Employment Effects of Technological and Organizational Innovations: Evidence Based on Linked Firm-Level Data for Austria

Martin Falk*
Austrian Institute of Economic Research (WIFO)

JEL O33; J23; J24; L23

technological innovations; organizational and marketing innovations; labour demand; quantile regressions; linked firm level data.

Received: 18.07.2013

Revision received: 15.04.2014

Accepted: 25.08.2014

Summary

This paper investigates the impact of technological and organizational innovations on subsequent employment growth using a standard labour demand model. The main novelty of the paper is the use of a unique dataset, which merges Community Innovation Survey (CIS) 2006 for Austria with structural business statistics from 2006-2008, resulting in 3,070 firm observations. For manufacturing firms, quantile regressions show that product innovations lagged two-years have a significantly positive but decreasing impact on employment growth over the conditional distribution given the impact of output and wage growth. For service firms, the positive employment effect of product innovations can only be observed for firms with high conditional employment growth rates. Results are robust with respect to the measurement of product innovations (e.g. market novelties or new to firm products). Process innovations exhibit a negative impact at the higher quantiles indicating that process innovations lead to an increase in labour productivity at the expense of employment. Furthermore organizational and marketing innovations do not have a significant impact on subsequent employment growth across the different quantiles.

1 Introduction

There has been ongoing discussion in the literature on the employment effects of technological and organizational innovations. While most studies find positive effects for product innovations, the results for process and organizational innovations are mixed (see Vivarelli 2014 for a recent survey and Dachs/Peters 2014, and Evangelista/Vezzani 2012 and Lachenmaier/Rottmann 2011 for recent studies). So far there is no consensus about the effects of different types of innovations on employment.

* I thank two anonymous referees for detailed and constructive comments. I would also like to thank Jessica Sloan for excellent proofreading of the manuscript. A previous version of the paper has been presented at 28th National Conference of Labour Economists (AIEL) in Rome September 2013.

In a more recent discussion several scholars suggest that the impact of technological innovations and/or R&D activities on employment growth differs between firms with shrinking and rising employment (Coad/Rao,2011; Zimmermann,2009, 2013). The majority of these studies show that the impact of innovation activities (measured either as R&D activities or innovation output) tends to increase when moving from the bottom to the top of the conditional distribution of employment growth.

This article provides further empirical evidence on the relationship between technological and non-technological innovations on labour demand. Unlike previous studies that applied the quantile regression method to the employment growth equation, this study uses the quantile regression technique applied to the standard labour demand model. In particular we investigate the effect of different types of innovations on subsequent employment growth rather than on employment growth during the same period. The data consists of the Community Innovation Survey (CIS) 2006 for Austria linked with the structural business statistics 2004 to 2008. The main focus of this research is on the effects of technological, organizational and marketing innovations on employment growth at the firm level given output and wage growth. By controlling for output change we implicitly consider the effects of technological innovations on the change in labour productivity.

This paper makes four contributions to the literature. Firstly, we use a unique dataset that links the community innovation survey with structural business statistics, where information on sales revenues, employment and wage costs is based on the latter and the remaining variables are based on CIS data. Secondly, we investigate the employment effects of technological and non technological innovations after successful introduction rather than during successful introduction. Thirdly, we investigate not only the impact of technological innovations but also that of organizational and marketing innovations on labour demand. Few studies have investigated the effects of organizational change on overall employment growth (for rare exceptions, see Bauer/Bender 2004; Bellmann 2011; Caroli/van Reenen 2001; Evangelista/Vezzani 2010, 2012; Greenan 2003). Fourthly, we investigate firm-level parameter heterogeneity in the employment effects of different types of innovation by distinguishing between service and manufacturing firms and using a quantile regression technique. Previous studies find significant differences in the impact of technological innovations between manufacturing and service firms (see Cainelli et al. 2004, 2006; Evangelista/Savona 2002, 2003, 2011). Since there are reasons to believe that even within manufacturing and services that the employment effects of innovations differ between firms with low and high employment growth rates, we use quantile regression techniques to investigate the determinants of labour demand.

This paper performs a scientific replication of the link between technological innovations and employment growth for both manufacturing and service firms. Hamermesh (2007) suggests that scientific replications are important to evaluate and assess empirical results and also crucial for scholars who are conducting a meta-analyses and/or reviews of the literature. It means re-examining an idea that is published in a refereed journal with a new or different data set. In this paper we use the standard labour demand model employed by Blechinger and Pfeiffer (1999), Lachenmaier and Rottmann (2007, 2011) and Rottmann and Ruschinski (1998) for German firm level data and apply it to Austrian firm level data. However, unlike the listed studies, except for the work of Blechinger and Pfeiffer (1999), here output and wages are firm-specific rather than industry specific.

The structure of this paper is as follows: Section 2 presents the theoretical background and the empirical model. In section 3 we present various summary statistics and the description of the data before providing the empirical results in section 4. Section 5 contains concluding remarks.

2 Theoretical background and empirical model

The theoretical literature does not offer an unambiguous prediction of the effect of technological and organizational innovations on employment. Product innovations are generally assumed to increase employment due to an increase in the demand for new products (Katsoulacos 1986; Harrison et al. 2008; Stoneman 1983). However the employment effects of process and organizational innovations are an open question.

A new product generates new demand and thereby increases output and labour demand in the case of a single product. When multiple products are produced new goods and services may replace olds goods and services and the overall output expansion effect is unclear (van Reenen 1997). Improving the range or quality of products also leads to an increase of the firm's output. However, when controlling for output growth most of the direct effects of product innovations are already captured by an increase in output. Even so, product innovations can still have an additional effect on employment growth if product innovations require a higher labour input at given output. For instance a change in the product mix towards more labour-intensive products can increase employment even when output stagnates. Unlike for process innovations the introduction of product innovations can lead to more labour intensive production.

The theoretical literature suggests that process innovations reduce the number of workers for any given output (Peters 2004, 2008). This is the so-called displacement effect. Process innovations often occur due the introduction of new machines (Edquist et al. 2001). At the same time process innovations can increase productivity and efficiency of firms. This is referred to as the compensation effect. A negative employment effect of process innovations occurs when the magnitude of the displacement effect exceeds that of the compensation effects. Process innovations can be defined widely by including not only process innovations, but also organizational process innovations whereas the former is related to the introduction of new machinery and the latter to new ways of organizing work (Edquist et al. 2001). However organizational change covers many other diverse activities, such as the adoption of new business practices, new work practices, knowledge management systems and change in external relations, such as outsourcing and contracting-out activities. It is generally accepted that changes in business practices, work practices and new human resource management systems lead to increases in productivity by reducing costs and/or improving the quality of existing products (Bresnahan et al. 1999; Ichniowski et al. 1997). In particular there is suggestive empirical evidence that certain types of human resource management practices, such as changes in work organization, raise a firm's productivity (Bloom/van Reenen 2011). Still, the implementation of new business practices can often lead to a reduction of the workforce. Outsourcing and sub-contracting are also expected to lead to cost savings because production and service activities with no comparative advantage are outsourced to external suppliers (Sharpe 2007). This may lead to a replacement of those activities previously conducted in-house and thereby reduce the number of jobs in-house.

In addition to products and process innovations there are also innovations in the marketing of goods and services. Marketing innovation as defined in the CIS consists of significant changes in product design or packaging, new techniques for product promotion, new methods for product placement or new methods of pricing (OECD Oslo Manual 2005). Unlike product or process innovation, marketing innovation has received little attention in the economic literature (Chen 2006). Marketing innovations can have a positive impact on the sales of the product. However the magnitude of the effects are likely to be small given that the product's functional or user characteristics are not affected by new marketing methods. The business literature finds that marketing capability has a stronger impact on firm performance than research and development activities (Krasnikov/Jayachandran 2008 based on a meta-analysis).

With no clear theoretical prediction, the employment effects of not only technological innovations but also organizational and marketing innovations are an empirical question. Empirical studies at the firm level using a standard labour demand model have provided strong evidence of a positive and significant impact of product innovations on employment growth (van Reenen 1997; Lachenmaier/Rottmann 2011 and Pianta 2005; Vivarelli 2014; VivarelliPianta 2000 for surveys of the literature). The employment effects of process innovations are however not clear-cut. While it is generally acknowledged that organizational change leads to an increase in the demand for skilled workers at the expense of unskilled workers (see e.g. Caroli/van Reenen 2001), the overall employment effect of organizational innovations is not clear-cut. Using firm-level CIS4 data for a number of EU countries, Evangelista and Vezzani (2012) find that organizational change has a positive impact on labour demand. Bellmann (2011) finds similar results for German establishments. More recently, based on CIS 2006 data for 15 OECD countries, Frenz and Lambert (2012) find that different types of innovations, including change in management, business strategy and new sales and distribution methods, do not reduce employment in most of the 15 countries. Using a matched employer-employee data set, Bauer and Bender (2004) find that firms introducing high performance work practices show significantly lower net employment growth rates. However, using firm level data for France, Greenan (2003) finds that organizational change does not lead to job losses.

There are two main theoretical approaches to model the employment effects of technological innovations. The first approach is based on a multi-output cost function where output is disaggregated into output due to new market products and not new to market products (i.e. old products). The corresponding labour demand equation can be derived using Shephard's Lemma. By taken first differences of the labour demand equation, employment growth can be modelled as a function of growth of turnover due to new and old products. This approach is used by Harrison et al. (2008) and Dachs and Peters (2014). This approach makes it possible to directly quantify the direct impact of the output of new products on employment. A successful introduction of new products leads to an increase in the demand for the product and thus directly increases employment (the so-called compensation effect). This demand effect can be the result of new demand or business stealing from competitors. To estimate such a model it is desirable to have information on the turnover of new products or new market products for two subsequent years. Evangelista and Vezzani (2012) introduce a related approach – a simultaneous model of employment and sales growth – where product innovations are assumed to only impact sales growth whereas the remaining types of innovations could affect both employment and sales growth.

The second approach measures the employment effects of product innovations given the impact of output. This approach has been used by Blechinger and Pfeiffer (1999) and Lachenmaier and Rottmann (2011). Using a CES cost function with two production factors, namely, labour and capital, a standard labour demand function can be derived (Hamermesh 1996). The main assumptions are perfect competition in the goods and factor markets, i.e. exogenous prices for labor and capital. Taking logs on both sides of the labour demand equation and adding an error term gives a log-linear static labour demand function where labour is a function of real wages, real output and technological change:

$$\ln L_{it} = \beta_i + \beta_1 \ln Y_{it} + \beta_2 \ln WP_{it} + \beta_3 \tau + \varepsilon_{it}$$

where i and t denote the firm and year, respectively. L denotes employment, Y real output and WP real wages, τ denotes the rate of technological change, β_i is the firm effect and ε is the error term with mean zero and assumed i.i.d. Since all variables except technological change enter the labour demand equation in logs, the coefficients can be directly interpreted as elasticities. Technological change can be measured by the introduction of product and process innovations. In addition non-technological innovations, such as organizational change and marketing innovations, can also affect employment. In order to wipe out firm effects we use a long difference specification resulting in the following short-run labour demand function:

$$\begin{aligned}\Delta \ln L_{it} &= \alpha_0 + \tilde{\beta}_1 \Delta \ln Y_{it} + \tilde{\Delta} \ln(WP)_{it} + \tilde{\beta}_3 PROD_{i,t-2} + \tilde{\beta}_4 PROC_{i,t-2} \\ &\quad + \tilde{\beta}_5 OC_{i,t-2} + \tilde{\beta} MKT_{i,t-2} + v_{it},\end{aligned}$$

where $\Delta \ln X_i = (\ln X_i - \ln X_{i,t-2})/2$ for $X = L$, Y and WP.
The new error term is defined as: $v_{it} \equiv \varepsilon_{it} - \varepsilon_{i,t-1}$, with zero mean and constant variance. Δ refers to the average annual change of the variables between 2006 and 2008. The variables are defined as follows:

$\Delta \ln L(t)$: average annual percentage change in employment between 2006 and 2008,
$\Delta \ln Y(t)$: annual average percentage change in sale revenues deflated by the industry specific gross output deflator between 2006 and 2008,
$\Delta \ln WP(t)$: average annual percentage change in the total wage costs per employee deflated by a specific value added deflator between 2006 and 2008,
$PROD(t-2)$: introduction of new or significantly improved goods and/or services between 2004 and 2006,
$PROC(t-2)$: implementation of a new or significantly improved production process, distribution method, or support activity for your goods or services between 2004 and 2006,
$OC(t-2)$: organisational innovation (e.g. business practices, knowledge management, workplace organisation or external relations) between 2004 and 2006, and
$MKT(t-2)$: a new marketing concept or strategy between 2004 and 2006.

The coefficients of technological and non technological innovations in the labour demand model can be interpreted as their impacts on the inverse of labour productivity. For instance a positive impact of β_3 means that product innovations lead to an increase in the requirement for labour at a given output change. A negative coefficient of process innovation means that less labour is required to produce a given output indicating an increase in labour productivity. When output is included in the employment equation, we measure the substitution effect between employment and process innovations rather than its direct effect.

Furthermore following the literature we assume that technological innovations affect employment growth only with a time lag. For instance, using firm level data for German manufacturing, Lachenmaier and Rottmann (2011) find that different product innovations and to a lesser extent process innovations take some time to show their impacts. In particular the authors find that process innovations affect employment only with a one and two-year lag whereas product innovations affect employment with a two-year lag. In contrast, using firm level data for Spain, Giuliodori and Stucchi (2012) find that the time lag of the impact of product and process innovations is rather low. By using the lag of different types of innovations we also try to mitigate the possible endogeneity problem of different types of technological innovations. Using instrumental variables to solve the endogeneity problem is not a feasible approach in this case, as strong instruments are either not available or there is generally the problem in the CIS data that information on variables measuring innovation input, such as R&D expenditures, are only available for innovating firms.

The coefficients of wages and output can be directly interpreted as short run elasticities. Given that employment, wage and output growth are all measured for the same time period there may be an endogeneity problem through reversed causality. However wage and output elasticities are not the key parameters of the paper.

The labour demand equation can in principle be estimated by Ordinary Least Squares (OLS). Nonetheless OLS estimations only allow one to look at the mean of the conditional distribution of the dependent variable. According to Buchinsky (1994) estimating average effects is not sufficient when studying a heterogeneous population of individuals. There are several advantages to applying quantile regression models to labour demand models. First, technological and organization innovations may have very different types of effects on firms with high, low and middle employment growth (given changes in output and wage growth). This is the primary advantage of quantile regression: that it allows the parameters of interest to vary across the distribution. Quantile regressions make it possible to use all data at once and to consider whether there is heterogeneity in the innovation and employment growth relationship across the conditional distribution of employment growth. In particular quantile regression models make it possible to investigate the effects of technological innovations for high growth firms – an area of interest which has recently become an intense focus of empirical research. It may also be the case that the effects of product innovations on employment growth given output growth are larger in firms with growing employment because the type of innovations in firms with rising employment might differ from those in firms with falling employment. Furthermore the negative effects of process innovations might be more pronounced in firms with falling employment which are operating in a shrinking market. In this case process innovations often exist in the form of new labour-saving production processes. Second, another reason that the effects of technological innovations are uneven between firms with rising and falling employment is that the outcome of innovations is generally uncertain and risky and therefore not all types of firms benefit from technological innovations (Marsili/Salter 2005; Mata/Woerter 2013). Third, quantile regressions are robust to outliers in the dependent variable.

To sum up it is interesting to know the effects of different types of technological innovations at different points of the conditional distribution of employment growth. Quantile regression makes it possible to estimate the effects of technological innovations across the whole distribution of employment growth, through firms with rising employment, moderate employment growth and falling employment.

Quantile regression has been frequently applied to analyse the impact of innovations on employment, productivity and/or sales growth (see e.g. Coad/Rao 2011; Falk 2012, 2014; Zimmermann 2009, 2013). We apply the quantile regression procedure developed by Koenker and Bassett (1978). In particular we use the simplex algorithm which is preferred for moderate sample sizes of a few thousand observations (Koenker 2005; Koenker/Hallock 2001). Standard errors of the coefficient estimates are obtained by using bootstrap methods with 200 replications.

3 Data and descriptive statistics

The database consists of a combination of two databases, namely, that of Austria's Structural Business Statistics (SBS, "*Leistungs- und Strukturerhebung*") and the Community Innovation Survey (CIS). The first survey is the CIS which is a representative random sample of firms stratified by industry, firm size, and region. It covers the business enterprise sector – except for construction, retail trade, hotels and restaurants – for those firms with at least 10 employees. The unit-non response rate is 65.5 per cent (Statistics Austria 2008).[1] The second data source is SBS which contains information on turnover, gross output, value added, total materials, and materials by type of use for the period 2004 to 2008. After merging CIS and SBS data, 90 per cent of the firms included in the CIS can be found in the SBS. Missing information on sales and wage costs slightly reduces the number of observations to 3,070.

The Community Innovation Survey provides a wide range of information on innovation activities. Product innovations are defined as the number of significantly improved goods and/or services from the three-year period of 2004 to 2006. Thus goods innovations and the introduction of new services products are combined into one group. Alternatively, product innovations are measured as new market products. Process innovations are defined as the implementation of a new or significantly improved production process, distribution method, or support activity for goods or services. Organizational change includes many diverse subcategories, such as new business practices for organising work or procedures, new knowledge management systems and new methods of workplace organisation and/or new methods of organising external relations with other firms. Product, process and organizational innovations are the most frequent forms of innovations. More than one third of firms introduce either new products or new production processes (see Table 1).

In particular, the share of firms with product and process innovations is 35.5 and 37.5 per cent, respectively. Among non technological innovations, changes in the organizational structure of the firms belong to the most frequent forms of innovation. About 35 per cent of the service and manufacturing firms have introduced new organizational practices or changed the organizational structure of the firm.

[1] Based on the IAB establishment panel Janik (2014) finds that the unit-non response rate increases with the size of the establishment. Statistics Austria finds no evidence that the response rate varies across groups (e.g. size and industry affiliation) (Source: Statistics Austria Quality Report CIS 2006).

Table 1 Descriptive statistics

	Q1	median	Q3	Mean/ percentages
		total		
average annual change in wage costs 2006–2008 in %	−2.9	1.3	5.4	1.4
average annual change in real sales 2006–2008 in %	−3.5	2.8	10.0	3.2
average annual change in employment 2006–2008 in %	−3.2	1.9	7.3	1.6
process innovations 2004–2006 (0/1)				37.5
product innovations 2004–2006 (0/1)				35.5
market novelties 2004–2006 (0/1)				19.4
organisational innovations 2004–2006 (0/1)				34.9
marketing innovations 2004–2006 (0/1)				19.4
		manufacturing		
average annual change in wage costs 2006–2008 in %	−1.8	2.1	5.7	2.3
average annual change in real sales 2006–2008 in %	−3.8	2.7	9.8	3.3
average annual change in employment 2006–2008 in %	−2.7	1.9	7.0	1.9
process innovations 2004–2006 (0/1)				43.5
product innovations 2004–2006 (0/1)				40.8
market novelties 2004–2006 (0/1)				21.6
organisational innovations 2004–2006 (0/1)				35.1
marketing innovations 2004–2006 (0/1)				21.6
		services		
average annual change in wage costs 2006–2008 in %	−4.0	0.5	4.8	0.4
average annual change in real sales 2006–2008 in %	−3.2	3.0	10.3	3.2
average annual change in employment 2006–2008 in %	−3.7	1.9	7.7	1.3
process innovations 2004–2006 (0/1)				30.6
product innovations 2004–2006 (0/1)				29.4
market novelties 2004–2006 (0/1)				17.0
organisational innovations 2004–2006 (0/1)				34.6
marketing innovations 2004–2006 (0/1)				17.0

Notes: Variables are multiplied by 100.
Source: Matched CIS 2006 and Structural Business Statistics 2006–2008. Statistics Austria, Calculations performed by STAT AT. Calculations are based on unweighted numbers. The sample size is 3,070 observations of which 1,642 firms belong to the manufacturing sector and 1,428 to the service sector. Q1 means the first quartile and Q3 means the third quartile.

4 Empirical results

Table 2 shows the results for the labour demand model estimated by quantile regression methods for the 10^{th} to 90^{th} percentile. This table provides results for the total sample and separate estimation results for manufacturing and service firms. Results of the quantile regression model can be compared to the median regression model (the 50th percentile) which focus on the conditional median employment growth rate.

For the total sample we find that new or improved products have a significant and positive impact on subsequent employment growth at the five per cent significance level. This holds true for the 0.5 quantile and most upper and lower quantiles, meaning that the successful introduction of new products leads to an increase in employment growth rate in the subsequent two-years as compared to non-innovators even when controlling for real output and wage growth. In other words, product innovations lead to a higher requirement for labour at given output change. The coefficient of 0.009 based on the 0.5 quantile (=median) means that the average employment growth rate of product innovators is 0.5 percentage points higher per year than that of non-innovators given the impact of wages, output, and other firm characteristics.

It is interesting to observe that the employment effects of product innovations differ widely in magnitude across the different deciles. In particular the coefficient of product innovations ranges between 0.009 and 0.02, with the lowest coefficient at the 0.5 quantile indicating a u-shaped pattern (see also Figure 1 the electronic Appendix at www.jbnst.de/en on the estimated coefficients of product innovations and the associated 95% confidence intervals). Unreported results show that F-Tests of the equality of the coefficient estimate of product innovations across the different quantile regressions are rejected at the five per cent level of significance.

For the 50th percentile (=median) we find that process innovations and organizational and marketing innovations do not lead to job losses in the subsequent two years given the impact of output and wage changes. While the non significance of process innovations is consistent with previous studies (see Harrison et al., 2008), the insignificant impact of organizational changes stands in contrast to previous studies (e.g. Bellmann 2011).

While organizational and marketing innovations do not have a significant impact on employment growth at different quantiles, process innovations exhibit a negative impact at the higher quantiles (namely, the 0.8 and 0.9 quantile). This indicates that process innovations lead to an increase in labour productivity at the expense of employment.

Separate estimation results for manufacturing and service firms show significant differences in the relationship between product innovations and employment growth across broad industry samples. For manufacturing firms we find a significantly positive but decreasing impact of product innovations for the first five deciles, i.e. from the 0.1 to 0.5 quantile. For the median (=0.5 quantile), the coefficient of product innovations is 0.011 indicating that firms with product innovations have employment growth rates that are 1.1 percentage points higher per year than compared to non-innovators on average given the impact of output and wage growth. The positive impact of product innovations for manufacturing firms is consistent with previous studies using a similar approach and lagged values for product innovations (see Lachenmaier/Rottmann 2007, 2011).

However, for manufacturing firms, product innovations do not have a significant impact on employment growth in the upper quantiles from the 0.6 to 0.9 quantiles (see also Figure 1 in the electronic Appendix at www.jbnst.de/en for quantile plots with the estimated coefficients and associated 95% confidence intervals for the coefficient of product innovations for the total sample and for manufacturing). For service firms the positive impact of product innovations on employment growth can only be observed for high growth firms (i.e. at 0.9 quantiles). Furthermore, with few exceptions, separate estimates for service and manufacturing firms show that the remaining types of innovations, namely, process innovations, organizational change and marketing innovations, are not significantly related to employment growth across the different quantiles. This holds true for both manufacturing and services.

Wage elasticity is about 0.3 with little differences across the quantiles, and between services and manufacturing. Output elasticity ranges between 0.4 and 0.5 with again little differences across the quantiles. The relatively low output elasticity might be partly related to the estimation method and the available data that only allow estimation of short run effects.

Table 2 Quantile regression estimates of the impact of different types of innovations on employment growth between 2006–2008

	total sample		industry		services
			0.1 quantile		
	coeff.	t	coeff.	t	coeff.
constant	−0.104***	−17.11	−0.098***	−13.62	−0.112***
process innovations	0.001	0.08	−0.008	−0.51	−0.006
product innovations	0.020*	1.79	0.043***	3.31	−0.008
organisational innovations	−0.004	−0.35	0.003	0.27	0.007
marketing innovations	0.012	1.01	0.001	0.09	0.004
average annual change in wage costs	−0.305***	−10.77	−0.333***	−8.84	−0.244***
average annual change in real sales	0.422***	23.18	0.456***	21.72	0.359***
			0.2 quantile		
	coeff.	t	coeff.	t	coeff.
Constant	−0.055***	−14.68	−0.052***	−11.18	−0.057***
process innovations	−0.001	−0.15	−0.003	−0.48	0.001
product innovations	0.019***	3.20	0.029***	4.47	−0.001
organisational innovations	0.000	0.05	−0.004	−0.60	0.006
marketing innovations	0.005	0.71	0.007	1.07	0.007
average annual change in wage costs	−0.294***	−9.84	−0.310***	−7.37	−0.294***
average annual change in real sales	0.388***	14.87	0.422***	16.03	0.335***
			0.3 quantile		
	coeff.	t	coeff.	t	coeff.
Constant	−0.028***	−11.85	−0.026***	−7.93	−0.028***
process innovations $t-2$	−0.001	−0.13	−0.007	−1.14	−0.004
product innovations	0.013***	2.81	0.021***	3.67	−0.003
organisational innovations	0.002	0.65	0.005	1.20	0.005
marketing innovations	0.006	1.36	0.005	1.02	0.005
average annual change in wage costs	−0.304***	−9.94	−0.311***	−8.52	−0.276***
average annual change in real sales	0.378***	13.93	0.415***	14.44	0.333***
			0.4 quantile		
	coeff.	t	coeff.	t	coeff.
Constant	−0.010***	−4.20	−0.009***	−2.85	−0.010***
process innovations	−0.001	−0.31	−0.002	−0.47	−0.001
product innovations	0.009**	2.13	0.013***	2.91	−0.001
organisational innovations	0.003	0.80	0.001	0.32	0.004
marketing innovations	0.007*	1.72	0.006	1.45	0.006
average annual change in wage costs	−0.281***	−8.63	−0.304***	−7.12	−0.293***
average annual change in realsales	0.387***	11.97	0.432***	13.46	0.328***
			0.5 quantile		
	coeff.	t	coeff.	t	coeff.
constant	0.007***	3.77	0.007***	2.42	0.007**
process innovations	−0.002	−0.52	−0.005	−1.23	−0.001
product innovations	0.009***	2.67	0.011***	2.85	0.004
organisational innovations	0.002	0.46	0.006	1.41	0.001
marketing innovations	0.006	1.67	0.007	1.46	0.003
average annual change in wage costs	−0.294***	−9.97	−0.293***	−6.41	−0.310***
average annual change in real sales	0.382***	12.51	0.459***	11.45	0.333***

Table 2 Continued

	total sample		industry		services
			0.6 quantile		
	coeff.	t	coeff.	t	coeff.
constant	0.023***	10.17	0.023***	6.55	0.024***
process innovations	−0.004	−0.90	−0.004	−0.66	−0.005
product innovations	0.009**	2.18	0.007	1.30	0.005
organisational innovations	0.003	0.66	0.006	1.09	0.003
marketing innovations	0.007	1.35	0.006	1.06	0.008
average annual change in wage costs	−0.300***	−8.31	−0.294***	−5.96	−0.333***
average annual change in real sales	0.384***	12.72	0.458***	11.72	0.326***
			0.7 quantile		
	coeff.	t	coeff.	t	coeff.
constant	0.044***	16.75	0.043***	11.83	0.046***
process innovations	−0.003	−0.73	−0.006	−1.01	0.002
product innovations	0.008*	1.94	0.008	1.51	0.005
organisational innovations	0.002	0.42	0.005	0.86	−0.003
marketing innovations	0.007	1.34	0.006	1.08	0.008
average annual change in wage costs	−0.295***	−11.35	−0.278***	−6.97	−0.330***
average annual change in real sales	0.392***	15.08	0.477***	14.57	0.320***
			0.8 quantile		
	coeff.	t	coeff.	t	coeff.
Cconstant	0.065***	19.10	0.067***	14.74	0.068***
process innovations	−0.012***	−2.53	−0.013*	−1.89	−0.007
product innovations	0.011**	2.00	0.010	1.57	0.014
organisational innovations	0.009**	2.09	0.009	1.62	0.002
marketing innovations	0.004	0.72	0.002	0.41	0.010
average annual change in wage costs	−0.282***	−11.70	−0.312***	−8.33	−0.293***
average annual change in real sales	0.413***	18.30	0.497***	23.40	0.319***
			0.9 quantile		
	coeff.	t	coeff.	t	coeff.
constant	0.120***	19.78	0.115***	15.85	0.121***
process innovations	−0.019**	−2.12	−0.023	−1.49	−0.009
product innovations	0.017**	2.13	0.009	0.67	0.028**
organisational innovations	−0.002	−0.17	0.002	0.16	−0.011
marketing innovations	−0.013	−1.29	−0.005	−0.47	0.006
average annual change in wage costs	−0.263***	−9.35	−0.326***	−6.53	−0.236***
average annual change in real sales	0.421***	17.45	0.548***	16.34	0.330***
number of observations	3072		1644	1428	

Note: The dependent variable is the average annual change in employment between 2006-2008. Quantile regression was carried out with the SAS QUANTREG procedure, using the simplex algorithm and bootstrapped standard errors using 200 replications. ***, ** and * denotes significance at the 1, 5 and 10 per cent levels. The number of observations is 3070.
Source: Statistics Austria Linked CIS-SBS data, own calculations.

Table 3 displays the quantile regression results for the nine deciles where product innovations are replaced by market novelties. For manufacturing we again find that market novelties have a positive, but decreasing impact on employment growth along the conditional contribution of employment growth given the impact of wage and output growth (see Figure 2 in the electronic Appendix at www.jbnst.de/en). The significantly positive but decreasing impact of market novelties over the conditional distribution indicates a convex relationship. For instance the coefficient of market novelties at the 0.1 quantile is 0.036, indicating that firms introducing market novelties have a 3.6 percentage higher average annual employment growth rate per year given the impact of output and wage growth. The coefficients for the 0.2 and 0.3 quantile are 0.023 and 0.013, respectively, and thus much lower than compared to the 0.1 quantile. At higher quantiles, namely, from the 0.6 to 0.9 quantile we observe an insignificant impact of market novelties. In contrast, for service firms, we find that market novelties have a significant and positive impact on employment growth only at the 0.8 and 0.9 quantiles. However the coefficients are only significant at the 10 per cent level. The remaining types of innovations, namely, process innovations, organisational innovations and marketing innovations, do not have an impact on employment growth in general once output and wage growth is controlled for.

Overall the results show that employment effects of product innovations differ significantly between manufacturing and service firms. For services, technological and non technological innovations as measured in the innovation surveys do not lead to higher employment growth. One reason is that innovation output is much more difficult to measure for services than for manufacturing firms (see Evangelista/Savona 2011).

The findings based on quantile regression methods are difficult to compare with the previous literature because of differences in the model specification (labour demand model versus firm growth specification not controlling for output growth, and/or using quantitative measure of output due to market products instead of dummy variables). In addition studies are not comparable because of the use of different time lags of technological innovations (either current or lagged values), use of different estimation samples (e.g. manufacturing firms or total business enterprises) and estimation techniques (both OLS and/or GMM estimator for the average effects, for the latter see Meriküll 2010 and Lachenmaier/Rottmann 2011), and treatment of heterogeneity (focusing on average effects and/or quantile regressions).

For instance, based on small and medium sized enterprises for Germany, including both manufacturing and service firms, Zimmermann (2009) finds that the impact of both product and process innovations on employment growth increases when moving from lower to higher quantiles. The insignificance of process innovations is consistent with the earlier literature. Using CIS data for several EU countries, Dachs and Peters (2014) find that process innovations are significantly negatively related to employment growth but are insignificant for service firms. As mentioned above the insignificance of organizational change stands in contrast to the earlier literature. Evangelista and Vezzani (2012) find that organizational innovations not combined with process innovations are significantly positively related with employment growth.

We have conducted a number of robustness checks. First we re-estimated the labour demand model with industry dummies at the two-digit level. However Wald tests show that industry dummies are jointly not significantly different from zero. Second we included interaction terms between the different types of innovations. A number of scholars mentioned that organizational and technological innovations are complementary to each

Table 3 Quantile Regression estimates of the impact of market novelties on employment growth

	total sample		industry		services
	0.1 quantile				
	coeff.	t	coeff.	t	coeff.
Constant	−0.103***	−17.35	−0.098***	−13.60	−0.111***
process innovations	0.006	0.51	0.008	0.64	−0.008
market novelties	0.014	1.27	0.036***	3.05	−0.010
organisational innovations	−0.003	−0.29	−0.003	−0.27	0.006
marketing innovations	0.014	1.12	0.017	1.24	0.005
average annual change in wage costs	−0.306	−10.60	−0.344	−9.68	−0.225***
average annual change in real sales	0.426***	23.62	0.460***	23.43	0.346***
	0.2 quantile				
	coeff.	t	coeff.	t	coeff.
Constant	−0.054***	−14.12	−0.050***	−11.30	−0.056***
process innovations	0.005	0.90	0.003	0.48	0.001
market novelties	0.016***	2.82	0.023***	4.19	−0.004
organisational innovations	−0.001	−0.26	−0.001	−0.14	0.005
marketing innovations	0.007	1.15	0.007	1.24	0.009
average annual change in wage costs	−0.291***	−10.22	−0.319***	−7.53	−0.292***
average annual change in real sales	0.394***	14.49	0.428***	17.47	0.333***
	0.3 quantile				
	coeff.	t	coeff.	t	coeff.
Constant	−0.027***	−11.60	−0.024***	−7.51	−0.028***
process innovations	0.003	0.81	0.001	0.28	−0.004
market novelties	0.011***	2.59	0.013**	2.30	−0.003
organisational innovations	0.002	0.72	0.005	1.13	0.006
marketing innovations	0.005	1.25	0.005	1.00	0.003
average annual change in wage costs	−0.307***	−9.83	−0.322***	−8.53	−0.280***
average annual change in real sales	0.380***	13.82	0.424***	14.73	0.334***
	0.4 quantile				
	coeff.	t	coeff.	t	coeff.
Constant	−0.009***	−3.90	−0.007**	−2.46	−0.010***
process innovations	0.000	0.02	−0.001	−0.24	−0.001
market novelties	0.011***	2.87	0.012***	2.60	0.000
organisational innovations	0.003	0.92	0.003	0.64	0.004
marketing innovations	0.006	1.57	0.005	1.11	0.005
average annual change in wage costs	−0.277***	−8.72	−0.307***	−7.18	−0.296***
average annual change in real sales	0.377***	12.20	0.424***	12.75	0.326***
	0.5 quantile				
	coeff.	t	coeff.	t	coeff.
Constant	0.008***	4.04	0.008***	2.72	0.007**
process innovations	0.000	−0.06	−0.003	−0.74	−0.001
market novelties	0.007**	2.01	0.009**	2.13	0.003
organisational innovations	0.003	1.03	0.006	1.47	0.001
marketing innovations	0.005	1.38	0.007	1.48	0.004
average annual change in wage costs	−0.297***	−10.00	−0.296***	−6.64	−0.310***
average annual change in real sales	0.385***	12.90	0.459***	11.74	0.333***

Table 3 Continued

	total sample		industry		services
			0.6 quantile		
	coeff.	t	coeff.	t	coeff.
Constant	0.024***	10.70	0.024***	7.17	0.024***
process innovations	−0.002	−0.52	−0.003	−0.51	−0.005
market novelties	0.007	1.60	0.005	0.81	0.005
organisational innovations	0.004	0.91	0.006	1.07	0.002
marketing innovations	0.007	1.52	0.009	1.67	0.009
average annual change in wage costs	−0.296***	−8.41	−0.295***	−6.23	−0.332***
average annual change in real sales	0.383***	12.79	0.456***	11.44	0.324***
			0.7 quantile		
	coeff.	t	coeff.	t	coeff.
Constant	0.044***	17.01	0.042***	12.12	0.047***
process innovations	−0.002	−0.39	−0.004	−0.81	0.001
market novelties	0.006	1.20	0.008	1.33	0.005
organisational innovations	0.003	0.60	0.006	1.15	−0.003
marketing innovations	0.008	1.60	0.004	0.64	0.008
average annual change in wage costs	−0.291***	−11.46	−0.273***	−6.69	−0.330***
average annual change in real sales	0.394***	15.10	0.477***	14.84	0.319***
			0.8 quantile		
	coeff.	t	coeff.	t	coeff.
Constant	0.066***	19.22	0.067***	14.51	0.069***
process innovations	−0.006	−1.51	−0.011	−1.57	−0.007
market novelties	0.006	1.07	0.006	1.04	0.018*
organisational innovations	0.009	2.00	0.009	1.64	0.003
marketing innovations	0.005	0.99	0.003	0.55	0.011
average annual change in wage costs	−0.284***	−11.97	−0.310***	−8.25	−0.300***
average annual change in real sales	0.412***	18.12	0.497***	22.78	0.320***
			0.9 quantile		
	coeff.	t	coeff.	t	coeff.
Constant	0.123***	20.79	0.116***	16.00	0.124***
process innovations	−0.010	−1.09	−0.018	−1.30	−0.001
market novelties	0.003	0.28	−0.008	−0.83	0.028*
organisational innovations	−0.001	−0.10	0.012	1.03	−0.013
marketing innovations	−0.011	−1.08	−0.004	−0.34	−0.003
average annual change in wage costs	−0.265***	−9.00	−0.323***	−6.25	−0.210***
average annual change in real sales	0.423***	18.29	0.547***	16.32	0.335***

Note: The dependent variable is the average annual change in employment between 2006–2008. ***, ** and * denotes significance at the 1, 5 and 10 per cent levels. Quantile regression was carried out with the SAS QUANTREG procedure, using the simplex algorithm and bootstrapped standard errors using 200 replications. The number of observations is 3070. Source: Statistics Austria Linked CIS-SBS data, own calculations.

other. In particular combinations of different types of innovations may have a larger impact on firm growth and/or employment growth. This may also hold true for employment change. However unreported results show that interaction terms between process innovations and organizational innovations are not significant. Similarly the interaction term between product innovations and organizational innovations is also not significant.

Another concern is the omitted variables bias. To account for this we included a number of other variables that could affect labour demand, such as investment, expenditures for external contract workers and expenditures for externally provided services. Nonetheless the factors are not significantly different from zero and also lead to substantial reduction of the estimation sample because a significant number of firms do not use contract workers or purchase external services.

5 Conclusions

We employed quantile regression techniques applied to a standard labour demand model to investigate whether different types of technological and organizational innovations affect employment growth differently in firms with falling and rising employment. We used a unique database merging CIS 2006 data for Austria with structural business statistics for the period 2006 to 2008. We found significant differences in the impact of product innovations across the quantiles and also between manufacturing and service firms. For manufacturing we found a significant and positive impact of product innovations on subsequent employment growth with a decreasing impact across the quantiles and insignificant effects at the higher quantiles. This is also true for the alternative measure of product innovation that is market novelties. For service firms we found that a positive link between product innovations and/or market novelties and subsequent employment change can only be observed for high growth firms. Overall this indicates that product innovations lead to an increase in the requirement for labour at given output change.

The other types of innovations, namely, organizational and marketing innovations, do not have a significant impact on subsequent employment growth at the different quantiles for both manufacturing and service firms. Labour costs and output growth show the expected sign with short run elasticities of -0.29 and 0.38 with little differences across the conditional distribution of employment growth.

For manufacturing, the positive employment effects of product innovations for the average firm are consistent with earlier literature. For service firms, product innovations do not lead to the generation of jobs in the subsequent years on average. However the finding for service firms are difficult to compare with results in the literature because there are still few studies explicitly focusing on service firms.

The results show that organizational innovations, such as the introduction of new business practices and/or new methods of organising work and or changes in external relations, are not destroying jobs when controlling for output growth and changes in wages. At first sight this seems to be surprising and contrary to many studies and anecdotal evidence. Yet it should be noted that organizational innovations refer to a specific point in time, namely, the 2006 to 2008 economic boom phase. It could be the case that job destroying organizational innovations are more prevalent in economic recession periods or phases of low output growth. Another possible explanation for the insignificance of organizational innovations is the measurement of organizational innovations as a dummy variable. It is likely that dummy variables are inadequate to fully capture the nature of organizational innovations.

This study is bound by several limitations. First, it was conducted based on Austrian firm-level data and the results may be difficult to generalize to other countries. Future research should apply the same methodology to other EU countries. Recently, Eurostat has funded a large scale project to provide linked-longitudinal firm-level surveys for several European countries (Bartelsman et al. 2014). Second, this study measures product innovations as a dummy variable. Note however that the effect of product innovations are likely to be underestimated given that product innovations are measured as a dummy variable rather than directly as the growth of output due to new products. An alternative preferred method is to use the change in new products as the measure of product innovations as suggested by Jaumandreu (2003) and Harrison et al. (2008). However cross sectional CIS data only include a measure of the share of sales from new products for a given year. Matching different CIS waves would in principle make it possible to calculate the change in turnover from new products. Yet due to the rotating nature of the Austrian CIS data, the same firms rarely overlap across different CIS waves. Therefore panel data methods would offer little additional insights. Third, analysis focused on the employment effects of technological innovations within firms. By doing so the analysis cannot account for the impact of technological innovations on non-innovating firms in the same or related industries (the so-called "business-stealing effect"). For example it might be the case that non-innovating firms can benefit from innovations via imitations and spillover effects. Fourth, we used a broad measure of organizational change that included a range of diverse activities, such as new business practices, business re-engineering, lean production, new knowledge management systems, new methods of workplace organization and outsourcing, and subcontracting activities. Future work should examine the impact of different types of organizational change on employment rather than focusing on a broad measure of organizational change.

References

Bartelsman, E.J., E. Hagsten, M. Polder, (2014). Cross-country analysis of ICT impact using firm-level data: The micro moments database and research infrastructure. mimeo.

Bauer, T., S. Bender (2004), Technological Change, Organizational Change, and Job Turnover. Labour Economics 11: 265–292.

Bellmann, L. (2011), Beschäftigungs- und Lohnwirkungen von betrieblichen Reorganisationsprozessen. Journal for Labour Market Research 1/2: 65–72.

Blechinger, D., F. Pfeiffer (1999), Qualifikation, Beschäftigung und technischer Fortschritt: empirische Evidenz mit den Daten des Mannheimer Innovationspanels. Jahrbücher für Nationalökonomie und Statistik 218: 1–2: 128–146.

Bloom, N., J. Van Reenen (2011), Human Resource Management and Productivity. CEPR discussion paper 7489.

Bresnahan, T.F., E.L. Brynjolfsson, M. Hitt (1999), Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-level Evidence. NBER working paper 7136.

Buchinsky, M. (1994), Changes in the U.S. wage structure 1963–1987: application of quantile regression. Econometrica 62: 405–458.

Cainelli, G., R., Evangelista, M. Savona (2006), Innovation and economic performance in services: a firm-level analysis. Cambridge Journal of Economics 30: 435–458.

Cainelli, G., R. Evangelista, M. Savona (2004), The impact of innovation on economic performance in services. The Service Industries Journal 24(1): 116–130.

Caroli, E., J. Van Reenen (2001), Skill biased organizational change? Evidence from a panel of. British and French establishments. Quarterly Journal of Economics 116(4): 1449–1492.

Chen, Y. (2006), Marketing innovation. Journal of Economics & Management Strategy 15(1): 101–123.

Coad A, R. Rao (2011), The firm-level employment effects of innovations in high-tech US manufacturing industries. Journal of Evolutionary Economics 21: 255–283.

Dachs, B., B. Peters, (2014), Innovation, employment growth, and foreign ownership of firms: A European perspective. Research Policy 43(1): 214–232.

Edquist, C., L. Hommen, M. McKelvey (2001), Innovation and Employment: Product Versus Process Innovation. Cheltenham, Elgar.

Evangelista, R., M. Savona, (2011), Innovation and employment in services. Pp. 371–391 in: The handbook of innovation and services: A multi-disciplinary perspective. Cheltenham Elgar.

Evangelista, R., A. Vezzani, (2012), The impact of technological and organizational innovations on employment in European Firms. Industrial and Corporate Change 21(4): 871–899.

Evangelista, R., M. Savona (2002), The impact of innovation on employment in services: Evidence from Italy. International Review of Applied Economics 16(3): 309–318.

Evangelista, R., A. Vezzani (2010), The economic impact of technological and organizational innovations. A firm-level analysis. Research Policy 39: 1253–1263.

Evangelista, R., M., Savona (2003), Innovation, Employment and Skills in Services: Firm and Sectoral Evidence. Structural Change and Economic Dynamics 14(4): 449–474.

Falk, M. (2012), Quantile estimates of the impact of R&D intensity on firm performance. Small Business Economics 39(1): 19.37.

Falk, M (2014), The Impact of New Goods and Service Products on Firm Growth: Evidence from Austrian Linked Firm-Level Data. Economics of Innovation and New Technology, forthcoming.

Frenz, M., R. Lambert (2012), Mixed Modes of Innovation: An Empiric Approach to Capturing Firms' Innovation Behaviour. OECD Science, Technology and Industry Working Papers, 2012/06, OECD Publishing.

Giuliodori, D., R. Stucchi (2012), Innovation and job creation in a dual labor market: evidence from Spain. Economics of Innovation and New Technology 21(8): 801–813.

Greenan, N. (2003), Organisational change, technology, employment and skills: an empirical study of French manufacturing. Cambridge Journal of Economics 27(2): 287–316.

Greenan, N., D. Guellec (2001), Organizational Change and Skill Accumulation. Industrial and Corporate Change 10: 481–506.

Hamermesh, D.S. (1996), Labor Demand. Princeton, NJ: Princeton University Press.

Hamermesh, D.S. (2007), Viewpoint: Replication in economics. Canadian Journal of Economics 40(3): 715–733.

Harrison, R., J., Jaumandreu, J., Mairesse, B. Peters (2008), Does innovation stimulate employment? A firm-level analysis using comparable micro data on four European countries. NBER working paper 14216.

Hooley, G.J., G.E. Greenley, J.W. Cadogan, J. Fahy (2005), The performance impact of marketing resources. Journal of Business Research 58(1): 18–27.

Ichniowski C., K. Shaw, G. Premushi (1997), The Effects of Human Resources Management Practices on Productivity, A Study of Steel Finishing Lines. American Economic Review 87(3): 291–313.

Janik, F. (2014), Teilnahmeverweigerungen in Betriebsbefragungen. Eine Analyse anhand des IAB-Betriebspanels 2009. JBNST 234(4): 474–489.

Jaumandreu, J. (2003), Does Innovation Spur Employment? A Firm-Level Analysis using Spanish CIS Data. Mimeo, university Carlos III de Madrid.

Katsoulacos Y.S. (1986), The Employment Effect of Technical Change. Harvester, Brighton

Koenker, R., (2005), Quantile Regression. Cambridge Books, Cambridge University Press.

Koenker, R., G.W Bassett (1978), Regression quantiles. Econometrica 46: 33–50.

Koenker. R., K. Hallock (2001), Quantile regression. Journal of Economic Perspectives 15(4): 143–156.

Krasnikov, A., S. Jayachandran (2008), The relative impact of marketing, research-and-development, and operations capabilities on firm performance. Journal of Marketing 72(4): 1–11.

Lachenmaier S., H. Rottmann (2007), Employment Effects of Innovation at the Firm Level. Jahrbücher für Nationalökonomie und Statistik 227(3): 254–272.

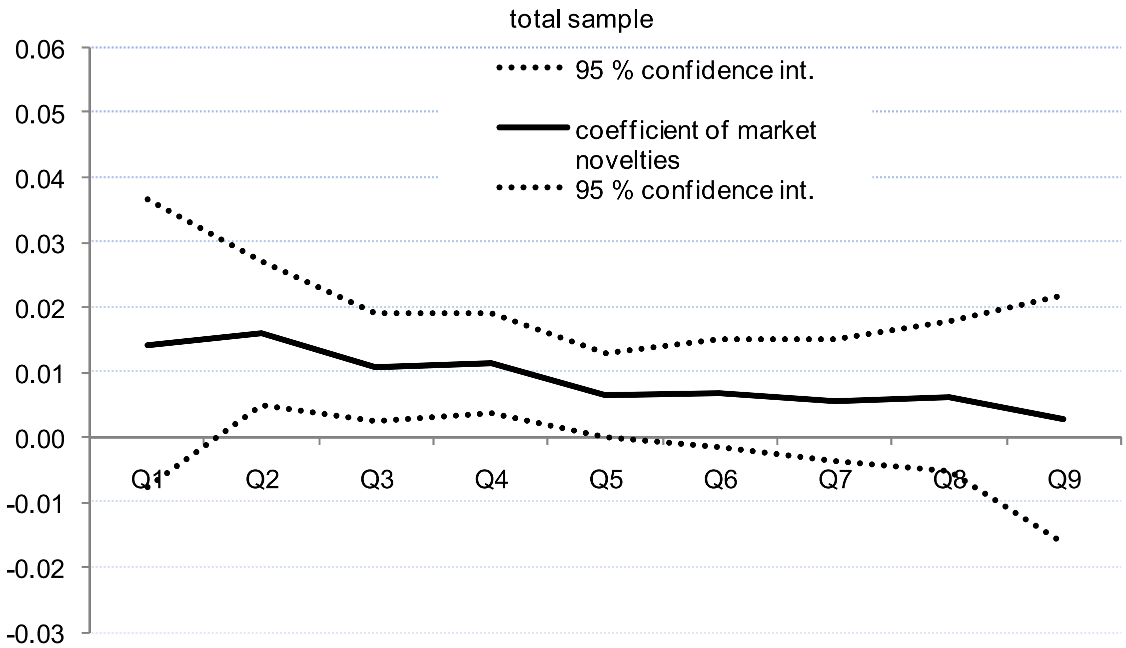
Lachenmaier, S., H. Rottmann (2011), Effects of innovation on employment: A dynamic panel analysis. International Journal of Industrial Organization 29(2): 210–220.

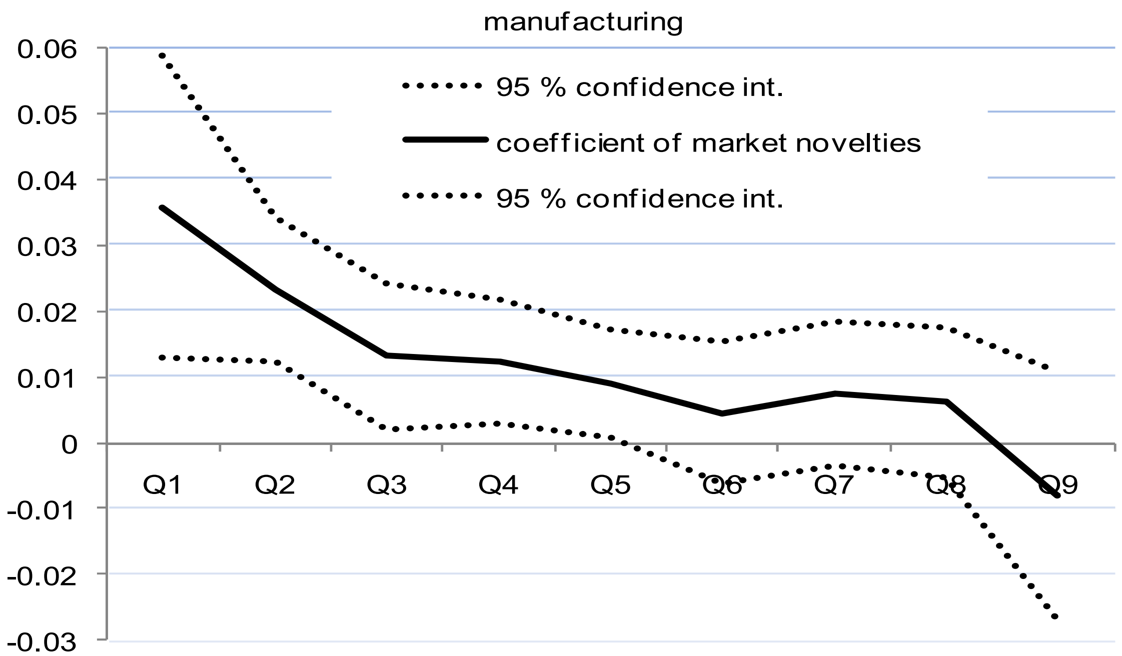
Marsili, O., A. Salter (2005), Inequality of Innovation: Skewed Distributions and the Returns to Innovation in Dutch Manufacturing. Economics of Innovation and New Technology 14(1–2): 83–102.
Mata J., M., Woerter (2013), Risky innovation: the impact of internal and external R&D strategies upon the distribution of returns. Research Policy 42: 495–501.
Meriküll, J. (2010), The impact of innovation on employment: firm- and industry-level evidence from a catching-up economy. Eastern European Economics 48(2): 25–38.
OECD (2005), Oslo Manual: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data. Paris.
Peters, B. (2004), Employment effects of different innovation activities microecomometric evidence. ZEW Discussion paper 04–73.
Peters, B. (2008), Innovation and firm performance: an empirical investigation for German firms. Heidelberg Physica.
Pianta, M. (2005), Innovation and employment. Pp. 568–598 in: J. Fagerberg. D. Mowery, R. Nelson (eds), Oxford Handbook of Innovation. Oxford: Oxford University Press.
Rottmann, H., M. Ruschinski (1998), The Labour Demand and the Innovation Behaviour of Firms. Jahrbücher für Nationalökonomie und Statistik 217: 741–752.
Sharpe, M. (1997), Outsourcing, Organizational Competitiveness, and Work. Journal of Labor Research 18(4): 535–549.
Smolny, W. (1998), Innovations, Prices and Employment: A Theoretical Model and an Empirical Application for West German Manufacturing Firms. Journal of Industrial Economics 46: 359–81.
Smolny W., T. Schneeweis (1999), Innovation, Wachstum und Beschäftigung. Eine empirische Untersuchung auf der Basis des ifo Unternehmenspanels. Jahrbücher für Nationalökonomie und Statistik 218(3+4): 457–472.
Stoneman P. (1983), The economic analysis of technological change. Oxford University Press, Oxford
Van Reenen, J. (1997), Employment and technological innovation: Evidence from U.K. manufacturing firms. Journal of Labor Economics 15(2): 255–284.
Vivarelli, M. (2014), Innovation, Employment and Skills in Advanced and Developing Countries: A Survey of Economic Literature. Journal of Economic Issues 48(1): 123–154.
Vivarelli, M., M. Pianta (2000), The Employment Impact of Innovation: Evidence and Policy. Routledge.
Zimmermann, V. (2009), The impact of innovation on employment in small and medium enterprises with different growth rates. Jahrbücher für Nationalökonomie und Statistik 229(2/3): 313–326.
Zimmermann, V. (2013), Innovation und Beschäftigung: die Beschäftigungswirkung verschiedener Arten von Innovationen in expandierenden und schrumpfenden mittelständischen Unternehmen. Zeitschrift für Betriebswirtschaft 4: 131–149.

Dr. Martin Falk, Österreichisches Institut für Wirtschaftsforschung WIFO (Austrian Institute of Economic Research), Arsenal Objekt 20, 1030 Wien, Austria.
Martin.Falk@wifo.ac.at
http://www.wifo.ac.at/martin.falk/

Appendix (for the online Appendix)

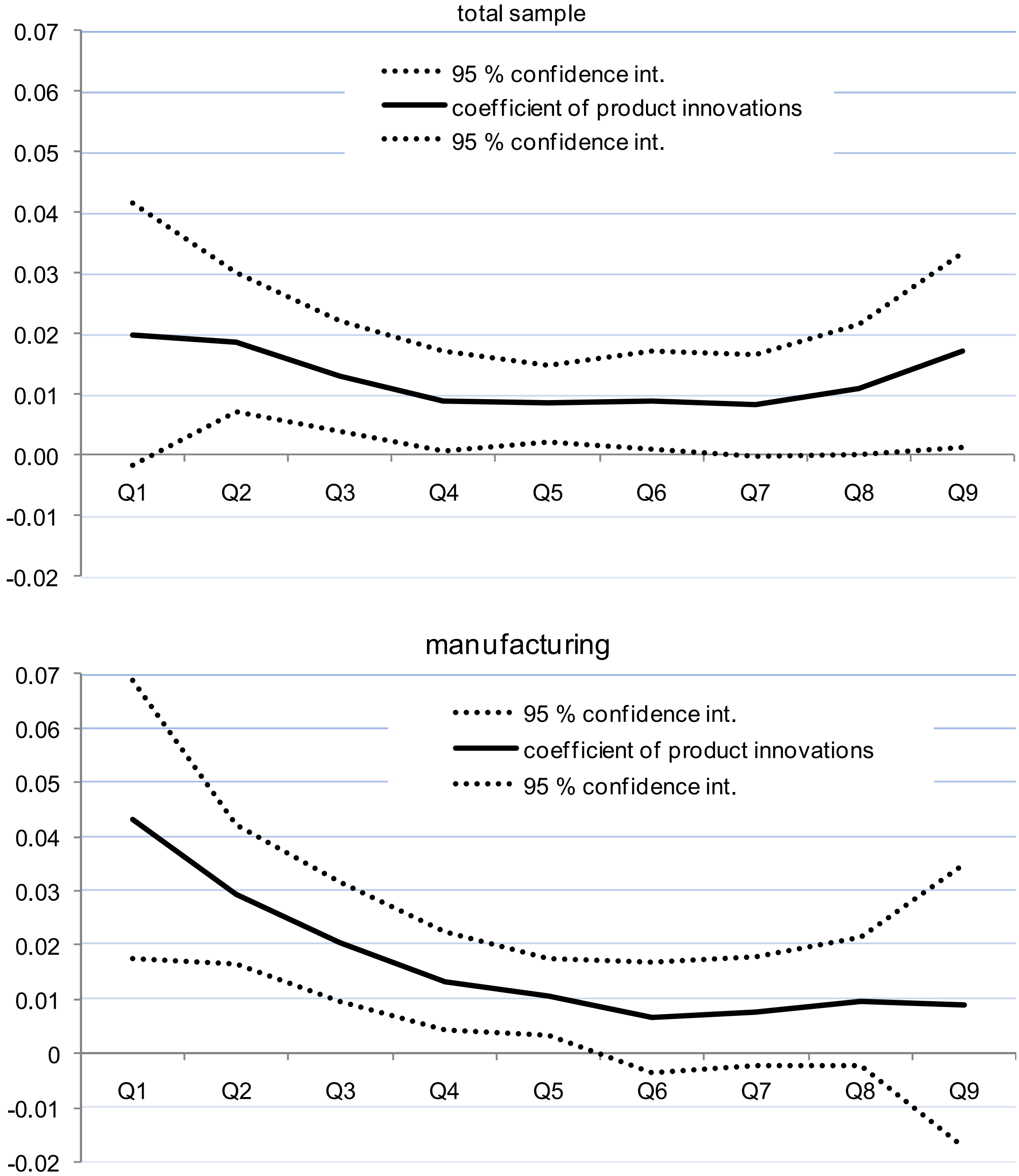
Figure 1: Quantile regression estimates of the impact of market novelties





Note: Quantile regression plot of the coefficient of market novelties for 2004-2006 on subsequent average annual employment growth 2006/2008. The coefficient can be interpreted as employment effect of market novelties as compared to non-innovators given the impact of control variables in percentage points. Confidence intervals for the quantile process are computed with the resampling method and 200 replications.

Figure 2: Quantile regression estimates of the impact of product innovations



Note: Quantile regression plot of the coefficient of new for 2004-2006 on subsequent average annual employment growth 2006/2008. Confidence intervals for the quantile process are computed with the resampling method and 200 replications.