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Employment effects of technological and organizational innovations:

Evidence based on linked Firm-Level Data

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Abstract

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 CIS 2006 data 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 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. The results are robust with respect to the measurement of product innovations (e.g. market novelties or new to firm products). Furthermore, process and organizational innovations do not have a significant impact on subsequent employment growth across the different quantiles.

Jelcodes:O33,J23

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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 CIS 2006 data 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 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. The results are robust with respect to the measurement of product innovations (e.g. market novelties or new to firm products). Furthermore, process and organizational innovations do not have a significant impact on subsequent employment growth across the different quantiles.

JEL: O33, J23, J24, L23

Keywords: technological innovations, organizational innovations, employment growth, quantile regressions, firm level data.

1 Introduction

There has been an 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 and Peters 2014, and Evangelista and Vezzani 2012 and Lachenmaier and Rottmann 2011 for recent studies). So far there is no consensus about the effects of different types of innovations on employment.

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 and Rao 2011; Falk, 2012; 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 2004-2008. The main focus of this research is on the direct effects of technological and organizational innovations on employment growth at the firm level given output and wage growth.

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 and Bender, 2004; Bellmann 2011; Caroli and Van Reenen, 2001; Evangelista and 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, Evangelista and Savona, 2004, 2006; Evangelista and Savona, 2002, 2003, 2011). Since there are reasons to believe that even within manufacturing and services 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. Unlike these studies, except Blechinger and Pfeiffer (1999), 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 about 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.

The theoretical literature suggests that process innovations can have a direct negative employment effect due to the replacement of labour by new machines and production processes (Edquist, Hommen and McKelvey, 2001; Peters, 2004, 2008). This is referred to as the displacement effect. 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, Hommen and McKelvey, 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, which are 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, Brynjolfsson and Hitt, 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 and Van Reenen, 2011). However, 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 will be outsourced to external suppliers (Sharpe, 2007). This may lead to a replacement of activities that are previously conducted in-house and thereby reduce the number of jobs in-house.

With no clear theoretical prediction, the employment effects of not only technological innovations but also organizational 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 and Rottmann, 2011 and Pianta, 2005; Vivarelli, 2014; Vivarelli and Pianta, 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 and Van Rennen, 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 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 (=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). It 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) introduced a related approach - a simultaneous model of employment and sales growth - where product innovations are assumed to impact sales growth only whereas the remaining types of innovations could affect both employment and sales growth.

The second approach measures the employment effects of product innovations given output of the firm. 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. exogeneous prices for labor and capital. Taken 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:

$$\ln L_{it} = \beta_0 + \beta_1 \ln Y_{it} + \beta_2 \ln WP_{it} + \beta_3 \tau + \varepsilon_{it},$$

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 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 apply first differences to the data. This gives the following short-run labour demand function:

$$\Delta \ln L_i = \alpha_i + \tilde{\beta}_1 \Delta \ln Y_i + \tilde{\beta}_2 \Delta \ln(WP)_i + \tilde{\beta}_3 PROD + \tilde{\beta}_4 PROC_i + \tilde{\beta}_5 OC_i + \tilde{\beta}_6 MKT_i + \nu_i,$$

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. $\nu_i \equiv \varepsilon_{it} - \varepsilon_{i,t-1}$, has zero mean and constant varianceΔ refers to the average annual change of the variables between 2006 and 2008. The variables are defined as follows:

ΔlnL: average annual percentage change in employment between 2006-2008,

ΔlnY: annual average percentage change in sale revenues deflated by the industry specific gross output deflator between 2006-2008,

ΔlnWP: average annual percentage change in the total wage costs per employee deflated by a specific value added deflator between 2006-2008,

PROD: introduction of new or significantly improved goods and/or services between 2004-2006,

PROC: implementation of a new or significantly improved production process, distribution method, or support activity for your goods or services between 2004-2006,

OC: organisational innovation (e.g. business practices, knowledge management, workplace organisation or external relations) between 2004-2006,

MKT: a new marketing concept or strategy between 2004-2006.

The labour demand equation can in principle be estimated by Ordinary least squares (OLS). The coefficients of wages and output can be directly interpreted as short run elasticities. However, 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.

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.

However, OLS estimations only allow one to look at the mean of the conditional distribution of the dependent variable. According to Buchinsky (1994) estimating the average effects is not sufficient when studying a heterogeneous population of individuals. There are strong theoretical arguments that the relationship between innovation and employment varies over the conditional employment growth distribution. For example, it may be the case that the employment effects of product innovations 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 employment 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 consist in the form of new labour-saving production processes. Another reason that the employment 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 and Salter, 2005; Mata and Woerter, 2013).

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 employment 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 and 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 and 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, hotel and restaurants with at least 10 employees. The response rate is 65.5 per cent (Statistics Austria, 2008). 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 2004-2008. 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 reduce the number of observations slightly 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 in 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).

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.

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.

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. This means 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. The coefficient of 0.009 based on the 0.5 quantile (=median) means that employment growth of product innovators is 0.5 percentage points higher than that of non-innovators given the impact of wages, output, and other firm characteristics. Note however that the effect of product innovations is 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.

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 in the Appendix 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.

While organizational and marketing innovations do not have a significant impact on employment growth at different quantiles, process innovations exhibit a negative relationship at the higher quantiles (namely the 0.8 and 0.9 quantile). For the 50th percentile (=median), we find that process innovations and organizational innovations do not lead to job losses in the subsequent two years. While the average effects of process innovations are consistent with previous studies (see Harrison et al. 2008), the results for the average effects of organizational changes are less optimistic to that of previous studies (Bellman, 2011; Lachenmaier and Rottmann, 2011)

Table 2: Quantile regression estimates of the impact of different types of innovations on employment growth

	total sample			industry			services		
				0.1 quantile					
	coeff.		t	coeff.		t	coeff.		T
constant	-0.104	***	-17.11	-0.098	***	-13.62	-0.112	***	-9.82
process innovations	0.001		0.08	-0.008		-0.51	-0.006		-0.30
product innovations	0.020	*	1.79	0.043	***	3.31	-0.008		-0.37
organisational innovations	-0.004		-0.35	0.003		0.27	0.007		0.44
marketing innovations	0.012		1.01	0.001		0.09	0.004		0.16
average annual change in wage costs	-0.305	***	-10.77	-0.333	***	-8.84	-0.244	***	-5.61
average change in real sales	0.422	***	23.18	0.456	***	21.72	0.359	***	9.51
				0.2 quantile					
	coeff.		t	coeff.		t	coeff.		T
constant	-0.055	***	-14.68	-0.052	***	-11.18	-0.057	***	-8.89
process innovations	-0.001		-0.15	-0.003		-0.48	0.001		0.05
product innovations	0.019	***	3.20	0.029	***	4.47	-0.001		-0.10
organisational innovations	0.000		0.05	-0.004		-0.60	0.006		0.68
marketing innovations	0.005		0.71	0.007		1.07	0.007		0.69
average annual change in wage costs	-0.294	***	-9.84	-0.310	***	-7.37	-0.294	***	-6.55
average change in real sales	0.388	***	14.87	0.422	***	16.03	0.335	***	9.62
				0.3 quantile					
	coeff.		t	coeff.		t	coeff.		T
constant	-0.028	***	-11.85	-0.026	***	-7.93	-0.028	***	-7.71
process innovations	-0.001		-0.13	-0.007		-1.14	-0.004		-0.55
product innovations	0.013	***	2.81	0.021	***	3.67	-0.003		-0.43
organisational innovations	0.002		0.65	0.005		1.20	0.005		0.98
marketing innovations	0.006		1.36	0.005		1.02	0.005		0.55
average annual change in wage costs	-0.304	***	-9.94	-0.311	***	-8.52	-0.276	***	-8.04
average change in real sales	0.378	***	13.93	0.415	***	14.44	0.333	***	10.42
				0.4 quantile					
	coeff.		t	coeff.		t	coeff.		T
constant	-0.010	***	-4.20	-0.009	***	-2.85	-0.010	***	-2.61
process innovations	-0.001		-0.31	-0.002		-0.47	-0.001		-0.13
product innovations	0.009	**	2.13	0.013	***	2.91	-0.001		-0.12
organisational innovations	0.003		0.80	0.001		0.32	0.004		0.84
marketing innovations	0.007	*	1.72	0.006		1.45	0.006		0.87
average annual change in wage costs	-0.281	***	-8.63	-0.304	***	-7.12	-0.293	***	-8.17
average change in real sales	0.387	***	11.97	0.432	***	13.46	0.328	***	8.16
				0.5 quantile					
	coeff.		t	coeff.		t	coeff.		t
constant	0.007	***	3.77	0.007	***	2.42	0.007	**	2.28
process innovations	-0.002		-0.52	-0.005		-1.23	-0.001		-0.15
product innovations	0.009	***	2.67	0.011	***	2.85	0.004		0.40
organisational innovations	0.002		0.46	0.006		1.41	0.001		0.22
marketing innovations	0.006		1.67	0.007		1.46	0.003		0.37
average annual change in wage costs	-0.294	***	-9.97	-0.293	***	-6.41	-0.310	***	-8.34
average change in real sales	0.382	***	12.51	0.459	***	11.45	0.333	***	8.32
				0.6 quantile					
	coeff.		t	coeff.		t	coeff.		t
constant	0.023	***	10.17	0.023	***	6.55	0.024	***	6.44
process innovations	-0.004		-0.90	-0.004		-0.66	-0.005		-0.68
product innovations	0.009	**	2.18	0.007		1.30	0.005		0.62
organisational innovations	0.003		0.66	0.006		1.09	0.003		0.55
marketing innovations	0.007		1.35	0.006		1.06	0.008		0.92
average annual change in wage costs	-0.300	***	-8.31	-0.294	***	-5.96	-0.333	***	-7.76
average change in real sales	0.384	***	12.72	0.458	***	11.72	0.326	***	8.89
				0.7 quantile					
	coeff.		t	coeff.		t	coeff.		t
constant	0.044	***	16.75	0.043	***	11.83	0.046	***	13.09
process innovations	-0.003		-0.73	-0.006		-1.01	0.002		0.32
product innovations	0.008	*	1.94	0.008		1.51	0.005		0.94
organisational innovations	0.002		0.42	0.005		0.86	-0.003		-0.45
marketing innovations	0.007		1.34	0.006		1.08	0.008		1.05
average annual change in wage costs	-0.295	***	-11.35	-0.278	***	-6.97	-0.330	***	-8.84
average change in real sales	0.392	***	15.08	0.477	***	14.57	0.320	***	9.14
				0.8 quantile					
	coeff.		t	coeff.		t	coeff.		t
Cconstant	0.065	***	19.10	0.067	***	14.74	0.068	***	13.39
process innovations	-0.012	***	-2.53	-0.013	*	-1.89	-0.007		-0.95
product innovations	0.011	**	2.00	0.010		1.57	0.014		1.57

organisational innovations	0.009	**	2.09	0.009		1.62	0.002		0.28
marketing innovations	0.004		0.72	0.002		0.41	0.010		1.06
average annual change in wage costs	-0.282	***	-11.70	-0.312	***	-8.33	-0.293	***	-7.10
average change in real sales	0.413	***	18.30	0.497	***	23.40	0.319	***	9.98
				0.9 quantile					
	coeff.		t	coeff.		t	coeff.		t
constant	0.120	***	19.78	0.115	***	15.85	0.121	***	13.97
process innovations	-0.019	**	-2.12	-0.023		-1.49	-0.009		-0.63
product innovations	0.017	**	2.13	0.009		0.67	0.028	**	2.35
organisational innovations	-0.002		-0.17	0.002		0.16	-0.011		-0.93
marketing innovations	-0.013		-1.29	-0.005		-0.47	0.006		0.34
average annual change in wage costs	-0.263	***	-9.35	-0.326	***	-6.53	-0.236	***	-4.39
average change in real sales	0.421	***	17.45	0.548	***	16.34	0.330	***	9.12
number of observations	3072			1644		1428			

Note: Quantile regression was carried out with the SAS QUANTREG procedure, using the simplex algorithm and bootstrapped standard errors using 200 replications.

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 innovation have employment growth rates that are 1.1 percentage points higher than compared to non-innovators on average. 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 and Rottmann, 2011 and Lachenmaier and Rottman, 2007).

However, 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 Appendix 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, 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 with few exceptions. This holds true for both manufacturing and services.

The wage elasticity is about 0.3 with little differences between services and manufacturing and across the quantiles. The 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 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 (see Figure 2 in the appendix). The significant 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 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 can 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.

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 the services than for manufacturing firms (see Evangelista and 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 Gibrat’s law 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 and Rottmann 2011), and treatment of heterogeneity (focusing on average effects and/or quantile regressions).

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.		t
constant	-0.103	***	-17.35	-0.098	***	-13.60	-0.111	***	-10.05
process innovations	0.006		0.51	0.008		0.64	-0.008		-0.41
market novelties	0.014		1.27	0.036	***	3.05	-0.010		-0.34
organisational innovations	-0.003		-0.29	-0.003		-0.27	0.006		0.40
marketing innovations	0.014		1.12	0.017		1.24	0.005		0.21
average annual change in wage costs	-0.306		-10.60	-0.344		-9.68	-0.225	***	-5.15
average change in real sales	0.426	***	23.62	0.460	***	23.43	0.346	***	9.35
				0.2 quantile					
	coeff.		t	coeff.		t	coeff.		t
Constant	-0.054	***	-14.12	-0.050	***	-11.30	-0.056	***	-8.70
process innovations	0.005		0.90	0.003		0.48	0.001		0.08
market novelties	0.016	***	2.82	0.023	***	4.19	-0.004		-0.30
organisational innovations	-0.001		-0.26	-0.001		-0.14	0.005		0.63
marketing innovations	0.007		1.15	0.007		1.24	0.009		0.85
average annual change in wage costs	-0.291	***	-10.22	-0.319	***	-7.53	-0.292	***	-6.68
average change in real sales	0.394	***	14.49	0.428	***	17.47	0.333	***	9.57
				0.3 quantile					
	coeff.		t	coeff.		t	coeff.		t
Constant	-0.027	***	-11.60	-0.024	***	-7.51	-0.028	***	-7.77
process innovations	0.003		0.81	0.001		0.28	-0.004		-0.54
market novelties	0.011	***	2.59	0.013	**	2.30	-0.003		-0.33
organisational innovations	0.002		0.72	0.005		1.13	0.006		1.02
marketing innovations	0.005		1.25	0.005		1.00	0.003		0.39
average annual change in wage costs	-0.307	***	-9.83	-0.322	***	-8.53	-0.280	***	-8.12
average change in real sales	0.380	***	13.82	0.424	***	14.73	0.334	***	10.36
				0.4 quantile					
	coeff.		t	coeff.		t	coeff.		t
constant	-0.009	***	-3.90	-0.007	**	-2.46	-0.010	***	-2.75
process innovations	0.000		0.02	-0.001		-0.24	-0.001		-0.13
market novelties	0.011	***	2.87	0.012	***	2.60	0.000		0.06
organisational innovations	0.003		0.92	0.003		0.64	0.004		0.78
marketing innovations	0.006		1.57	0.005		1.11	0.005		0.70
average annual change in wage costs	-0.277	***	-8.72	-0.307	***	-7.18	-0.296	***	-8.44
average change in real sales	0.377	***	12.20	0.424	***	12.75	0.326	***	8.10
				0.5 quantile					
	coeff.		t	coeff.		t	coeff.		t
constant	0.008	***	4.04	0.008	***	2.72	0.007	**	2.30
process innovations	0.000		-0.06	-0.003		-0.74	-0.001		-0.18
market novelties	0.007	**	2.01	0.009	**	2.13	0.003		0.41
organisational innovations	0.003		1.03	0.006		1.47	0.001		0.25
marketing innovations	0.005		1.38	0.007		1.48	0.004		0.45
average annual change in wage costs	-0.297	***	-10.00	-0.296	***	-6.64	-0.310	***	-8.46
average change in real sales	0.385	***	12.90	0.459	***	11.74	0.333	***	8.30
				0.6 quantile					
	coeff.		t	coeff.		t	coeff.		t
constant	0.024	***	10.70	0.024	***	7.17	0.024	***	6.74
process innovations	-0.002		-0.52	-0.003		-0.51	-0.005		-0.64
market novelties	0.007		1.60	0.005		0.81	0.005		0.62
organisational innovations	0.004		0.91	0.006		1.07	0.002		0.37
marketing innovations	0.007		1.52	0.009		1.67	0.009		1.21
average annual change in wage costs	-0.296	***	-8.41	-0.295	***	-6.23	-0.332	***	-7.61
average change in real sales	0.383	***	12.79	0.456	***	11.44	0.324	***	8.76
				0.7 quantile					
	coeff.		t	coeff.		t	coeff.		t
constant	0.044	***	17.01	0.042	***	12.12	0.047	***	13.46
process innovations	-0.002		-0.39	-0.004		-0.81	0.001		0.23
market novelties	0.006		1.20	0.008		1.33	0.005		0.81
organisational innovations	0.003		0.60	0.006		1.15	-0.003		-0.54
marketing innovations	0.008		1.60	0.004		0.64	0.008		1.07
average annual change in wage costs	-0.291	***	-11.46	-0.273	***	-6.69	-0.330	***	-8.64
average change in real sales	0.394	***	15.10	0.477	***	14.84	0.319	***	9.03
				0.8 quantile					
	coeff.		t	coeff.		t	coeff.		t
constant	0.066	***	19.22	0.067	***	14.51	0.069	***	13.94
process innovations	-0.006		-1.51	-0.011		-1.57	-0.007		-1.08
market novelties	0.006		1.07	0.006		1.04	0.018	*	1.86

	coeff.		t	coeff.		t	coeff.		t
organisational innovations	0.009		2.00	0.009		1.64	0.003		0.45
marketing innovations	0.005		0.99	0.003		0.55	0.011		1.24
average annual change in wage costs	-0.284	***	-11.97	-0.310	***	-8.25	-0.300	***	-7.40
average change in real sales	0.412	***	18.12	0.497	***	22.78	0.320	***	10.39
				0.9 quantile					
	coeff.		t	coeff.		t	coeff.		t
constant	0.123	***	20.79	0.116	***	16.00	0.124	***	13.59
process innovations	-0.010		-1.09	-0.018		-1.30	-0.001		-0.03
market novelties	0.003		0.28	-0.008		-0.83	0.028	*	1.67
organisational innovations	-0.001		-0.10	0.012		1.03	-0.013		-1.02
marketing innovations	-0.011		-1.08	-0.004		-0.34	-0.003		-0.18
average annual change in wage costs	-0.265	***	-9.00	-0.323	***	-6.25	-0.210	***	-3.87
average change in real sales	0.423	***	18.29	0.547	***	16.32	0.335	***	8.74

Note: The number of observations is 3070. Source: Statistics Austria Linked CIS-SBS data, own calculations.

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 increase when moving from lower to higher quantiles. The insignificance of process innovations is partly significant 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 both measured in the same period but are insignificant for service firms. As mentioned above the insignificance of organizational changes 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 reestimated 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 have included interaction terms between the different types of innovations. A number of scholars mentioned that organizational and technological innovations are complementary to each 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 omitted variables bias. To account for this, we have 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. However, the factors are not significantly different from zero and also lead to significant reduction of the estimation sample because a significant number of firms do not use contract workers or purchased external services.

5 Conclusions

In this paper we have 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 services. 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 be only observed for high growth firms. 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 shows 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 the earlier literature. It is important to note that possible effects of product innovations are likely to be underestimated given that the empirical model controls for output changes. 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. However, it should be noted that organizational innovations refer to a specific point in time namely the 2006-2008 boom phase. It could be the case that job destroying organizational innovations are more prevalent in economic recession periods or phases of low 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. Second, this study measures product innovations as a dummy variable. An alternative preferred way 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. Due to the rotating nature of the Austrian CIS data, however, the same firms rarely overlap across different CIS waves. Therefore, panel data methods would thus 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. For example, it might be the case that non-innovating firms can benefit from innovations via imitations and spillover effects. Fourth, we use a broad measure of organizational change that includes 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.

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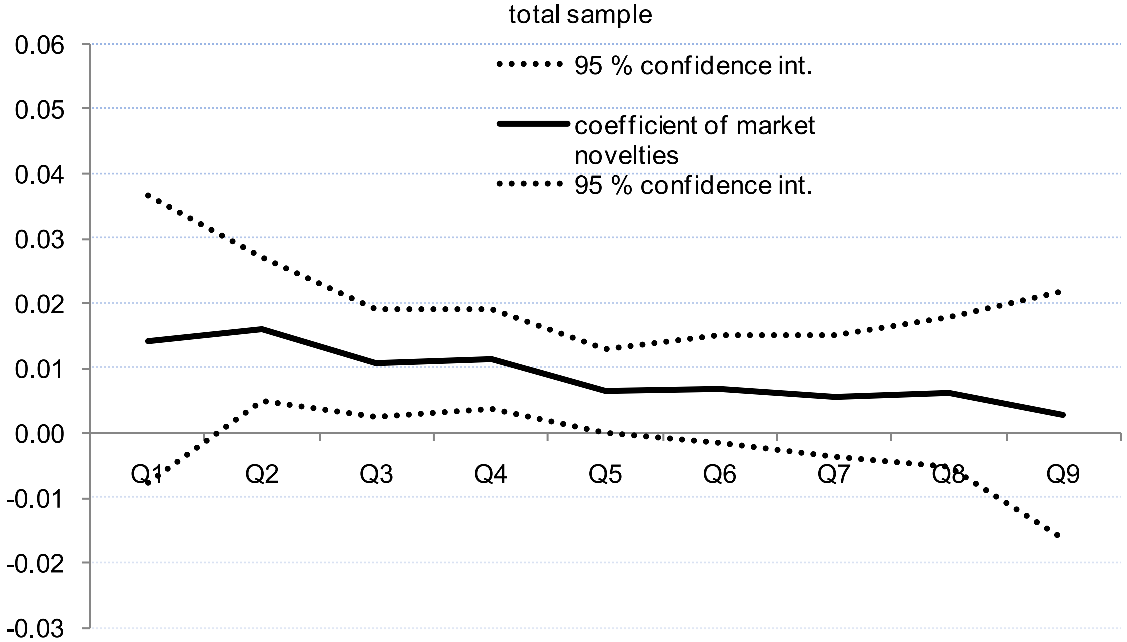
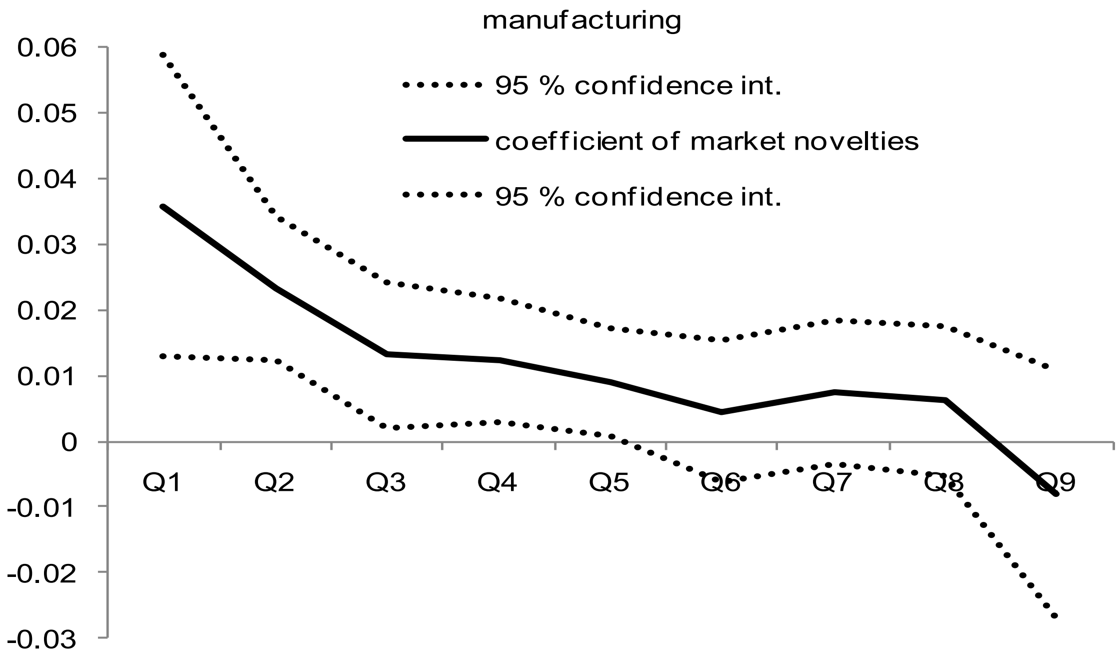
Appendix

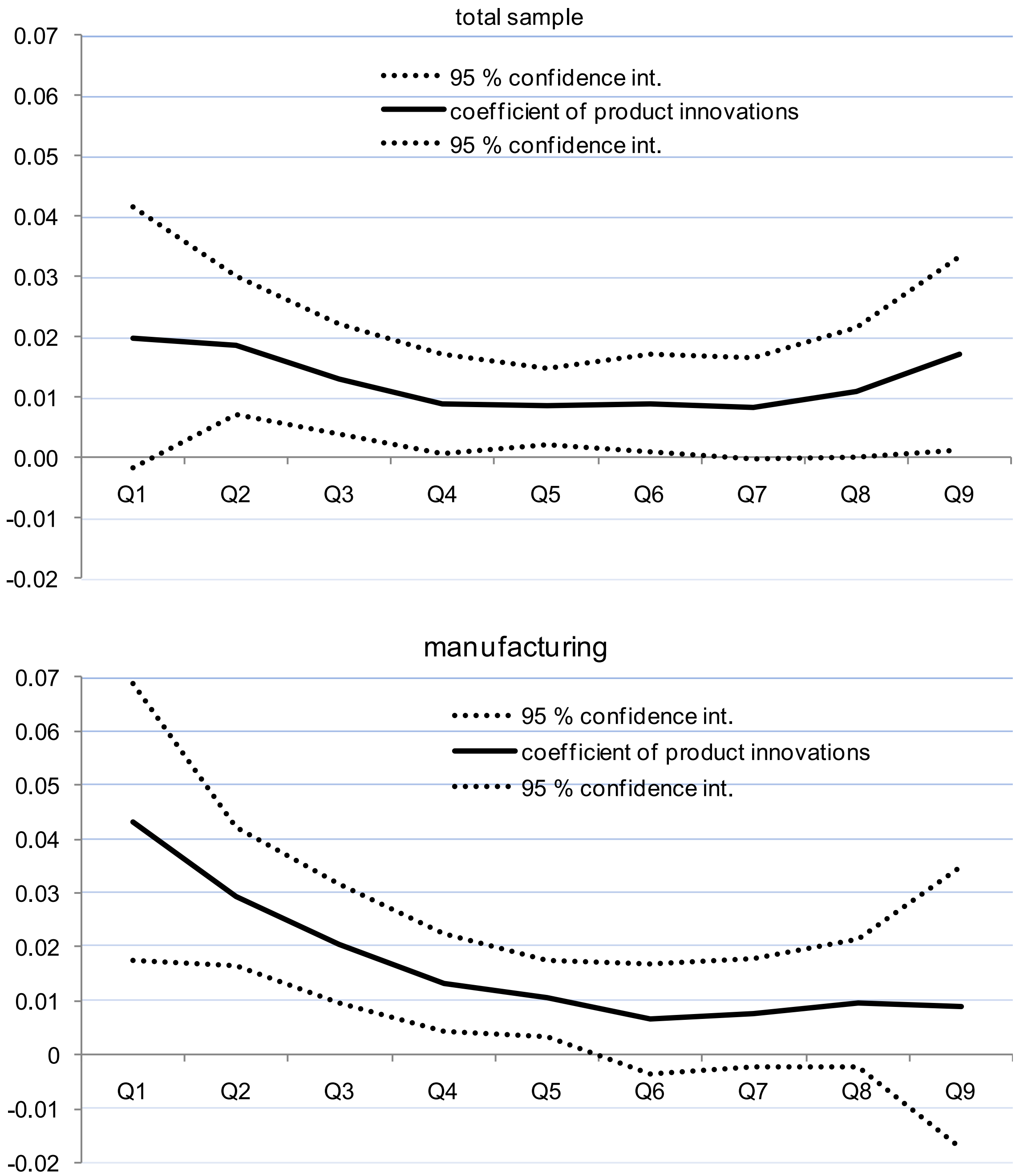
Figure 1: Quantile regression estimates of the impact of market novelties





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.