Wiener Institut für Internationale Wirtschaftsvergleiche
The Vienna Institute for International Economic Studies

Working Papers | 72 | January 2011

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Change Begets Change: Employment Effects of Technological and Non Technological Innovations – a Comparison across Countries

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This publication was produced in the framework of MICRO-DYN (www.micro-dyn.eu), an international economic research project focusing on the competitiveness of firms, regions and industries in the knowledge-based economy. The project is funded by the EU Sixth Framework Programme (www.cordis.lu) with socio-economic sciences and humanities (http://ec.europa.eu/research/social-sciences/index_en.html).

SIXTH FRAMEWORK PROGRAMME

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and Robert Stehrer

Change Begets Change: Employment Effects of Technological and Non Technological Innovations – a Comparison across Countries

Contents

List of Tables and Figures

Abstract

This paper attempts to shed new light on the effect innovation has on employment. Specifically, it identifies the net employment effects of technological product and process innovations as well as complementary non-technological organizational innovations which have so far mostly been bypassed in comparable analyses. The analysis applies the 4th Community Innovation Survey and determines and compares innovation-induced employment effects in both manufacturing and service sectors across three country-groups: i) a set of Central and Eastern European transition countries, ii) a group of Southern EU member states as well as iii) a pool of Core EU member countries. The results reveal interesting differences across types of innovation, sectors or country-groups analyzed. Particularly, in both manufacturing and service sectors of Central and Eastern European transition countries and Southern European countries employment expands in response to the introduction of product novelties or process innovations only. Non-technological organizational innovations, on the other hand, had a detrimental effect on employment in the manufacturing sector of Central and Eastern European countries only. In contrast, employment in both manufacturing and service sectors of Core European countries only reacts to the introduction of new products but remains unaffected by the implementation of process or organizational innovations.

Keywords: *employment, technological and non-technological innovations, manufacturing and services, CIS 4*

JEL classification: *J2, O33*

Sandra M. Leitner, Johannes Pöschl and Robert Stehrer

Change begets change: employment effects of technological and non-technological innovations – a comparison across countries

> "In the 17th century nearly all Europe experienced revolts of the work-people against the ribbon-loom, a machine for weaving ribbons and trimmings, called in Germany Bandmühle, Schnurmühle, and Mühlenstuhl. These machines were invented in Germany. Abbé Lancellotti, in a work that appeared in Venice in 1636, but which was written in 1579, says as follows:
>
>> *'Anthony Müller of Danzig saw about 50 years ago in that town, a very ingenious machine, which weaves 4 to 6 pieces at once. But the Mayor being apprehensive that this invention might throw a large number of workmen on the streets, caused the inventor to be secretly strangled or drowned.'*
>
> In Leyden, this machine was not used till 1629; there the riots of the ribbon-weavers at length compelled the Town Council to prohibit it."
>
> (Karl Marx in "Capital. *A Critique of Political Economy*", Volume I Book One: "The Process of Production of Capital", 1977, Chapter 15, p 283)

1. Introduction

Whether technological change tends to create or destroy employment has been an issue of scientific concern and policy debate for decades now. Particularly, ever since the Industrial Revolution the world has witnessed the creation of novel products and processes at an ever increasing pace. And while a positive long-term effect on aggregate employment seems apparent, the precise impact on employment at the firm level is less well known.

Theoretically, product and process innovations may both create and destroy jobs, rendering the net effect an a priori unclear outcome. Specifically, newly introduced products are likely to increase overall demand for a firm's products and, as a consequence, stimulate production and increase employment. This *labor compensation effect* is stronger the lower the degree of competition innovative firms face on their markets and the lower prevailing production synergies between old and new products. However, the demand for labor may fall should the product novelty replace a firm's old products. Furthermore, additional *labor displacement effects* may surface as, even in the absence of accompanying process innovations, product innovations tend to give rise to labor-saving productivity effects as a result of changes in production methods or input mixes.

Process innovations, on the other hand, tend to reduce employment – at least in the short run - as, in response to associated productivity improvements, overall factor input requirements fall which allows process innovators to produce the same amount of output with fewer employees and lower unit costs. The exact scale of this *labor displacement effect* depends on the degree of substitutability of input factors and the labor-saving nature of the production technologies utilized. Moreover, successful process innovators may pass on cost reductions to consumers and reduce prices which, in turn, spurs demand and production and increases the demand for labor. This countervailing *labor compensation effect* is stronger the fiercer competition on the goods market as process innovators attempt to capture additional market shares and, at least temporarily, outpace their competitors by undercutting their prices.

Surprisingly however, empirical analyses have so far almost without exception bypassed potential employment effects of non-technological organizational innovations.[1] Innovative firms not only develop and introduce product and process innovations but also continuously adopt and reorganize organizational routines or practices and external relations so as to improve the utilization or exchange of information, knowledge or skills, the efficiency of work flows or the relations with other partners. Such organizational innovations which (1) are complementary to ICT investments, require almost no R&D resources for their development (Polder et al., 2010) but partly substantial investments in training activities (Antonelli et al., 2010), (2) tend to be implemented when real output prices or productivity is dwindling (Nickell et al., 2001), (3) are found to be complementary to product and process innovations (Cozzarin and Perzival, 2006, Polder et al., 2010, Schmidt and Rammer, 2007) and (4) tend to magnify the gains obtained through the introduction of technological product and process innovations (Faria and Lima, 2009) also affect labor productivity and employment. Specifically, some organizational innovations are labor-saving in that their strong labor-productivity enhancing effect decreases labor demand and employment. In that respect, such labor-saving organizational innovations are similar to process innovations. Other organizational innovations are capital-saving in nature and reduce the amount of material inputs required without cutting down on employment.

The ensuing analysis contributes to the ongoing discussion by identifying the net employment effects of technological product and process innovations as well as complementary non-technological organizational innovations in both manufacturing and service sectors of a diverse pool of European countries. Specifically, the analysis applies the 4th Community Innovation Survey for 14 different European countries, including six Central and Eastern European transition countries (the Czech Republic, Estonia, Hungary, Latvia, Slovenia and Slovakia which joined the EU in 2004), four Southern EU-member states (Spain, Greece, Italy and Portugal) and four Core EU-member countries (Denmark, France, Luxembourg

[1] Organizational innovation refer to new elements introduced into an organization´s production or service operations - input materials, task specifications, equipment used to produce a product or render a service (Damanpour, 1991).

and Sweden). Methodologically, a modified version of Jaumandreu's (2003) production-function framework is used. Moreover, the analysis explicitly accounts for employment effects of organizational innovations. It thereby addresses the obvious gap in the literature and provides evidence for an almost neglected innovation-employment nexus.

Overall, the results demonstrate that innovation-induced employment responses differ partly substantially across sectors or country-groups considered. Particularly, both manufacturing and service sectors of Central and Eastern European transition countries and Southern European countries display very similar employment responses to technological innovations. Employment expands as the result of the introduction of product novelties or of process innovations only, but shrinks as a consequence of jointly introduced product and process innovations. However, non-technological organizational innovations appear to have destroyed employment in the manufacturing sector of Central and Eastern European countries only which may be traced back to the widespread implementation of labor-saving managerial or relational organizational innovations like outsourcing or subcontracting. In contrast, hardly any innovation-induced employment responses come to light in Core European countries. And while both manufacturing and service sector employment expand in the course of the introduction of a new product, practically no employment effects result from either process or organizational innovations.

The rest of the paper is organized as follows: Section 2 presents and discusses some previous research on the employment effects of product, process as well as non-technological organizational innovations while section 3 outlines the underlying theoretical model and addresses some emerging statistical issues. A discussion of the data used in the empirical analysis is provided in section 4. Section 5 presents the main empirical results for both the overall sample as well as separately for the three country-groups considered while section 6 concludes.

2. Empirical evidence

The question as to whether technological change affects employment is an old one (Say, 1803) and has aroused interest of economists and politicians alike. Since then a rich strand of literature has emerged which has attempted to identify the employment effects of product and process innovations or, to a lesser extent, the employment effects of complementary non-technological organizational innovations.

All in all, conclusive evidence is found that *product innovations* are associated with employment growth at the firm level (Van Reenen, 1997, Smolny, 1998, Rottmann and Ruschinski, 1998, Lachenmaier and Rottmann, 2006, Becker and Ecker, 2007, Garcia et al., 2002, Hall et al., 2007, or Benavente and Lauterbach, 2008). A less optimistic picture is drawn by Klette and Forre (1998) in their study on a panel of Norwegian manufacturing plants which is unable to discover any straightforward positive relationship between innovation and net job creation.

More recently, Community Innovation Surveys (CIS) became subject of similar analyses. In contrast to firm panels, these Surveys are representative of the overall economy and harmonized with renders them comparable across countries. Moreover, unlike most of the above-cited studies which almost exclusively focus on the manufacturing sector, Community Innovation Surveys are not confined to the manufacturing sector and therefore account for the increasing importance of business R&D and innovation reported for the service sector (Sirilli and Evangelista, 1998; Evangelista, 2000). Empirical results underscore the importance of product innovations in stimulating employment. Whether the expected employment effect of product innovations differs by employees' skill-level is addressed by Falk (1999) who focuses on West German innovators as covered by the 2nd Community Innovation Survey. He concludes that firstly, university graduates experience the strongest employment growth in response to the implementation of product innovations and that secondly, irrespective of employees' skill-level, the joint implementation of new products and processes results in higher overall employment growth as compared to the implementation of either product or process innovations only.

First evidence on the effect innovation has on employment in the service sector is provided by Evangelista and Savona (2003) and Jaumandreu (2003). Specifically, Evangelista and Savona (2003) use information collected by the Italian Innovation Survey and show that firms which introduce service innovations are more likely to undergo positive employment changes. They also demonstrate that the effect differs by employees' skill-levels as product innovations are more likely to stimulate employment of highly skilled employees while no significant employment effect emerges for low-skilled employees. Moreover, Jaumandreu (2003) develops a production-function framework which allows him to disentangle the labor displacement and compensation effects of innovations. His analysis which is based on the 3rd Spanish Community Innovation Survey highlights that product innovations generate positive net employment effects in both the manufacturing and service sectors.

Similar analyses were conducted by Harrison et al. (2005) and Peters (2004) which also rest on the methodology developed by Jaumandreu (2003). Specifically, Harrison et al. (2005) take a multi-country approach to identify and compare innovation-related employment effects of four of the largest European economies: France, Germany, Spain and the UK. They stress that while, in general, product innovations are associated with positive net employment effects in both the manufacturing and service sector, interesting cross-country and cross-sectoral differences emerge: Firstly, product innovations appear to have the strongest role in stimulating employment growth in Germany and secondly, employment effects are generally not stronger in the manufacturing sector. Instead, the service sectors of France and the UK experience higher innovation-related employment growth while more pronounced effects become apparent in the manufacturing sectors of Germany and Spain.

That employment effects may differ by the degree of novelty of product innovations is taken up by Peters (2004). Specifically, she seeks to identify in how far the introduction of market novelties, as compared to the introduction of firm novelties only, is related to more pronounced employment effects. The analysis uses the 3rd German Community Innovation Survey and shows that the degree of novelty of the product innovation hardly matters since in both the manufacturing and service sectors alike employment effects are positive but not significantly different from each other.

And that technological leadership matters little is suggested by the findings of Meriküll (2008). She applies the 3rd and 4th Community Innovation Surveys for Estonia and highlights that even for a technologically lagging economy like Estonia product innovations are associated with positive overall employment effects.

In contrast, however, results are mixed and less clear-cut for employment effects of *process innovations*. Specifically, positive effects are found by Smolny (1998), Lachenmaier and Rottmann (2006) and Becker and Egger (2007) for West German firms or Garcia et al. (2002) for a set of Spanish firms. A negative employment effect is identified by Ross and Zimmermann (1993) for German manufacturing firms. Finally, Van Reenen (1997) for UK manufacturing firms, Rottmann and Ruschinski (1998) for West German firms, Hall et al. (2007) for a panel of Italian firms and Benavente and Lauterbach for Chilean firms find no significant effect of process innovations on firm-level employment at all.

Moreover, CIS-based analyses reach similar mixed conclusions. That process innovations lead to the loss of employment in German manufacturing but remains insignificant in German services is highlighted by Peters (2004). Furthermore, she also takes into account that process innovations are introduced for various reasons, potentially entailing very different employment effects. Specifically, the employment effects of two different types of process innovations are analyzed: process innovation intended to reduce production costs – so called rationalization innovations - on the one hand, and process innovations intended to improve product quality, increase production capacity or to reduce personnel costs, on the other. The results highlight that only manufacturing firms which introduced process innovations for rationalization purposes significantly reduced employment while no such effect is apparent for service firms.

Finally, no significant effects are found by Harrison et al. (2008) for France, Germany and the UK and Meriküll (2008) for Estonia while slightly positive employment effects of process innovations emerge in Spanish manufacturing (Harrison et al., 2008).

However, in contrast to comprehensive empirical evidence on the employment effects of both product and process innovations, only very few studies have examined the likely effect the implementation of non-technological *organizational innovations* has on firm-level employment. This can partly be traced back to the fact that no clear or uniform definition exists of what organizational innovations really are or how to best quantify their effects on output, productivity or employment.

Greenan (1995) provides an early contribution to the discussion and stresses that labor-saving organizational innovations tend to have positive employment effects only if they are introduced together with technological process innovations.

Recently, Evangelista and Vezzani (2010) used the fourth Community Innovation Survey for a pool of countries including the Czech Republic, Spain, France, Italy, Portugal and Slovenia to demonstrate that the introduction of new or improved organizational practices intended to bring about efficiency and quality improvements stimulates employment. Hence, activities affected or modified by organizational innovations tend to become more labor intensive. Moreover, the effect is stronger in the manufacturing sector. However, if introduced together with productivity-enhancing process innovations, organizational innovations appear to have a labor-saving effect in the manufacturing sector only.

The service sector is center-stage in the study conducted by Falk (2001) who stresses that German service firms which adopted new organizational practices like total quality management (TQM) systems, certified ISO 9000, lean administration, flatter hierarchies, delegation of authority and ICT-enabled organizational changes grew three percent points faster than non-adopters. Moreover, no discernible differences can be identified across the different new organizational practices analyzed.

3. Model

Following Jaumandreu (2003), a firm can produce two different types of products: an old or only marginally modified or improved product – labeled *'old product'* - as well as a new or significantly improved product – labeled *'new product'*. The output of the old product is denoted by Y_{1t} while the output of the new product is denoted by Y_{2t} .

Firms are observed at two points in time, at the beginning of the period ($t = 1$) as well as at the end of the period ($t = 2$). At the beginning of the period, all products are old products and in the course of the period the firm decides whether to introduce a new product. Each type of product is produced with an identical constant-returns-to-scale production technology

$$Y_{it} = \theta_{it} F(K_{it}, L_{it}, M_{it}) \qquad \text{with } i = 1, 2 \text{ and } t = 1, 2, \qquad (1)$$

where θ_{it} represents an efficiency parameter which captures productivity improvements of all inputs used, K_{it} refers to capital, L_{it} stands for labor and M_{it} denotes materials. Production efficiencies θ_{it} of either type of product are variable over time and change should the firm decide to invest in and implement productivity-enhancing process or organizational innovations. Generally, production efficiencies of old and new products can differ in that new products may be produced more efficiently than old products such that $\theta_{2t} > \theta_{1t}$, or vice versa such that $\theta_{2t} < \theta_{1t}$.

These production functions for old and new products correspond to the following cost functions at time t:

$$C(w_{1t}, w_{2t}, Y_{1t}, Y_{2t}, \theta_{1t}, \theta_{2t}) = c(w_{1t})\frac{Y_{1t}}{\theta_{1t}} + c(w_{2t})\frac{Y_{2t}}{\theta_{2t}} + F , \qquad (2)$$

where $c(w_{it})$ refers to marginal costs of either old or new products while F denotes fixed costs. Applying Shepard's Lemma which states that the partial derivative of expenditure-functions with respect to the price gives the Hicksian demand function, labor demand at time t can be derived as:

$$L_{it} = c_L(w_{it})\frac{Y_{it}}{\theta_{it}} , \qquad (3)$$

where $c_L(w_{it})$ is the derivative of marginal costs with respect to wages. Hence, labor demand for the production of either old or new products is higher the higher the product's output Y_{it} and the lower the product's production efficiency θ_{it}.

Employment growth over the entire period is defined as follows

$$\frac{\Delta L}{L} = \frac{\Delta L_1 + \Delta L_2}{L_1} = \frac{L_{12} - L_{11}}{L_{11}} + \frac{L_{22} - L_{21}}{L_{11}} = \frac{L_{12} - L_{11}}{L_{11}} + \frac{L_{22}}{L_{11}} , \qquad (4)$$

as the sum of employment growth due to the production of the old product and of employment growth due to the production of the new product. Since production of the new product only commences in the course of the period but is still zero at the beginning of the period, labor demand at $t = 1$ is $L_{21} = 0$.

As outlined above, production efficiencies of old products θ_1 are not constant but are subject to change. Specifically, overall efficiency changes of old products $\Delta\theta_1$ either result from efficiency changes due to process innovations $\Delta\delta_1$ or from efficiency changes due to non-technological organizational innovations $\Delta\omega$, so that $\Delta\theta_1 = \Delta\delta_1 + \Delta\omega$. Together with constant wages w, and $L_{11} = c_L(w)\frac{Y_1}{\theta_1}$ denoting employment for the production of the old product at the beginning of the period, $L_{12} = c_L(w)\frac{Y_1 + \Delta Y_1}{\theta_1 + \Delta\theta_1}$ denoting employment for the production of the old product at the end of the period and $L_{22} = c_L(w)\frac{Y_2}{\theta_2}$ denoting employment for the production of the new product at the end of the period, equation (4) then becomes:

$$\frac{\Delta L}{L} = \left(\frac{Y_1 + \Delta Y_1}{\theta_1 + \Delta\theta_1}\right)\left(\frac{\theta_1}{Y_1}\right) - 1 + \frac{Y_2}{Y_1}\frac{\theta_1}{\theta_2} \cong \underbrace{-\frac{\Delta\delta_1}{\theta_1}}_{1} \underbrace{-\frac{\Delta\omega}{\theta_1}}_{2} + \underbrace{\frac{\Delta Y_1}{Y_1}}_{3} + \underbrace{\left(\frac{Y_2}{Y_1}\right)\left(\frac{\theta_1}{\theta_2}\right)}_{4}. \quad (5)$$

Hence, with constant input prices, employment changes are the result of four forces: 1) the change in the production efficiency in the production of the *old product* stemming from process innovations, 2) the change in the production efficiency in the production of the *old product* arising from organizational innovations, 3) the change in the output of the *old product* and 4) the relative output and efficiency of the *new product* (relative to the old product).

Improvements in the production efficiency of old products result from both newly implemented process innovations as well as organizational change in terms of new or improved routines and practices. However, efficiency improvements in the production of old products not only accrue to firms which actually implement process and organizational innovations in their production processes but also arise to firms which abstain from adopting such innovations at all. But any such efficiency improvements are expected to be higher for process and organizational innovators while efficiency gains of non-process/organizational innovators are expected to be more moderate, predominantly resulting from exogenous technological change, learning-by-doing or spillover effects.

Moreover, the employment effect of the production of new products depends on the relative efficiencies of producing old and new products. And if the production efficiency of the new product θ_2 is higher than the production efficiency of the old product θ_1, so that $(\theta_1/\theta_2) < 1$, then a labor-displacement effect emerges and employment does not grow one-for-one with output growth accounted for by the new product.

Equation (5) then translates into the following econometric specification:

$$l = \alpha_0 + \alpha_1 d_p + \alpha_2 d_o + y_1 + \beta y_2 + u, \quad (6)$$

where:

l refers to the employment growth rate,
α_1 denotes the average efficiency growth of process innovators,
d_p is a dummy variable for process innovations,
α_2 denotes the average efficiency growth of organizational innovators,
d_o is a dummy variable for organizational innovations,
y_1 refers to real output growth due to old products,

β captures the relative efficiency of the production of old and new products,

y_2 refers to real output growth due to new products and

u is an error term with $E(u \mid d_p, d_o, y_1, y_2) = 0$.

However, real output growth is not observable in the data but instead needs to be approximated with nominal sales growth. Additionally, observed nominal sales growth is split up into nominal sales growth due to the old product (g_1) and into nominal sales growth due to the new product (g_2). Furthermore, with π_1 denoting price variations of the old product, nominal sales growth of the old product is approximately $g_1 = y_1 + \pi_1$. Moreover, denoting $\pi_2 = \frac{p_2 - p_1}{p_1}$ as the proportional difference of prices of new products with respect to the old prices, sales growth of new products becomes approximately $g_2 = y_2 + \pi_2 y_2$. Substituting g_1 and g_2 for y_1 and y_2 in equation (6) gives

$$l - g_1 = \alpha_0 + \alpha_1 d_p + \alpha_2 d_o + \beta g_2 + \upsilon . \tag{7}$$

$l - g_1$ refers to total employment growth minus growth of nominal sales of unchanged products,

β captures the relative efficiency of the production of *old* and *new* products,

g_2 refers to sales growth of *new* products and

υ is an error term with $E(\pi_2 \mid y_2) = 0$.

All other variables (α_1, d_p, α_2 and d_o) are as specified in equation (6).[2]

Equation (7) then provides the net employment effect of product, process and organizational innovations.

However, the estimation of equation (7) is plagued by two issues. Firstly, an endogeneity problem is present since sales growth of new products g_2 is correlated with the error term υ. To address this problem, an instrumental variable (IV) approach is applied which will guarantee that estimators are unbiased. Potential instruments for the endogenous variable must be related to sales growth of new products but unrelated to the error term. Several candidates were taken into account and based on Sargan-Hansen overidentification tests the following sets of instruments were used: *new to market* (as the market share of goods and services introduced during 2002 and 2004 that were new to the firm's market), *R&D intensity* (as the ratio of total (intramural and extramural) R&D expenditures to firm turnover in 2004.), *patent* (a dummy which takes the value 1 if the firm applied for a patent between 2002 and 2004) and *science* (a dummy which is 1 if institutional sources like universities or other higher education institutions or government or public research institutes were of 'high'

2 For information on the variables' definitions please refer to the Appendix.

or ‘medium’ importance as sources of information for a firm’s innovation activities) for analyses of the manufacturing sector. Moreover, *new to market*, *patent* and *continuous innovator* (a dummy which is 1 if the firm reported continuous R&D activities during 2002 and 2004) were applied as instruments in the analyses of the service sector.

Secondly, an identification problem arises since firm-level price changes are unobservable in the dataset and therefore incorporated in the error term υ. To remedy this identification problem and to control for firm-level price changes, country-specific disaggregated 2-digit industry-level price indices $\tilde{\pi}_1$ are included in the analysis. Hence, the dependent variable then becomes $l-(g_1-\tilde{\pi}_1)$, which captures total employment growth minus real sales growth of unchanged products, instead of $l-g_1$ (from equation (7)) which refers to total employment growth minus growth of nominal sales of unchanged products. Provided that price changes at the firm level do not deviate much from sectoral averages, this then allows for the identification of the average gross real productivity effect. The analysis pursued in section 5 will focus on total employment growth minus real sales growth of unchanged products ($l-(g_1-\tilde{\pi}_1)$) only.

4. Data

The analysis uses the fourth wave of the Community Innovation Survey (CIS-4), covering the three-year period from 2002 to 2004. Generally, the Community Innovation Survey is a harmonized and periodic survey designed to monitor firms’ innovative activities, progress or obstacles over a pre-specified period and covers product and process innovations.

Moreover, the CIS-4 also collects more detailed information on non-technological innovations like organizational and marketing innovations. Specifically, *organizational innovations* refer to (i) new or significantly improved knowledge management systems aimed at better using or exchanging information, knowledge and skills, to (ii) major changes to the organization of work such as changes in management structures and to (iii) new or significant changes in the firm’s external relations through alliances, partnerships, outsourcing or subcontracting. *Marketing innovations*, on the other hand, capture either significant changes to the design or packaging of goods and/or services, or new or significant changes in sales or distribution methods. Additionally, for organizational innovations, also their effects are determined in terms of reducing the response time to customer and supplier needs, improving the quality of goods or services, reducing costs per unit of output and improving employee satisfaction and/or reducing employee turnover.

The Fourth Community Innovation Survey was carried out in 25 EU-Member States, some EU-candidate countries as well as Iceland and Norway. It was made available for scientific research at the EUROSTAT Safe Center in Luxembourg by 18 participating countries.

In order to avoid that results are distorted by outliers (like new entrants) and to guarantee comparability across country micro-data the analysis is restricted to incumbent firms only which were established before 2002 and excludes all firms with less than 15 employees. Furthermore, it focuses on the manufacturing sector (NACE 15-37) and the service sector (NACE 51-74) but excludes the mining and quarrying sector (NACE 10-14) which is comparatively small and of little significance in terms of the degree of technological innovativeness and change.

As for the growth rate of prices, corresponding to the industry classifications and industry-groups used, two-digit industry-level price indices were applied. These were taken from the EU KLEMS database which provides comparable price indices across countries. However, no price indices were available for Bulgaria, Iceland, Norway and Romania which were therefore left out from the analysis. The ensuing analysis uses these anonymized micro-level data sets for 14 countries.

Table 1

Overall sample

	Non-innovators	Innovators	Total	Non-innovators (in %)	Innovators (in %)
CENTRAL AND EASTERN EUROPE (CEEC)					
Czech Republic	2,844	2,178	5,022	56.6	43.4
Estonia	602	722	1,324	45.5	54.5
Hungary	2,054	813	2,867	71.6	28.4
Latvia	1,515	265	1,780	85.1	14.9
Slovenia	934	537	1,471	63.5	36.5
Slovakia	1,290	669	1,959	6.6	34.2
Total	**9,239**	**5,184**	**14,423**	**64.1**	**35.9**
SOUTHERN EUROPE (SOUTH)					
Spain	7,491	6,951	14,442	51.9	48.1
Greece	61	289	350	17.4	82.6
Italy	9,823	5,053	14,876	66.0	34.0
Portugal	1,875	1,754	3,629	51.7	48.3
Total	**19,250**	**14,047**	**33,297**	**57.8**	**42.2**
CORE EUROPE (CORE)					
Denmark	0	690	690	0.0	100.0
France	10,086	7,731	17,817	56.6	43.4
Luxembourg	179	262	441	40.6	59.4
Sweden	933	1,348	2,281	40.9	59.1
Total	**11,198**	**10,031**	**21,229**	**52.7**	**47.3**
Overall sample (ALL)	***39,687***	***29,262***	***68,949***	***57.6***	***42.4***

Note: an innovator is a firm that either successfully introduced a new or improved product or process, had still ongoing innovative activities or had to abandon its innovative activities during the respective survey period (2002-2004).

Source: EUROSTAT

All in all, the analysis covers about 69,000 firms operating in 14 different European countries, including six Central and Eastern European transition countries (the Czech Republic, Estonia, Hungary, Latvia, Slovenia and Slovakia which joined the EU in 2004), four Southern EU-member states (Spain, Greece, Italy and Portugal) and four Core European countries (Denmark, France, Luxembourg and Sweden). More specifically, in terms of regional distribution, some 14,400 firms (or 21 percent of the overall sample analyzed) were located in the eight Central and Eastern European transition countries, another 33,300 firms (or 48 percent of the overall sample) were located in the four Southern EU-member states, while 21,200 firms (or 31 percent of the overall sample) were based in the six Core European countries (Table 1).

Approximately 42 percent of all firms analyzed were innovators in the sense that they have either successfully introduced a new or improved product or process, had still ongoing innovative activities or had to abandon their innovative activities during the 2002-2004 survey period. The prevalence of innovators differs partly substantially across regions and countries analyzed: only about 36 percent of firms located in the New Member States of Central and Eastern Europe conducted any innovative activities while 42 percent and 47 percent of all firms operating in Southern Europe and Core Europe, respectively, pursued any innovative activities.

5. Results

Empirical results for the employment effects of different types of innovations are presented in Table 2 below for both the manufacturing and service sectors for the overall pool of countries as well as for three more homogeneous country-groups, applying an Instrumental Variable (IV) approach. All estimations were also repeated applying the General Method of Moments (GMM) technique which guarantees that, if heteroskedasticity is present, efficient estimates can be obtained. Results, which are qualitatively comparable to the ones based on the IV approach, are presented in Table 3 in the Appendix.

5.1 Overall pool of countries

Generally, the analysis of the overall pool of countries provides robust and consistent evidence that the successful introduction of a *new product* on a firm's market has positive employment effects, in both manufacturing and services sectors. Hence, the additional demand created by the new product leads to the expansion of the firm's production (and market) and, consequently, to higher employment. Moreover, all coefficients are smaller than one, suggesting that new products are produced more efficiently than old ones. And this productivity-induced labor-saving effect results in employment to grow less than one-for-one with growth of sales accounted for by new products. Interestingly though, any employment effects appear to be slightly higher – though not significantly - for the service sector which indicates that productivity improvements in the production of new products are lower in the service sector than in the manufacturing sector.

Table 2

Effects of product and process innovations on employment in Manufacturing and Services, by country-groups

	Manufacturing				Services			
Country group	ALL	CEEC	CORE	SOUTH	ALL	CEEC	CORE	SOUTH
Method	IV	IV	IV	IV	IV	IV	IV	IV
Dependent variable	$l-(g_1-\tilde{\pi}_1)$				$l-(g_1-\tilde{\pi}_1)$			
Sales growth - new products	0.621	0.624	0.455	0.661	0.691	0.911	0.888	0.418
	(7.60)***	(5.25)***	(2.01)**	(5.53)***	(8.52)***	(4.95)***	(5.82)***	(3.75)***
Process innovations only	2.397	3.164	-0.525	3.832	1.668	3.442	-0.677	3.382
	(3.76)***	(1.90)*	(0.52)	(4.57)***	(1.73)*	(1.41)	(0.48)	(2.17)**
Process and product innovations	-5.193	-7.453	-1.272	-6.565	-5.896	-9.302	-1.487	-10.041
	(8.32)***	(5.12)***	(1.39)	(7.36)***	(5.88)***	(3.89)***	(1.01)	(5.93)***
Organizational innovations	-1.197	-1.876	-0.904	-0.850	0.502	0.549	-0.475	1.874
	(2.62)***	(1.79)*	(1.25)	(1.32)	(0.71)	(0.36)	(0.45)	(1.57)
No. of observations	25,809	7,502	7,006	11,301	17,083	3,798	7,336	5,949
Sargan test	6.172	14.442	3.572	5.709	0.157	1.623	0.0252	4.663
degrees of freedom	(3)	(3)	(3)	(3)	(2)	(2)	(2)	(2)
p-value	0.1035	0.0024	0.3115	0.1267	0.9246	0.4442	0.0252	0.0972

Notes: All specifications for the manufacturing sector use new to the market, R&D intensity, patent, science as instruments while all specifications for the service sector use new to the market, patent and continuous innovator as instruments. Country and industry dummies are included in all specifications.

The pooled sample (ALL) consists of the Czech Republic, Denmark, Estonia, France, Greece, Hungary, Italy, Latvia, Luxembourg, Portugal, Slovenia, Slovakia, Spain and Sweden.

Central and Eastern European transition countries (CEEC) comprise the Czech Republic, Estonia, Hungary, Latvia, Slovenia and Slovakia.

The group of Core European countries (CORE) comprises Denmark, France, Luxembourg and Sweden.

Southern European countries (SOUTH) comprise Greece, Italy, Portugal and Spain.

Country and industry dummies are included in all regressions.

Absolute value of t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Moreover, the analysis sheds light on the employment effects associated with the introduction of *process innovations,* either in terms of (i) new or significantly improved methods of manufacturing or producing goods and services, of (ii) new or significantly improved logistics, delivery or distribution methods for inputs, goods or services or in terms of (iii) new or significantly improved supporting activities for processes. These observable process innovations may be associated with both old as well as new products. However, the model outlined above explicitly highlights the role of old products only to have relevant employment effects. Therefore, the overall group of process innovators was split up into one group comprising process innovators only and one group comprising product and process innovators. Hence, employment effects of process innovations are determined separately as a response to the implementation of *process innovations (of old products) only* on the one hand and as a response to the implementation of *both product and process innovations (of old and new products)*, on the other.

The results highlight that, on average, firms in both manufacturing and service sectors which introduced *process innovations only* grew and significantly expanded their labor forces, while firms which introduced both *process and product innovations jointly* drastically reduced employment. The strong employment compensation effect observable for process innovators only is indicative of a strong cost-reduction effect of process innovations that was passed on to lower output prices. This, in turn, stimulated the demand for old products and, consequently, employment in order to satisfy the resulting increase in demand. Generally, positive employment effects of *process innovations only* appear to be stronger in the manufacturing sector which might reflect that fiercer competition on markets for manufacturing commodities induced manufacturing firms to pass a higher fraction of cost reductions on to output prices.

Additionally, theoretical analyses and empirical evidence emphasize that process and product innovations tend to be complementary and therefore implemented jointly in order to exploit emerging synergy effects, minimize associated adjustment costs and maximize/optimize profits (Damanpour and Gopalakrishnan, 2001; Mantovani, 2006). The findings highlight that *jointly implemented product and process innovations* entail sizeable displacement effects and lead to substantial employment reductions. Observable displacement effects are slightly stronger in the service sector which, in contrast to the manufacturing sector, suffered higher employment losses due to the joint introduction of both product and process innovations.

Finally, the analysis also accounts for potential employment effects associated with *organizational innovations* in terms of either (i) new or significantly improved knowledge management systems, (ii) major changes to the organization of work or (iii) new or significant changes in the relations with other firms or public institutions. Apparently, in the manufacturing sector, organizational innovations entail significant employment displacement effects as firms tend to reduce employment in the course of the implementation of strategic reorganization measures. In contrast, no significant employment effects emerge in the service sector which implies that service firms implement organizational innovations without major lay-offs.

However, these findings refer to a very heterogeneous pool of economies, including countries with very diverse levels of economic or technological development. Hence, dynamics and specificities of individual countries or more homogeneous country-groups may remain obscured. Therefore, to unveil any hidden effects or dynamics, all sector specific analyses were also conducted for the following three more homogeneous groups of countries: 1) technologically and economically lagging Central and Eastern European transition countries, (2) economically lagging Southern EU-member countries and, (3) economically more advanced Core European countries. The results are discussed in subsection 5.2.

5.2 By regions

A cross-regional comparison of innovation-induced employment effects consistently demonstrates that successfully introduced product novelties entail positive employment effects, irrespective of sector considered. Except for the South, these effects tend to be stronger in the service sector which therefore benefited more from product innovations by generating more employment opportunities. Moreover, the elasticity of employment with respect to sales growth of new products is close to one in the service sectors of Central and Eastern European transition countries and of Core European countries. This indicates that old and new products were produced with similar efficiency levels so that employment in the service sectors of all Central and Eastern European transition countries and Core European countries analyzed grew by almost one-to-one with sales growth of new products. In contrast, more moderate employment expansions are associated with sales growth of new products in the groups' manufacturing sectors which implies that new manufacturing products were produced considerably more efficiently than old ones which then translated into employment growth in the manufacturing sector to substantially lag behind sales growth of new products.

Additionally, interesting cross-country and sectoral differences are revealed once employment effects of process innovations are analyzed. Specifically, process innovators located in Southern European countries which successfully introduced *process innovations only* considerably expanded employment in both the manufacturing and service sectors. This effect appears to be slightly stronger in the manufacturing sector which suggests that possibly due to fiercer competition in the market for manufacturing goods a stronger pass-through mechanism of productivity improvements to cost-reductions and to reductions in output prices prevailed. This in turn rendered products more attractive and strongly stimulated demand and employment. Moreover, sector-specific employment responses to the introduction of process innovations only are apparent in Central and Eastern European transition countries. Specifically, while successful process-only innovators operating in the manufacturing sector considerably expanded their workforces, no significant employment effects were observable in the service sector. However, the results for Central and Eastern European transition countries and Southern European countries stand in stark contrast to findings for Core European countries where, irrespective of sector considered, employment remained unresponsive to the introduction of process innovations only. Hence, unlike in the other two groups considered, process innovations only were unable to generate any additional employment opportunities in Core European countries. This, in turn, indicates that any labor compensation effects emanating from higher labor demand in response to lower output prices is exactly compensated by any labor displacement effects resulting from a change in the input-factor requirements associated with newly implemented processes.

In contrast, however, firms which introduced *both process and product innovations* jointly drastically reduced their workforces. Hence, firms which introduce both types of innovations jointly were able to save labor. This labor-saving or labor displacement effect tends to be stronger in the service sector which suffered more pronounced innovation-induced employment losses. Interestingly, a comparison highlights that these negative employment effects emerge for Central and Eastern European transition countries and Southern European countries only while, in contrast, employment in Core European countries is unaffected by the simultaneous introduction of process and product innovations. Hence, Core European countries did not experience any destruction of employment due to jointly introduced process and product innovations.

Finally, the analysis also sheds light on potential employment effects associated with the introduction of *organizational innovations.* As outlined above, organizational innovations are either intended to (i) improve prevailing internal knowledge management systems, (ii) to modify the firm's organization of work or (iii) to change external relations with other firms or institutions. The findings demonstrate that except for the manufacturing sectors of Central and Eastern European transition countries which suffered non-negligible employment losses, no employment effects emerge in conjunction with organizational restructuring measures of firms. This is good news for employment in either manufacturing or service sectors of South European or Core European countries which remained unaffected by the implementation of organizational innovations. These marked differences in employment responses across country-groups and sectors can be traced back to the very nature of the different organizational innovations covered by the general indicator 'organizational innovations' and the labor and capital saving effects they each entail. Specifically, (managerial) organizational innovations like (i) improved knowledge management systems intended to ease the use and exchange of information, knowledge and skills within a firm tend to increase labor productivity and, consequently, save labor which leads to major personnel cut-backs. Additionally, (relational) organizational innovations in terms of (iii) changes in external relations with other firms or organizations through, for example, outsourcing or subcontracting tend to destroy jobs and reduce employment. In contrast, organizational innovations in terms of (ii) a reorganization of work are likely to enhance capital productivity only, leaving labor productivity and labor demand unaffected. Hence, above results may indicate that manufacturing firms located in Central and Eastern European countries predominantly implemented labor-saving managerial and relational organizational innovations while capital-saving innovations which modify the organization of work dominated in firms located in Southern European countries and Core European countries.

6. Summary and conclusion

Theoretically, technological change has all the potentials to create, but more worryingly, to also destroy employment. Empirical evidence seems to suggest that, in the long run, aggregate employment benefits from technological change. However, short-run employment responses at the firm-level are still less well known, a shortcoming this study seeks to remedy. Specifically, this analysis seeks to indentify the employment effects of different types of innovation in the manufacturing and service sectors of three specific country-groups within the European Union. It uses the 4th Community Innovation Survey covering the period 2002 to 2004 for a set of 14 countries including six economically and technologically lagging Central and Eastern European transition countries which joined the EU in 2004 (the Czech Republic, Estonia, Hungary, Latvia, Slovenia and Slovakia), four economically lagging Southern EU-member states (Spain, Greece, Italy and Portugal) and four economically and technologically more advanced Core European countries (Denmark, France, Luxembourg and Sweden).

Generally, empirical findings reveal interesting and diverse innovation-induced employment responses that differ partly greatly across sectors or country-groups considered. The results consistently demonstrate that, irrespective of country-group or sector considered, the successful introduction of *product novelties* stimulates employment. Hence, firms expand their workforces as demand for and production of their new product increases. Moreover, except for the Southern EU-member states, this effect tends to be stronger in the service sector which is indicative of less pronounced efficiency improvements in the production of new service products.

In contrast, however, employment effects are mixed and less clear-cut in response to either newly implemented process innovations or non-technological organizational innovations. Specifically, sizeable positive employment effects emerge in both manufacturing and service sectors of Southern European countries in conjunction with the introduction of *process innovations only*. Similar positive effects are apparent in the manufacturing sector of Central and Eastern European transition countries while no such effect exists for these countries' service sectors. All in all, these findings suggest that a strong pass-through mechanism of productivity improvements to cost-reductions and to reductions in output prices prevailed in these two country-groups. This, in turn, rendered new products more affordable and attractive, strongly stimulated demand, production and, consequently, employment. In contrast, however, process innovations only were unable to stimulate employment in either sector in Core European countries.

However, firms which introduced *both process and product innovations* jointly were able to save labor and to drastically reduced their workforces. These effects again only emerge for both sectors in Central and Eastern European transition countries and Southern European countries while, in contrast, Core European countries did not experience any destruction of employment due to jointly introduced process and product innovations.

Finally, *organizational innovations* turn out to be detrimental to employment in the manufacturing sector of Central and Eastern European countries only which suffered non-negligible employment losses. In contrast, employment appears to be unresponsive to organizational change in both sectors of Southern European EU-member countries and Core European countries. The losses of employment observed in the manufacturing sector of Central and Eastern European transition countries may result from the widespread implementation of labor-saving managerial organizational innovations like improved knowledge management systems intended to ease the use and exchange of information, knowledge and skills or relational organizational innovations intended to modify external relations with other firms or organizations via, for example, outsourcing or subcontracting which tend to destroy jobs. On the other hand, capital-saving organizational innovations appear to have dominated organizational innovations in Southern European countries and Core European countries, leaving employment unaffected in both sectors.

All in all, the results emphasize that different types of innovation trigger similar employment effects in both sectors of Central and Eastern European transition countries and Southern European countries, partly creating, partly destroying employment. In Core European countries, however, employment only reacts to successfully introduced product innovations while process innovations or non-technological organizational innovations entail no net employment effect whatsoever.

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8. Appendix

8.1 Regressors

New products – sales growth: Rate of change of a firm's turnover due to newly introduced products.

Process innovations: Dummy which is 1 if the firm introduced either new or significantly improved methods of manufacturing or producing goods and services, new or significantly improved logistics, delivery or distribution methods for inputs, goods or services or new or significantly improved supporting activities for processes, such as maintenance systems or operations for purchasing, accounting, or computing.

Process innovations only: Dummy which is 1 if the firm implemented a process innovation only.

Product and process innovations: Dummy which is 1 if the firm implemented both product and process innovations.

Organizational innovations: Dummy which is 1 if the firm introduced either new or significantly improved knowledge management systems, a major change to the organization of work or new or significant changes in the relations with other firms or public institutions.

Country dummies: Czech Republic, Denmark, Estonia, France, Greece, Hungary, Italy, Latvia, Luxembourg, Portugal, Slovenia, Slovakia, Spain, Sweden.

Industry dummies:

15-37	MANUFACTURING
15-16	Food products; beverages and tobacco
17-19	Textiles and textile products; manufacture of leather and leather products
20-22	Wood and wood products, manufacture of pulp, paper and paper products, publishing and printing
23-24	Coke, refined petroleum products and nuclear fuel; chemicals, chemical products and man-made fibres
25-26	Rubber and plastic; other non-metallic mineral products
27-28	Basic metals; fabricated metal products, except machinery and equipment
29	Machinery and equipment n.e.c
30-33	Office machinery and computers; electrical machinery and apparatus n.e.c; radio, television and communication equipment and apparatus; medical, precision and optical instruments, watches and clocks
34-35	Motor vehicles, trailers and semi-trailers; other transport equipment
36-37	Furniture; manufacturing n.e.c; Recycling
51-74	SERVICES
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
60-63	Transport; Supporting and auxiliary transport activities
64	Post and telecommunications
65-67	Banking and insurance
72	Computer and related activities
73	Research and Development
74.2	Architectural and engineering activities and related technical consultancy
74.3	Technical testing and analysis

8.2 Instruments

New to market: Market share of goods and services introduced during 2002 and 2004 that were new to the firm's market.

Patent: Dummy which is 1 if the firm applied for a patent between 2002 and 2004.

Science: Dummy which is 1 if institutional sources like universities or other higher education institutions or government or public research institutes were of 'high' or 'medium' importance as sources of information for a firm's innovation activities.

R&D intensity: Ratio of total (intramural and extramural) R&D expenditures to firm turnover in 2004.

Continuous innovator: Dummy which is 1 if, during 2002 and 2004, the firm performed R&D continuously.

Table 3

Effects of product and process innovations on employment in Manufacturing and Services, by country-groups (GMM)

	Manufacturing				Services			
Country group	ALL	CEEC	CORE	SOUTH	ALL	CEEC	CORE	SOUTH
Method	GMM	GMM	GMM	GMM	GMM	GMM	GMM	GMM
Dependent variable	$l-(g_1-\tilde{\pi}_1)$				$l-(g_1-\tilde{\pi}_1)$			
Sales growth - new products	0.632	0.655	0.409	0.664	0.695	0.903	0.904	0.431
	(8.09)***	(6.41)***	(2.16)**	(5.41)***	(7.23)***	(4.43)***	(4.70)***	(3.42)***
Process innovations only	2.355	2.801	-0.540	3.803	1.664	3.156	-0.900	3.436
	(3.61)***	(1.57)	(0.49)	(4.51)***	(1.78)*	(1.25)	(0.69)	(2.25)**
Process and product innovations	-5.222	-7.657	-1.347	-6.590	-5.919	-9.388	-1.495	-10.182
	(8.63)***	(5.70)***	(1.58)	(7.06)***	(5.79)***	(3.84)***	(1.03)	(5.69)***
Organizational innovations	-1.199	-2.066	-0.837	-0.873	0.506	0.521	-0.480	1.842
	(2.58)***	(1.99)**	(1.15)	(1.29)	(0.72)	(0.34)	(0.45)	(1.54)
No. of observations	25,809	7,502	7,006	11,301	17,083	3,798	7,336	5,949
Hansen J-test p-value	5.219	3.985	4.107	5.272	0.137	1.878	8.332	4.300
degrees of freedom	(3)	(3)	(3)	(3)	(2)	(2)	(2)	(2)
p-value	0.1565	0.2631	0.2502	0.1530	0.9339	0.3910	0.0155	0.1165

Notes: All specifications for the manufacturing sector use new to the market, R&D intensity, patent, science as instruments while all specifications for the service sector use new to the market, patent and continuous innovator as instruments. Country and industry dummies are included in all specifications.

The pooled sample (ALL) consists of the Czech Republic, Denmark, Estonia, France, Greece, Hungary, Italy, Latvia, Luxembourg, Portugal, Slovenia, Slovakia, Spain and Sweden.

Central and Eastern European transition countries (CEEC) comprise the Czech Republic, Estonia, Hungary, Latvia, Slovenia and Slovakia.

The group of Core European countries (CORE) comprises Denmark, France, Luxembourg and Sweden.

Southern European countries (SOUTH) comprise Greece, Italy, Portugal and Spain.

Country and industry dummies are included in all regressions.

Absolute value of t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

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P.b.b. Verlagspostamt 1060 Wien