Employment effects of technological and organizational innovations: Evidence based on linked Firm-Level Data

Martin Falk (Austrian Institute of Economic Research, WIFO)

Abstract:

This paper investigates the impact of technological, organizational and marketing innovations on subsequent employment growth. The main novelty of the paper is the use of a unique dataset merging CIS 2006 data with the structural business statistics 2006-2008 resulting in 3150 firm observations. Quantile regressions based on manufacturing firms shows that product innovations have significantly positive but decreasing impact on employment growth over its conditional distribution. For services high growth firms only benefit from product innovations. The results are robust with respect to the measurement of product innovations (e.g. market novelties). Furthermore, process, organizational and marketing 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

In the literature there is an ongoing discussion to what extent the impact of technological innovations on performance and employment growth differ along the conditional distribution. The key question is to what extent low growth and high growth firms benefit from technological innovations. Previous studies find a large degree of parameter heterogeneity in the impact of technological innovations on firm performance and/or employment growth (see, for example, Coad & Rao, 2006 and 2008; Falk, 2012; García-Manjón & Romero-Merino, 2012; Hölzl, 2009; Spithoven et al. 2010; Zimmermann, 2009). 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 firm growth. In particular, the impact of innovation output and/or R&D is only significant for the higher quantiles, while the average effect is quite small and often insignificant. Other studies find a R&D and innovation variables are not significant at the upper quantiles indicating diminishing returns (Ebersberger et al., 2010). Similarly, Damijan, Kostevc, and Rojec (2012) find that firms with low TFP growth benefit more from product and process innovation than do firms with high productivity growth rates based on firm level manufacturing data for Slovenia.

This article provides further empirical evidence on the relationship between technological and non technological innovations on employment growth. Unlike previous studies that focus on firm growth this study use the quantile regression technique applied to labour demand model to study the heterogeneity of employment effects of technological and organizational. 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 data for Austria linked with the structural business statistics. The main focus of this research is on the direct effects of innovation on employment growth at the firm level. This paper makes three main contributions to the literature. Firstly, we use a unique dataset that links the community innovation survey with the structural business statistics where information on sales revenues, employment and wage costs is based on the latter and the remaining variables based on CIS data. Secondly, we investigate the employment effects of technological and non technological innovations after the successful introduction rather than during its successful introduction. Thirdly, we investigate the impact of organizational change on employment. Few studies have investigated the effecs of organizational change on overall employment (for rare exceptions see Bauer and Bender 2004; Caroli and Van Reenen 2001; Evangelista and Vezzani 2010, 2012). Fourthly, we investigate the firm-level heterogeneity in the employment effects of different types of innovation by distinguishing between services and manufacturing firms. Previous studies find significant differences in the impact of technological innovations between manufacturing and service firms (see Cainelli, Evangelista, Savona

2004, 2006). 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. Hamermesh (2007) suggests that scientific replications are important to evaluate and assess empirical results and for scholars who are conducting a meta-analyses. It means re-examining an idea in some published research by studying it using a different data set chosen from a different sample and different population. In this paper we use the labour demand model of Lachenmaier and Rottmann (2011) and Zimmermann (2009) and apply it to a different data set. Unlike these studies 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 some summary statistics and the description of the data before providing the empirical results in section 4. Section 5 contains some concluding remarks.

2 Theoretical background and empirical model

Empirical studies at the firm level have provided strong evidence of a positive and significant impact of product innovations on employment (Van Reenen, 1997; Greenan and Guellec, 2001; Harrison, Jaumandreu, Mairesse and Peters, 2008; Lachenmaier and Rottmann, 2011; see Pianta, 2005; Vivarelli 2012 for recent surveys of the literature). The employment effects of process innovations are, however, not clear cut. The literature suggests that process innovations can have a direct negative employment effect by the replacement of labour by new machines and production processes (Edquist, Hommen, and McKelvey, 2001; Peters, 2004). This is referred as the displacement effect. However, process innovations can increase productivity and efficiency. This is referred 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 to organize 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 is 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 (Brynjolsson and Hitt 2002; 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 raises the firms productivity (Bloom and Van Reenen, 2011). However, the implementation of new business practices often leads to a reduction of the workforce. While it is generally acknowledged that organizational change leads to increase in the demand for skilled workers at the expense of unskilled workers (see e.g Caroli and Van Rennenm 2001), the overall employment effect is not clear cut. Using firm-level data CIS4 data for a number of EU countries Evangelista and Vezzani (2012) find that organizational change have a positive impact on sales revenues and thereby increase labour demand. Using a matched employer employee data set, Bauer and Bender (2004) find firms introducing high performance work practices show significantly lower net employment growth rates.

Outsourcing is also expected to lead to cost savings because production and service activities with no comparative advantage will be outsourced to external suppliers (Sharpe 2007). However, changes in external relations with other firms such as the first use outsourcing and/or sub-contracting 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 technological and organizational innovation are an empirical question. Using a CES cost function with the production factors 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 denotes the firm and year respectively. L denotes employment, Y real output and WP real wages and τ denotes technological change. Since all variables except technological change enter the labour demand equation in logs, the coefficients can be 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 long differences to the data. This gives the short-run labour demand function:

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

where the variables are defined as:

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

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

ΔlnY: annual average percentage change in sale revenues deflated by the industry specific gross output 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 (business practices, knowledge management, workplace organisation or external relations between 2004-2006,

MKT: a new marketing concept or strategy.

The labour demand equations can be in principle estimated by Ordinary least squares (OLS). However, OLS model only look at the mean of the conditional distribution of the dependent variable. There are several reasons to believe that the employment effects of technological and organizational innovations are uneven between firms with rising and falling employment. One reason is that the outcome of innovations is generally uncertain and risky and therefore not all types of firms benefit from innovations (Marsili and Salter, 2005; Mata and Woerter, 2013). Therefore, it is interesting to know the effects of different types of innovations at different points of the conditional distribution of employment growth. We apply a quantile regression procedure developed by Koenker and Bassett (1978) to estimate to what extent different types of technological innovations affects employment growth differently for firms between falling and rising employment. Quantile regression has been frequently applied to analyse issues related to the distribution of returns to innovation (Coad and Rao, 2006; Coad and Rao, 2008; Ebersberger et al. 2019; Goedhuys and Sleuwaegen, 2010; Hölzl, 2009; Kaiser, 2009; Love et al., 2009; Falk, 2012; Mata and Wörter, 2013; Bartelsman et al., 2013). We use the simplex algorithm which is preferred for moderate sample sizes of few thousands observations (Koenker, 2005). Standard errors of the coefficient estimates are obtained by using bootstrap methods with 200 replications.

Since we would expect the introduction of technological innovations effect employment growth only with a time lag, different types of innovations are lagged one period that is 2004-2006. We assume that the causality goes from technological innovations and/or new organizational practices introduced in the past on subsequent employment growth. By using one period lag of different types of innovations we 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 and there is generally the problem in the CIS data that information on variables measuring innovation input are only available for innovating firms.

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 CIS is a representative random sample of firms that is stratified by industry, firm size, and region. It covers the manufacturing, mining, energy, water supply, and specific service industries (e.g. wholesale trade, transport, banking and insurance, computer and related activities, architectural and engineering activities, and technical testing and analysis). All enterprises with at least 10 employees in the target industries are included. The CIS 2006 questionnaire was sent to out 5,412 firms, of which 3,513 provided reliable information. This resulted in a response rate of 65.5 per cent (Statistics Austria, 2008). The second data source, SBS, contains information on turnover, gross output, value added, total materials, and materials by type for the period 2004-2008. The majority of firms included in the CIS are also covered in this database. After merging CIS and SBS data 3,142 firm observations remains; 90 per cent of the firms included in the CIS are thus covered in the linked dataset.[1]

Product and process 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). Among non technological innovations changes in the organizational structure of the firms belong to the most frequent forms of innovations. About 35 percent of the service and manufacturing firms introduced new organizational practices or changed the organizational structure of the firm. Organizational change include 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.

[1] For previous studies based on matched innovation survey and industrial census or production survey data, see Le Bas, Haned, and Colombelli (2011) for France; Bartelsman et al. (1998), Klomp and van Leeuwen (2001), and Raymond et al. (2010) for the Netherlands; Cainelli, Evangelista, and Savona (2004, 2006) for Italy; Aas and Pederson (2011) for Norway; Damijan, Kostevc and Rojec (2012) for Slovenia, Lööf and Heshmati (2006) for Sweden; and Tether and Bascavusoglu-Moreau (2012) for the UK and Meriküll (2010) for Estonia.

Table 1: Descriptive statistics

	Q1	median	Q3	mean
		total		
average annual change in wage costs	-2.9	1.3	5.4	1.4
average annual change in real sales	-3.5	2.8	10.0	3.2
average annual change in employment	-3.2	1.9	7.3	1.6
process innovations				37.5
product innovations				35.5
market novelties				19.4
organisational innovations				34.9
marketing innovations				19.4
		manufacturing		
average annual change in wage costs	-1.8	2.1	5.7	2.3
average annual change in real sales	-3.8	2.7	9.8	3.3
average annual change in employment	-2.7	1.9	7.0	1.9
process innovations				43.5
product innovations				40.8
market novelties				21.6
organisational innovations				35.1
marketing innovations				21.6
		services		
average annual change in wage costs	-4.0	0.5	4.8	0.4
average annual change in real sales	-3.2	3.0	10.3	3.2
average annual change in employment	-3.7	1.9	7.7	1.3
process innovations				30.6
product innovations				29.4
market novelties				17.0
organisational innovations				34.6
marketing innovations				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.

4 Empirical results

Table 2 shows the quantile regression results for the employment effects of different types of innovations. This table provides results for the total sample and separate results for industry and service firms. For the total sample we find that the new or successful improved products have a significant impact on subsequent employment growth at the 5 % significance level at the different quantiles. 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. It is interesting to note that the employment effects of product innovations differ widely in magnitude across the different deciles. In particular, the coefficient of production 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). The coefficient of 0.02 means that the employment growth of product innovators is 2 percentage points higher than that of non-innovators given the impact of wages, output and other firm characteristics. Unreported results shows that F-Tests of the equality of the coefficient estimate of product innovations across the different quantiles are rejected at the 5 percent level of significance.

Separate estimation results for manufacturing and service firms show significant difference in the relationship between product innovations and employment growth. 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 (see also Figure 1 in the Appendix). However, production innovations do not have an insignificant impact on employment growth in the upper quantiles from the 0.6 to 0.9 quantiles.

The results stands in contrast to Zimmermann (2009) who finds that the impact of both product and process innovations increase when moving from the lower to the higher quantiles. For manufacturing the results are consistent with Damijan Kostevc and Rojec (2012) who find that product innovations have a significant impact on total factor productivity growth from the 0.1 to 0.4 quantile of productivity growth based on linked CIS data and balance sheets data for Slovenian manufacturing. Furthermore, 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.

For service firms high growth firms only benefit from product innovations with significant coefficients at the 0.8 and 0.9 quantiles. Figure 1 plots the estimated coefficients and associated 95% confidence intervals for the coefficient of product innovations for the total sample and for manufacturing. 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.

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
av. annual change in wage costs	-0.305	***	-10.77	-0.333	***	-8.84	-0.244	***	-5.61
av. 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
av. annual change in wage costs	-0.294	***	-9.84	-0.310	***	-7.37	-0.294	***	-6.55
av. 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

av. annual change in wage costs	-0.304	***	-9.94	-0.311	***	-8.52	-0.276	***	-8.04
av. change in real sales	0.378	***	13.93	0.415	***	14.44	0.333	***	10.42
				0.4 quantile					
	coeff.f.		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
av. annual change in wage costs	-0.281	***	-8.63	-0.304	***	-7.12	-0.293	***	-8.17
av. 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
av. annual change in wage costs	-0.294	***	-9.97	-0.293	***	-6.41	-0.310	***	-8.34
av. change in real sales	0.382	***	12.51	0.459	***	11.45	0.333	***	8.32
				0.6 quantile					
Parameter	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
av. annual change in wage costs	-0.300	***	-8.31	-0.294	***	-5.96	-0.333	***	-7.76
av. 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
av. annual change in wage costs	-0.295	***	-11.35	-0.278	***	-6.97	-0.330	***	-8.84
av. 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
constant	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
av. annual change in wage costs	-0.282	***	-11.70	-0.312	***	-8.33	-0.293	***	-7.10
av. 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
av. annual change in wage costs	-0.263	***	-9.35	-0.326	***	-6.53	-0.236	***	-4.39
av. change in real sales	0.421	***	17.45	0.548	***	16.34	0.330	***	9.12
no of obs	3072			1644		1428			

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

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 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 product innovations over the distribution indicates a convex relationship. For instance the coefficients 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. The coefficients for the 0.2 and 0.3 quantile are 0.023 and 0.013 respectively and thus much lower as compared to the 0.1 quantile. At higher quantiles we find a positive but insignificant impact of market novelties. In contrast for services 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 coefficient is only significant at the 10 percent level.

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
av. annual change in wage costs	-0.306		-10.60	-0.344		-9.68	-0.225	***	-5.15
av. 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
av. annual change in wage costs	-0.291	***	-10.22	-0.319	***	-7.53	-0.292	***	-6.68
av. 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
av. annual change in wage costs	-0.307	***	-9.83	-0.322	***	-8.53	-0.280	***	-8.12
av. 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
av. annual change in wage costs	-0.277	***	-8.72	-0.307	***	-7.18	-0.296	***	-8.44
av. 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
av. annual change in wage costs	-0.297	***	-10.00	-0.296	***	-6.64	-0.310	***	-8.46
av. 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
av. annual change in wage costs	-0.296	***	-8.41	-0.295	***	-6.23	-0.332	***	-7.61
av. 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
av. annual change in wage costs	-0.291	***	-11.46	-0.273	***	-6.69	-0.330	***	-8.64
av. 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
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
av. annual change in wage costs	-0.284	***	-11.97	-0.310	***	-8.25	-0.300	***	-7.40
av. 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
av. annual change in wage costs	-0.265	***	-9.00	-0.323	***	-6.25	-0.210	***	-3.87
av. 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

We have conducted a number of robustness checks. First, we have included interaction terms between the different types of innovations. Bresnahan et al. (2002) and Damanpour, Walker, and Avellaneda (2009) suggest that combinations of different types of innovations may have a larger impact on firms performance. This may also hold for employment change. However, unreported results show that interaction terms between process innovations and organizational innovations are not significant. This also holds for the interaction term between product innovations and organizational innovations. Another concern is possible omitted variables. We have included a number of other variables that could affect labour demand such as expenditure for external contract workers and expenditures for externally provided services. However, the factors are not significantly different from zero and also leads to significant reduction of the estimation sample because a significant number of firms do use contract workers or purchase external services.

5 Conclusions

In this paper we have employed quantile regression techniques to investigate whether different types of innovations affect employment growth differently in firm with falling and rising employment. We used a unique database merging CIS 2006 data with the structural business statistics for the period 2006 to 2008 for Austria. 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. The holds also for the alternative measure of product innovation that is market novelties. For service firms we find that high

growth firms benefit only from product innovations and/or market novelties. 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 and do not vary much over the conditional distribution.

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 technological and organizational innovations as a dummy variable. An alternative preferred way is to use the change in new products as the measure of product innovations (Jaumandreu 2003). However, cross section CIS data only include a measure of the share of sales from new products for a given year. In principle, matching different CIS waves would make it possible to calculate the change in sales from new products. Due to the rotating nature of the CIS data, however, the same firms rarely overlap across different CIS waves; panel data methods would thus offer little additional insights. Third, 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 a broad measure of organizational change.

References

Aas T. H., & Pedersen, P. E. (2011). The impact of service innovation on firm-level financial performance. The Service Industries Journal, 31(13), 2071-2090.

Bartelsman, E.J., van Leeuwen, G., & Nieuwenhuijsen, H.R. (1998). Adoption of Advanced Manufacturing Technology and Firm Performance in the Netherlands. The Economics of Innovation and New Technology, 6, 291 312.

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

Bloom N. & Van Reenen J. (2011), Human Resource Management and Productivity. In: Orley Ashenfelter, David Card, editors. Handbook of Labor Economics. Amsterdam: Elsevier North-Holland.

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

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

Coad, A., & Rao, R. (2006). Innovation and market value: A quantile regression analysis. Economics Bulletin, 15(13), 1–10.

Coad, A., & Rao, R. (2008). Innovation and firm growth in high-tech sectors: A quantile regression approach. Research Policy, 37(4), 633–648.

Damanpour, F., Walker, R. M., & Avellaneda, C. N. (2009). Combinative Effects of Innovation Types and Organizational Performance: A Longitudinal Study of Service Organizations. Journal of Management Studies, 46(4), 650-675.

Damijan J. P., Kostevc, Č, & Rojec, M. (2012). Does innovation help the good or the poor performing firms? Economics Letters, 115 (2) 190-195.

Ebersberger, B., Marsili, O., Reichstein, T., Salter, A., (2010). Into thin air: using a quantile regression approach to explore the relationship between R&D and innovation. International Review of Applied Economics 24(1), 95-102.

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

Evangelista, R., & Savona, M. (2002). The impact of innovation on employment in services: Evidence from Italy. International Review of Applied Economics, 16(3), 309–18.

Evangelista, R., Savona, M., (2003). Innovation, Employment and Skills in Services: Firm and Sectoral Evidence. Structural Change and Economic Dynamics 14 (4), 449–74.

Evangelista, R. & Savona, M. (2011). Innovation and employment in services. The handbook of innovation and services: A multi-disciplinary perspective, Cheltenham Elgar, 367–391.

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

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

Falk, M. (2012). Quantile estimates of the impact of R&D intensity on firm performance. Small Business Economics, 39(1), 19–37.

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

García-Manjóna, J. V., & Romero-Merino, M.E. (2012). Research, development, and firm growth. Empirical evidence from European top R&D spending firms. Research Policy, 41, 1084–1092.

Goedhuys, M., & Sleuwaegen, L. (2010). High-growth entrepreneurial firms in Africa: A quantile regression approach. Small Business Economics, 34, 31–51.

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

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

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

Hölzl, W. (2009). Is the R&D behaviour of fast-growing SMEs different? Evidence from CIS III data for 16 countries. Small Business Economics, 33, 59–75.

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

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

Kaiser, U., (2009). Patents and profit rates. Economics Letters 104(2), 79-80.

Klomp, L. & van Leeuwen, G. (2011). Linking Innovation and Firm Performance: A New Approach. International Journal of the Economics of Business, 8, 343–364.

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

Koenker. R., & Hallock, K. (2001). Quantile regression. Journal of Economic Perspectives. 15 (4). 143–56.

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

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

Le Bas, C., Haned, N., & Colombelli, A., (2011). On firm growth and innovation – some new empirical perspectives using French CIS, 1992–2004. ICER Working Paper No. 7/2011.

Lin, C. Y.-Y. & Chen, M. Y.-C. (2007). Does innovation lead to performance? An empirical study of SMEs in Taiwan. Management Research News, 30(2), 115–132.

Lööf, H. & Heshmati, A. (2006). On the relationship between innovation and performance: A sensitivity analysis. Economics of Innovation and New Technology, 15(4-5), 317–344.

Love, J.H, Roper, S., & Du, J. (2009). Innovation, ownership and profitability. International Journal of Industrial Organization 27(3), 424-434.

Marsili, O. & Salter, A (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., & Woerter M., (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.

Peters, B. (2008). Innovation and firm performance: an empirical investigation for German firms. Heidelberg Physica.

Pianta, M. (2005). Innovation and employment. In: J. Fagerberg. D. Mowery and R. Nelson (eds). Oxford Handbook of Innovation. Oxford: Oxford University Press. 568–598.

Reichstein, T., Dahl, MS., Ebersberger, B., Jensen, MB. (2010). The devil dwells in the tails: a quantile regression approach to firm growth. Journal of Evolutionary Economics 20, 219–231.

Rottmann, H. & Ruschinski M. (1998). The Labour Demand and the Innovation Behaviour of Firms, Jahrbücher für Nationalökonomie und Statistik 217, 741–752.

Sharpe, M. (1997). Outsourcing, organizational competitveness, and work', Journal of labor Research XVIII(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, . (2002). Employment Adjustment at the Firm Level. A Theoretical Model and an Empirical Investigation for West German Manufacturing Firms, Labour 16, 65-88.

Spithoven, A., Frantzen, D. & Clarysse B. (2010). Heterogeneous Firm-Level Effects of Knowledge Exchanges on Product Innovation: Differences between Dynamic and Lagging Product Innovators, Journal of Product Innovation Management 27(3): pp. 362–381

Van Reenen, J. (1997). Employment and technological innovation: Evidence from U.K. manufacturing firms. Journal of Labor Economics, 15(2), 255–84.

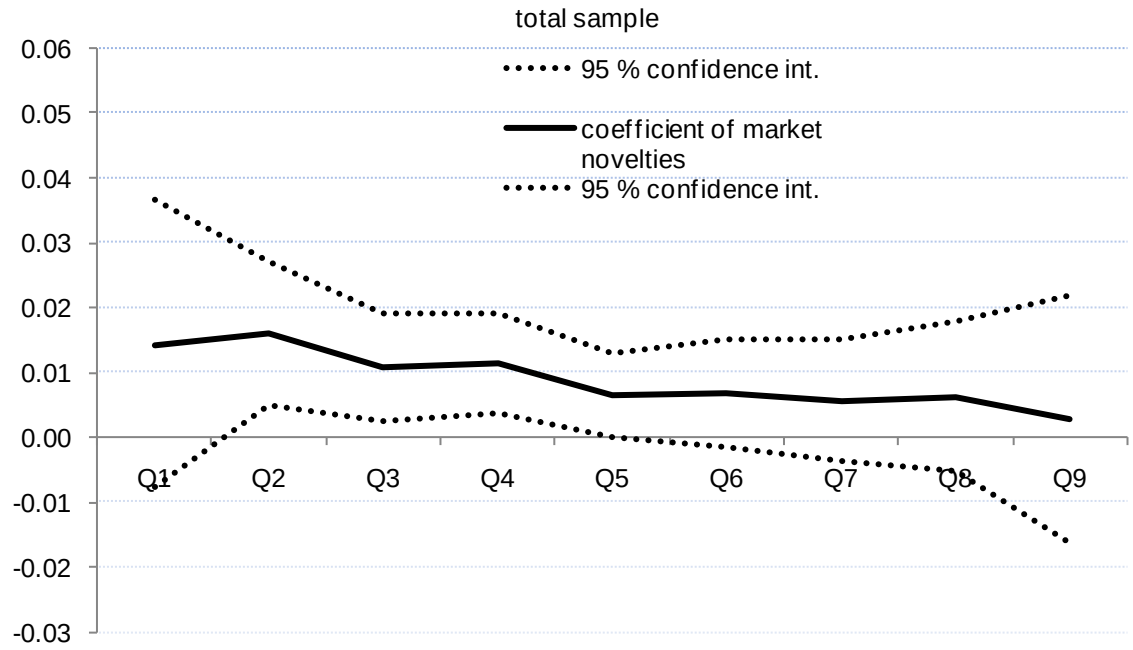
Vivarelli, M. (2012). Innovation. employment and skills in advanced and developing countries: A survey of the literature. IZA discussion paper 6291.

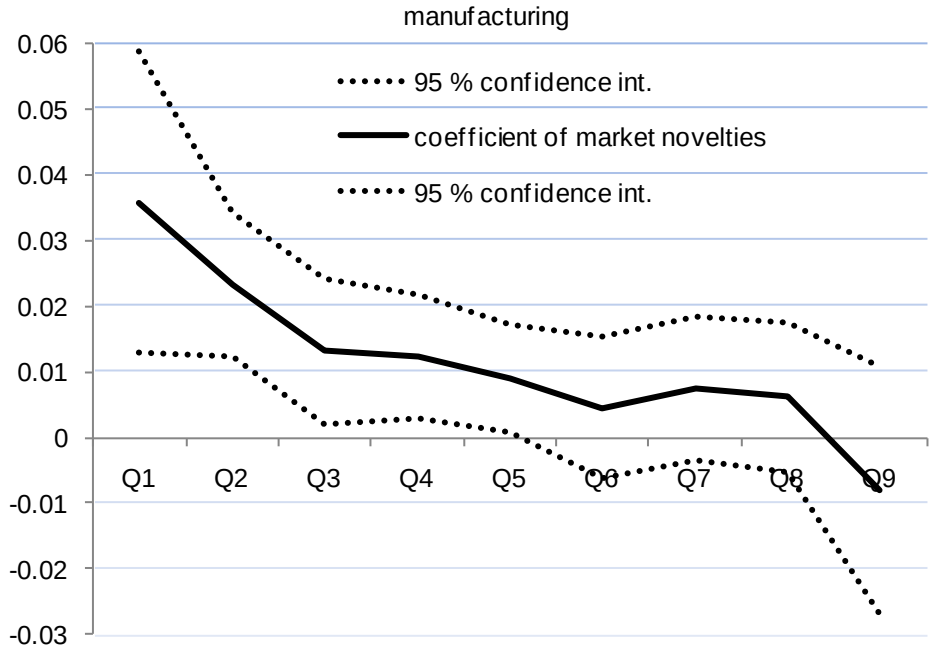
Vivarelli, M. and M. Pianta (2000), The Employment Impact of Innovation: Evidence and Policy. Routledge.

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.

Appendix

Figure 1: Quantile regression estimates of the impact of product innovations





Note: Confidence intervals for the quantile process are computed with the resampling method and 200 replications.

Figure 2: Quantile regression estimates of the impact of market novelties