effects of innovation in services. To account for this, we employ a general framework that accounts for the impact of firm own innovation as well as innovation spillovers from vertically linked services sector on individual firm's employment growth and changes in skill composition. We first evaluate the impact of firms' own technology and non-technology innovations on employment and skills composition in manufacturing and in services firms. And second, we study how innovation in manufacturing and services industries affects employment and skill composition in vertically linked manufacturing and services firms via spillover effects. We focus on two EU economies – Spain and Slovenia – by using unique representative samples of micro data. While other studies using micro data on innovation are (due to restrictions on merging different waves of CIS) constrained to use cross-sectional data that allows only for studying correlation, our data enable us to study causality between innovation and employment.

Empirical estimations show mixed results. We were unable to find general pattern in terms of employment effects of firm own innovation and innovation spillovers. In Spain we find positive effects of firms' own innovation both on future employment growth and on the increases of high-skilled labor shares, whereby in Slovenia no such effects were found. In terms of innovation spillover effects on employment, we find on the sample of Spanish firms that product innovation in vertically linked industries is positively affecting firms' future employment growth, while process innovation is shown to have a negative impact. The opposite results were found on the sample of Slovenian firms. In terms of the effects of innovation spillovers on skill composition of labor, we find that in both countries only manufacturing firms experience some significant innovation spillover effects. Positive effects of vertical spillovers are found from product and marketing and organizational innovations and negative spillovers effects from process innovations. The difference is that in Spain these significant innovation spillovers stem from service industries, while in Slovenia they originate in manufacturing industries.

Our results hence show a substantial heterogeneity of innovation effects on employment and skill composition of labor. This implies that, first, the effects depend a lot on the specific structure of each economy, whereby results can vary substantially across industries that generate spillovers and across firms that are potential beneficiaries of the spillovers. And second, innovation in service industries do not seem to have a different spillover effect on employment and skill structure when compared to innovation in manufacturing industries.

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Tables to be included in text

Table 1: Change in total employment between 1996 and 2008, and share of innovative firms in 2008, by economic activity (in %)

	change in employment (%)		share of innovative firms* in 2008 (%)	
Activity, Nace Rev. 1	Spain	Slovenia	Spain	Slovenia
Total	57.4	13.2	49.6	55.4
D Manufacturing	26.4	-11.6	49.6	50.3
E Electricity, Gas and Water Supply	20.3	-30.8	41.5	8.1
F Construction	95.8	29.8	38.3	
G Wholesale and Retail Trade	51.5	15.5	45.8	48.8
H Hotels and Restaurants	84.0	8.8	25.4	
I Transport, Storage and Communications	53.0	17.6	35.9	38.7
J Financial Intermediation	44.2	9.5	69.3	54.5
K Real Estate, Renting and Business Activ.	166.9	83.3	38.5	48.0
L Public Adm. and Defence; Social Security	52.4	43.9		
M Education	51.5	41.8		
N Health and Social Work	80.4	29.5	100.0	
O Other Comm.,Social and Personal Service	76.8	41.9	41.8	
LKIS**	70.7	17.9	39.4	48.8
KIS***	77.5	38.7	39.5	44.8

Note: *share of firms declaring technological and non-technological innovation in total number of surveyed firms; ** LKIS – less knowledge intensive service sectors; *** KIS – knowledge intensive service sectors.

Source: ILO, Eurostat; own calculations.

Table 2: Average changes in total employment, high-skilled and low-skilled labor in Spanish and Slovenian firms in the period 1994-2006 by innovation type, in percent

		Spain#	Slovenia
Innov. status		1994-2006	1996-2008
no innov.	total emp.	-9.1	-31.5
	HS emp.*	-6.6	-4.3
	LS emp.**	-0.1	-44.1
	number of firms***	3,837	2,119
prod&proc innov.	total emp.	70.2	32.0
	HS emp.*	29.6	25.9
	LS emp.**	37.3	35.4
	number of firms***	255	529
Total	total emp.	8.0	13.8
	HS emp.*	0.9	29.8
	LS emp.**	9.5	5.8
	number of firms***	4,629	3,007

Notes: # manufacturing firms only for Spain; * share of high-skilled labor (12 or more years of education); ** share of low-skilled labor (less than 12 years of education); ***number of surveyed firms in 2008.

Source: ESEE, AJPES and SURS; own calculations.

Table 3: Impact of services innovation spillovers on employment growth of Spanish manufacturing firms (period 1994-2008)

	(1) Pooled	(2) Man_Serv	(3) Kis_Lkis
own prod_inov only	-0.005	-0.006	-0.006
	[-0.83]	[-1.11]	[-1.13]
own proc_inov only	0.011***	0.010**	0.009**
	[2.59]	[2.20]	[2.03]
own prod & proc inov	0.010**	0.007	0.006
	[2.07]	[1.47]	[1.33]
All prod_inov spill	0.581***		
	[7.87]		
All proc_inov spill	-0.176***		
	[-3.21]		
All mkt&org_inov spill	-0.023		
	[-1.51]		
Manuf. prod_inov spill		1.267***	0.992***
		[3.52]	[2.71]
Manuf. proc_inov spill		-0.621**	-0.497*
		[-2.13]	[-1.72]
Manuf. mkt&org_inov spill		0.079	0.020
		[0.97]	[0.24]
Serv. prod_inov spill		1.164***	
		[3.26]	
Serv. proc_inov spill		0.478**	
		[2.08]	
Serv. mkt&org_inov spill		-0.005	
		[-0.05]	
Kis prod_inov spill			0.915**
			[2.05]
Kis proc_inov spill			-0.201
			[-0.37]
Kis mkt&org_inov spill			0.394***
			[2.59]
Lkis prod_inov spill			-0.858
			[-0.37]
Lkis proc_inov spill			0.166
			[0.09]
Lkis mkt&org_inov spill			-1.712**
			[-2.24]
Export share	0.001	0.001	0.001
	[1.06]	[1.07]	[1.19]
Import share	0.000	0.000	0.000
	[0.32]	[0.24]	[0.34]
Constant	-0.029**	-0.108***	-0.030
	[-2.55]	[-5.73]	[-1.07]
Observations	18,393	18,393	18,393
R-squared	0.015	0.018	0.019

Notes: Dependent variable is annual growth rate. All explanatory variables lagged 2 years. t-statistics in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Impact of innovation spillovers on employment growth of Slovenian manufacturing and service firms (period 1996-2008)

	Manufacturing firms			Service firms		
	(1) Pooled	(2) Man_Serv	(3) Kis_Lkis	(4) Pooled	(5) Man_Serv	(6) Kis_Lkis
own prod_inov only	-0.015	-0.014	-0.077	0.003	-0.074	-0.052
	[-0.17]	[-0.17]	[-0.87]	[0.0082]	[-0.21]	[-0.15]
own proc_inov only	0.075	0.077	0.022	0.068	0.023	0.031
	[0.64]	[0.66]	[0.19]	[0.44]	[0.14]	[0.19]
own mkt_inov only	-0.034	-0.031	-0.088	-0.22	-0.266	-0.261
	[-0.18]	[-0.17]	[-0.47]	[-0.89]	[-1.08]	[-1.05]
own org_inov only	0.047	0.048	-0.007	0.00	-0.017	-0.018
	[0.84]	[0.85]	[-0.12]	[0.004]	[-0.27]	[-0.27]
All prod_inov spill	-2.25***			-4.272***		
	[-5.46]			[-4.74]		
All proc_inov spill	2.741***			4.632***		
	[5.99]			[4.55]		
All mkt&org_inov spill	-0.17***			-0.418***		
	[-3.99]			[-4.67]		
Manuf. prod_inov spill		-1.395			1.839	
		[-1.31]			[0.36]	
Manuf. proc_inov spill		1.848*			-2.662	
		[1.60]			[-0.48]	
Man. mkt&org_inov spill		-0.117			0.297	
		[-1.20]			[0.64]	
Serv. prod_inov spill		-2.41***			-1.269	
		[-4.32]			[-1.35]	
Serv. proc_inov spill		2.970***			2.171*	
		[4.98]			[1.80]	
Serv. mkt&org_inov spill		-0.252***			-0.097	
		[-4.71]			[-0.60]	
Kis.prod_inov spill			0.492			-0.454
			[1.21]			[-0.090]
Kis.proc_inov spill			-0.241			1.097
			[-0.56]			[0.17]
Kis.mkt&org_inov spill			0.217			0.016
			[1.31]			[0.031]
Lkis.prod_inov spill			-17.57***			10.295
			[-2.70]			[0.88]
Lkis.proc_inov spill			23.433***			-11.884
			[2.79]			[-0.85]
Lkis.mkt&org_inov spill			-1.446**			2.584
			[-2.08]			[1.03]
Export share	0.000*	0	0	-0.01***	-0.01***	-0.01***
	[1.69]	[1.56]	[0.97]	[-3.39]	[-3.23]	[-3.18]
Import share	0	0.000*	0.000*	0.001***	0.001***	0.001***
	[1.62]	[1.68]	[1.78]	[4.46]	[3.37]	[3.28]
Value added/emp	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	[9.80]	[9.67]	[9.47]	[5.74]	[5.14]	[5.18]
Constant	0.106***	0.127***	0.152***	0.448***	0.510***	0.546***
	[3.09]	[2.61]	[2.77]	[8.38]	[9.66]	[8.61]
Observations	6,230	6,230	6,230	4,347	4,347	4,347
R-squared	0.032	0.034	0.038	0.026	0.032	0.031

Notes: Dependent variable is annual growth rate. All explanatory variables lagged 2 years. t-statistics in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Impact of services innovation spillovers on high-skilled labor shares' increases of Spanish manufacturing firms (period 1994-2008)

	(1) Pooled	(2) Man_Serv	(3) Kis_Lkis
own prod_inov only	0.044*	0.043*	0.043*
	[1.66]	[1.64]	[1.65]
own proc_inov only	0.122***	0.120***	0.119***
	[5.85]	[5.79]	[5.73]
own prod & proc inov	0.097***	0.097***	0.096***
	[4.34]	[4.35]	[4.32]
Firm size (log empl.)	-0.006	-0.005	-0.006
	[-1.14]	[-1.06]	[-1.17]
All prod_inov spill	1.176***		
	[3.89]		
All proc_inov spill	-1.286***		
	[-6.03]		
All mkt&org_inov spill	0.606***		
	[8.93]		
Manuf. prod_inov spill		-1.615	-1.489
		[-1.17]	[-1.08]
Manuf. proc_inov spill		0.712	0.636
		[0.71]	[0.64]
Manuf. mkt&org_inov spill		0.079	0.133
		[0.24]	[0.41]
Serv. prod_inov spill		3.265*	
		[1.89]	
Serv. proc_inov spill		-3.398***	
		[-3.16]	
Serv. mkt&org_inov spill		1.193***	
		[2.97]	
Kis prod_inov spill			6.091
			[1.25]
Kis proc_inov spill			-6.124
			[-1.51]
Kis mkt&org_inov spill			1.799**
			[2.02]
Lkis prod_inov spill			5.545
			[0.27]
Lkis proc_inov spill			-6.574
			[-0.31]
Lkis mkt&org_inov spill			-1.319
			[-0.12]
Export share	0.005*	0.005*	0.005*
	[1.91]	[1.90]	[1.94]
Import share	0.002	0.002	0.002
	[0.43]	[0.41]	[0.44]
Constant	0.468***	0.484***	0.478***
	[8.80]	[3.68]	[3.67]
Observations	4,708	4,708	4,708
R-squared	0.035	0.036	0.036

Notes: Dependent variable is a dummy variable, where 1 indicates increase in high-skilled labor shares over the last 4-year period, and 0 indicates lack thereof. All explanatory variables lagged 2 years. *t*-statistics in brackets, *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Impact of innovation spillovers on high-skilled labor shares' increases of Slovenian manufacturing and service firms (period 1996-2008)

	Manufacturing firms			Service firms		
	(1) Pooled	(2) Man_Serv	(3) Kis_Lkis	(4) Pooled	(5) Man_Serv	(6) Kis_Lkis
own prod_inov only	0.155	0.11	0.123	-0.613	-0.614	-0.553
	[1.16]	[0.82]	[0.91]	[-1.23]	[-1.23]	[-1.10]
own proc_inov only	-0.106	-0.129	-0.113	-0.542*	-0.534*	-0.466
	[-0.60]	[-0.73]	[-0.64]	[-1.88]	[-1.84]	[-1.59]
own mkt_inov only	0.461	0.448	0.45	0.434	0.467	0.565
	[0.93]	[0.90]	[0.91]	[0.87]	[0.93]	[1.12]
own org_inov only	0.005	-0.032	-0.012	-0.069	-0.039	0.045
	[0.047]	[-0.30]	[-0.11]	[-0.75]	[-0.41]	[0.43]
Firm size (log empl.)	0.021***	0.019**	0.020**	0.022*	0.025*	0.028**
	[2.70]	[2.36]	[2.47]	[1.74]	[1.90]	[2.09]
All prod_inov spill	0.086			-1.475		
	[0.14]			[-1.12]		
All proc_inov spill	-0.177			1.611		
	[-0.26]			[1.08]		
All mkt&org_inov spill	0.057			-0.1		
	[0.90]			[-0.76]		
Manuf. prod_inov spill		3.156**	-0.617		-9.394	0.883
		[1.99]	[-0.74]		[-1.15]	[0.27]
Manuf. proc_inov spill		-3.512**	0.607		10.087	-1.484
		[-2.03]	[0.68]		[1.13]	[-0.42]
Man. mkt&org_inov spill		0.342**	-0.016		-0.763	0.456
		[2.34]	[-0.20]		[-1.02]	[1.47]
Serv. prod_inov spill		-0.448			1.498	
		[-0.74]			[1.00]	
Serv. proc_inov spill		1.018			-1.737	
		[1.60]			[-0.90]	
Serv. mkt&org_inov spill		0.331			0.191	
		[1.41]			[0.76]	
Kisprod_inov spill			-5.748			12.646
			[-0.60]			[1.55]
Kisproc_inov spill			7.827			-16.195
			[0.64]			[-1.52]
Kismkt&org_inov spill			-0.231			1.199
			[-0.23]			[1.44]
Lkisprod_inov spill			-14.144			-23.706
			[-0.60]			[-1.35]
Lkisproc_inov spill			17.702			29.576
			[0.63]			[1.41]
Lkismkt&org_inov spill			-2.84			-5.402
			[-0.58]			[-1.42]
Export share	0	0	0	0	0	0
	[-1.09]	[-0.57]	[-0.56]	[0.31]	[0.28]	[0.29]
Import share	0	0	0	0	0	0
	[-0.0001]	[-0.40]	[-0.29]	[0.97]	[0.39]	[0.45]
Constant	0.495***	0.371***	0.402***	0.434***	0.462***	0.457***
	[8.42]	[4.92]	[4.83]	[5.17]	[5.40]	[4.24]
Observations	3,193	3,193	3,193	2,007	2,007	2,007
R-squared	0.01	0.013	0.012	0.007	0.008	0.011

Notes: Dependent variable is a dummy variable, where 1 indicates increase in high-skilled labor shares over the last 4-year period, and 0 indicates lack thereof. All explanatory variables lagged 2 years. *t*-statistics in brackets, *** p<0.01, ** p<0.05, * p<0.1.