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Employment Effects of Innovation over the Business Cycle: Evidence from European Countries

Bernhard Dachs
AIT - Austrian Institute of Technology
Innovation Systems
Bernhard.Dachs@ait.ac.at

Martin Hud
ZEW (Center for European Economic Research)
Industrial Organization and International Management
hud@zew.de

Christian Koehler
ZEW (Center for European Economic Research)
Industrial Organization and International Managament
koehler@zew.de

Bettina Peters
ZEW Centre for European Economic Research
Industrial Economics and International Management
b.peters@zew.de

Abstract

A growing literature has investigated how firms? R&D and innovation behaviour react to changes in the business cycle. However, so far it has not been analysed to what extent the employment effects of innovation vary over the business cycle despite the literature has been stressing that these effects are largely driven by demand. This paper fills this gap by studying how the ability of firms to transform innovation into employment growth changes over the business cycle. The empirical analysis is based on the model of Harrison et al. (2014) and employs observations for about 234.000 manufacturing firms from 26 European countries over the period 1998-2010. The empirical evidence reveals that product innovations induce similar gross employment growth in all phases of the business cycle. The effect of product innovation on net employment growth is positive except in recessions when gains from new products cannot fully compensate losses in old products. However, employment losses are far lower than for non-product innovators. Process and organizational innovations reduce employment growth during economic up- and downturns implying labour displacement effects to exceed labour compensating effects. A sample split into different European country groups shows regional heterogeneity concerning the effect of process and organizational innovations over the business cycle but not for product innovations.

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Employment Effects of Innovation over the Business Cycle: Firm-Level Evidence from European Countries[1]

February 2015

Abstract

A growing literature has investigated how firms' R&D and innovation behaviour react to changes in the business cycle. However, so far it has not been analysed to what extent the employment effects of innovation vary over the business cycle despite the literature has been stressing that these effects are largely driven by demand. This paper fills this gap by studying how the ability of firms to transform innovation into employment growth changes over the business cycle. The empirical analysis is based on the model of Harrison et al. (2014) and employs observations for about 234.000 manufacturing firms from 26 European countries over the period 1998-2010. The empirical evidence reveals that product innovations induce similar gross employment growth in all phases of the business cycle. The effect of product innovation on net employment growth is positive except in recessions when gains from new products cannot fully compensate losses in old products. However, employment losses are far lower than for non-product innovators. Process and organizational innovations reduce employment growth during economic up- and downturns implying labour displacement effects to exceed labour compensating effects. A sample split into different European country groups shows regional heterogeneity concerning the effect of process and organizational innovations over the business cycle but not for product innovations.

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Keywords

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1 Introduction

Overcoming the global economic crisis, set off in 2008 and still ongoing in many European countries, and ensuring long-term competitiveness and growth is a key challenge for European policymakers. Research and development (R&D) and innovation activities are regarded as main drivers for the competitiveness of firms and, consequently, for economic growth and job creation. Therefore, fostering R&D and innovation activities is one of the major goals of the Europe 2020 Strategy – an European action plan prioritizing the implementation of a knowledge- and innovation-based economy, a more sustainable and competitive economy and a high-employment economy (EC, 2010). Within the Europe 2020 Strategy, the "Innovation Union" is one of seven flagship initiatives and aims at improving the conditions as well as the access to finance for research and innovation to create growth and jobs (EC, 2010). A key issue in the current debate on achieving the Europe 2020 Strategy's targets is to what extent the EU countries hit by the crisis are able to translate new products and technologies into employment growth. This largely hinges upon both cyclical fluctuations of firms' innovation behaviour as well as cyclical variations in the ability of firms to transform innovation into employment growth.

There is a large literature on the effect of innovation on employment growth (for surveys see Chennells and Van Reenen, 2002 and Vivarelli 2012). Despite the literature has been stressing employment effects of both product and process innovation to considerably depend on demand-driven effects, there is to the best of our knowledge no firm-level study that investigates to what extent the ability of firms to transform innovation into employment growth changes over the business cycle.[2] This paper fills this gap in the literature by studying the employment-creating and destructing effects of innovation over different phases of the business cycle. Since the business cycle, innovation and employment dynamics are interlinked in a complex way, a better comprehension on this interrelationship is important.

Our analysis disentangles this complex relationship by using the structural model of Harrison et al. (2008, 2014), which has been recently used by many studies to estimate employment effects of product and process innovation (see e.g. Benavente and Lauterbach, 2007; Hall et al., 2008; Crespi and Zuñiga, 2012; Dachs and Peters 2014). Most importantly, the model establishes a theoretical link between employment growth and innovation output in terms of the sales growth generated by new products as well as efficiency gains attributable to process innovations. We extend the model's standard specification by allowing efficiency gains to depend on organizational innovations as well. This also allows us to identify employment effects of process innovation more accurately. We apply this model to separately estimate displacement and compensation effects of innovation over the business cycle.

The empirical analysis is based on the European Community Innovation Survey (CIS). Our sample includes 234,406 manufacturing firms from 26 European countries that have been observed between 1998 and 2010. To account for business cycle effects, observations in the sample are classified into the four stages of the business cycle - economic upturn, boom, economic downturn and recession. Our results reveal that product innovations induce similar gross employment growth in all phases of the business cycle. The net employment effect of product innovation is positive except in recessions when gains from new products cannot fully compensate losses in old products. However, employment losses are far lower than for non-product innovators. Thus they can be seen as an important mechanism to secure jobs in recessions. Process and organizational innovations reduce employment growth during economic up- and downturns implying labour displacement effects to exceed labour compensating effects. In boom periods, however, both effects balance each other. Sample splits into different European country groups, however, show some interesting regional heterogeneity concerning the effect of process and organizational innovations over the business cycle but not for product innovations.

The paper is structured as follows. The next section reviews the relevant literature and develops the hypothesis, while section 3 describes and discusses the underlying model. Section 4 presents the empirical implementation by presenting data and the estimation approach. Section 5 depicts and comments on the empirical findings. Section 6 briefly summarizes and concludes.

2 Related Literature and Hypotheses

2.1 Employment Effects of Innovations

The impact of technological change on the labour market has been debated for centuries. Basically, the discussion focuses on whether technological progress is labour-saving or labour-creating and whether it causes a change in the skill composition. The following review neglects the latter aspect since our data only allows us to study total employment effects of innovation at the firm level.[3]

The theoretical literature does not find an a priori clear-cut evidence for innovations to be either job destructing or job creating (se e.g. Stoneman, 1983; Katsoulacos, 1986 or Petit, 1995, for an overview). To elaborate on that, it is necessary to separate the employment effects of product and process innovations (Blechinger et al., 1998).

At the firm level, product innovations might affect employment via three channels. First, introducing new products on the market generates demand for the new products and therefore increases employment (*demand effect of product innovation*). Compared to existing products, these new products may be produced more (less) efficient, implying that they also require less (more) inputs for a given output which dampens (strengthens) the positive demand effect and thus also employment growth (*productivity effect of product innovation*). Third, the extent to which new products impact employment further depends on the magnitude of the *indirect demand effects of product innovation*. If consumers start to buy the firm’s new products they may partially or totally replaces the innovator’s old products. This so called cannibalization effect will reduce labour demand related to the old products resulting in an ambiguous *net employment effect* for product innovators. In contrast, the innovator’s labour demand further

[3] For the literature on skill-biased technological change see e.g. Caroli and Van Reenen (2001),, Acemoglu (2002) or Bresnahan et al. (2002)

increases if the new and the old products are complementary to each other. An increase in new product demand is then be accompanied by increasing demand of the old products. At the industry and macroeconomic level, additional employment effects arise. For instance, the increase in demand for product innovators might come at the expense of a reduced demand for competitors' products (business stealing effect) which in turn lowers their labour demand. In contrast, demand and employment rise in firms offering complements to the new products.

Despite ambiguous theoretical outcomes, the large majority of empirical studies found product innovations to be job-creating. This means that employment-inducing (*compensating*) effects outweigh employment-reducing (*displacement*) effects of product innovations (see e.g. Entorf and Pohlmeier,1990; Brouwer et al., 1993; Van Reenen, 1997; Smolny, 1998; Garcia et al., 2004; Hall et al., 2008; Peters, 2008; Lachenmaier and Rottmann, 2011; Leitner et al., 2011; Dachs and Peters, 2014; Harrison et al., 2014).

In contrast to product innovations, the main effect of process innovations is an increase in the innovator's production efficiency (*productivity effect of process innovation*). Higher production efficiency implies that the same output can be produced with less input factors (labour and/or capital depending on the type of technological progress). Thus, the productivity effect of process innovation is likely to reduce labour demand. However, marginal production costs decline due to the improved efficiency opening up possibilities for price reductions. Lower prices enable the innovator to gain from increasing product demand while alleviating the employment losses or even reversing them (*price effect of process innovations*). The magnitude of this price effect is determined by the size of the price reduction, the price elasticity of demand and the competitive environment and competitors' reaction to price reductions.

In contrast to product innovation, empirical results for the effect of process innovation are inconclusive. While Peters (2008), Dachs and Peters (2014) and Harrison et al. (2014) disclose a negative relationship between process innovations and employment, Entorf and Pohlmeier (1990), Van Reenen (1997) and Hall et al. (2008) and find no significant effect of process innovations on employment. In contrast, Leitner et al. (2011), Greenan and Guellec (2000) and Lachenmaier and Rottmann (2011) report a significant positive employment impact of process innovations. The latter two analyses even find process innovations to create more jobs than product innovations.

The majority of the studies has focused on product and process innovations (technological innovation). This is a significant drawback, since an analysis of employment effects of innovations requires also the adoption of a non-technological perspective in the form of organizational innovations (Edquist et al., 2001). Schumpeter (1934) already stated that companies not only introduce new products or new processes on the market, but also adjust their business practices and external relations and reorganize their organizational structures. One reason why organizational innovations have been neglected for a long time were measurement problems due to the lack of a precise definition (Lam, 2005). Eurostat and OECD (2005) provide a first harmonized definition of organizational innovation and how to measure them in innovation surveys. Tether and Tajar (2008) and Evangelista and Vezzani (2011) showed that among European firms there are more organizational innovators than product and process innovators. In addition, studies have pointed towards a complementary relationship between organizational and technological innovations (see e.g. Schmidt and Rammer, 2007; Polder et al., 2010).

There is no theoretical model explicitly considering employment impacts of organizational innovations. But one might expect similar mechanisms as for process innovations. That is, a direct productivity effect reducing firm's labour demand and a potentially counterbalancing indirect positive demand effect due to lower marginal costs and prices (Bellmann and Pahnke, 2006). Additional positive employment effects might arise if a firm absorbes or integrates other business units (insourcing) whereas the same holds vice versa (Alda and Bellmann, 2002). Gera and Gu (2004) and Black and Lynch (2004) find organizational innovations to significantly improve firm productivity. With respect to employment, Greenan (2003) finds a shift towards a more flexible organization to significantly increase a firm's job destruction rate. Likewise, Bauer and Bender (2004) find delayering and transferring of responsibilities to significantly decrease net employment growth rates whereas team work induce employment to increase. Positive employment effects have also been found, for instance, by Falk (2001), Bellmann and Pahnke (2006), Addison et al. (2008), Bellmann (2011) and Evangelista and Vezzani (2011). Furthermore, the effects appear to depend on the observed region (Alda and Bellmann, 2002; Leitner et al., 2011) and the specific sector (Peters et al., 2013).

2.2 Hypotheses

The gross employment effect of product innovations depends on the size of the direct demand effect and the size and direction of the productivity effect, that is the production efficiency of the new compared to the old products. Since the efficiency in the production of new products is mainly technology-driven, we expect the relative productivity to not be significantly affected by macroeconomic demand conditions. However, we expect the direct demand effect to vary with the business cycle. In particular, the innovators are most likely successful in selling their new products when the economy is stably growing. Hence, it is assumed to be positive in all phases of the business cycle but larger (smaller) in booms (recessions).

Hypothesis 1a: The productivity effect of product innovations is independent of the business cycle phase.

Hypothesis 1b: The direct demand effect is positive in all phases of the business cycle and it is largest in boom periods and smallest in recession periods.

The net effect of product innovations on employment growth is not clear and largely hinges upon the size of the direct demand effect, productivity effect and direction and size of the indirect demand effects (cannibalization effect). The extent, to which these effects drive net employment growth, also depends on the macroeconomic environment. In flourishing market conditions, the potential cannibalization effect should be more moderate, that is, less employment-reducing. In contrast, recession and downturn periods most likely lead to a stronger reduction of the firm's demand for old products, on average. Combining the direct and indirect demand effect and the productivity effect, we expect the net effect of product innovation to be positive and largest in boom periods. In downturns and recessions the net effect of product innovation is smaller than in boom periods and might become negative.

Hypothesis 1c: The net employment growth induced by product innovations is higher (lower) the stronger (poorer) the economy grows.

According to theory, there are only two basic mechanisms involved for process innovations to increase employment growth, that is, the labour-inducing price effect and the labour-displacing productivity effect. To give a basic intuition for the opposing productivity and price effects, we subsume upturns and booms to be expansion periods and downturns and recessions to be contraction periods. Hypothesis 1a implies that the productivity effect is constant over the business cycle while the demand effects are not. This means, product demand basically increases more during expansion periods than during contraction periods. A price reduction, which is supposed to be translated into higher product demand, thus has a stronger compensating effect during expansion periods compared to contraction periods. The job destructing effect will thus be more pronounced and the job creating effect will be less pronounced, respectively, during contraction compared to expansion periods. The opposite is assumed to hold vice versa.

Hypothesis 2: Process innovations lead to stronger job destruction and less job creation, respectively, during contracting than during expanding periods.

To go into more detail, both underlying mechanisms influencing the employment growth effect of process innovations differ within and between expansion and contraction periods. During an economic upturn there are more firms entering the market than during downturns or recessions. These market entrants are inclined to gain market shares by competing on product prices. As a consequence, established companies react to them by implementing process innovations. This response enables the companies to reduce marginal costs and prices. However, the increased competition puts the innovator's price-induced demand increase at risk. From another point of view, established companies have to overcome the negative effects of the previous recession they have survived. In that environment, process innovations can be an effective tool to recover the companies' business. Increasing production efficiency reduces marginal costs, which allows the company to accumulate profits. However, new companies entering the market compete for market shares. This results in an appearing downward trend in the price development. The established companies run into the danger of not generating sufficient profits because of the new firms gaining market shares. Both views just described imply the price reductions to not be strong or long enough to sufficiently increase the innovator's product and thus labour demand. The employment-inducing compensation mechanism is disabled. Therefore, we expect that the productivity effect dominates the disabled compensation mechanism during economic upturns.

Hypothesis 3a: Process innovations reduce the innovator's labour demand during economic upturn periods.

Ultimately, economic upturns enable the firms to update their production efficiency. The firms modernize their production methods allowing them to well prepare for the following period of high and stable demand. During these so called economic booms companies who implement process innovations are then able to most efficiently satisfy their own product demand. At the end of the economic upturn or at the beginning of the boom period, wage pressures will arise. Employees and unions will more intensively claim higher wages from their employers. A boom period is most likely the only convenient period for companies to increase the wages. We assume that employees and unions are aware of that. As a response, the average wage level within most of the industries is expected to increase, on average. The companies, in turn, are able to at least partially translate this increase in marginal costs into higher prices. A boom period is most likely the only convenient period for a company to raise product prices without running the risk of a significantly fall in demand. Thus, the strong and stable demand leads to higher prices. In that situation, process innovators that want to strengthen their market position are assumed to not primarily focus on an increase in the production efficiency. We rather expect process innovators to improve the quality of their products and the flexibility in the production. This is in line with Tether and Tajar (2008). They descriptively show for European companies that the majority among the process innovators targets the flexibility and adaptability of the production to market needs. These types of process innovations do not primarily aim at reducing marginal costs. The innovators are rather focused on contrasting their products to competing products. This strategy of product differentiation also enables the innovator to increase its product price. Despite a potential markup of the differentiated products, the innovator's turnover is rather expected to increase leading the labour demand not to fall.

Hypothesis 3b: Process innovations introduced during economic boom periods do not significantly reduce the innovator's labour demand.

In Schumpeter's famous theory of "creative destruction", economic downturns reorganize markets and encourage firms to innovate, while firms unable to innovate exit the market. This means that when the economic growth cools off, the competitive pressure rises. Reducing the marginal costs will thus be prioritized by process innovators expecting the future product demand to fall. The stronger the economic growth cools off the more companies attempt to increase their production efficiency. There are two possible opposing scenarios leading to different results. On the one hand, the process innovators translate the decrease in marginal costs into a price reduction. However, in such a tight economic situation the competitors immediately match the reduced price so that no additional demand is induced. Even worse, the price level decreases while the demand level stays constant. The companies' turnover falls and reduces the labour demand. This leads over to the second situation. Process innovators enhance the production efficiency but anticipate the effect caused by a price reduction and do not reduce the price leaving the employment level unaffected. However, we do expect the first situation to prevail since in the second situation the incentive for one company to deviate is too strong. If one company deviates the competitors also do.

Hypothesis 3c: During economic downturns the labour demand decreases if process innovations have been implemented.

While during economic upturn periods the companies prepare for a potentially upcoming high demand period, during economic downturns the companies prepare for a potentially upcoming recession period. Process innovations increase the production efficiency and reduce the price level. In contrast, during recessions the market does not call for efficiency increases because the low demand level does not enable the compensation mechanism to work as a response to price reductions. Therefore, we do not expect a significant decrease in the labour demand of the process innovator. In addition, recessions bring increasing policy interventions on the agenda. Policy measures, as for instance the expansion of short-time work, can act as a buffer for process innovators. They can reduce the price while taking the risk of low demand without necessarily reducing the employment level, since the wage costs are partially covered by the governmental action plan. It could even be that such interventions eventually increase the innovator's labour demand. Policy measures are very heterogeneous across countries and only some – if any – can connect employment growth and process innovations. Therefore, we do not expect the labour demand to increase.

Hypothesis 3d: There are no employment changes induced by process innovations implemented during recessions.

3 Empirical Model

We adopt the approach developed by Harrison et al. (2014) to examine the impact of innovation on employment growth. It establishes a theoretical relationship between employment growth and different types of innovations output indicators on the firm level. That approach is tailor-made for answering the question how product and process innovation translate into employment growth using information provided by CIS data. In particular, a main virtue of the model is that it leans on innovation output indicators and therefore incorporates the demand situation of the respective firms, which is an important factor for firms' labour demand. The model was originally used to identify the effects of product and process innovations on employment growth in a cross-section covering three years. In its original form it has been used to analyze employment effects for different European and Latin American countries and China (see Benavente and Lauterbach, 2007; Hall et al., 2008; Mairesse et al., 2011; Crespi and Zuniga, 2012; Crespi and Tacsir, 2013; Harrison et al., 2014; Mairesse and Wu, 2014). Peters (2008) used the model to study different types of product innovations. Licht and Peters (2013) extended the model to investigate employment effects of environmental and non-environmental product and process innovations. Peters et al. (2013) and Damijan et al. (2014) incorporated organizational innovations. We also extend the model by including a measure for organizational innovations. In addition, we examine whether and to what extent employment effects of the different types of innovations differ during the four phases of the business cycle. In the following, we briefly describe the model; for more details see Harrison et al. (2014).

The model is based on a two period, multiproduct framework. A firm is assumed to produce two different kinds of products. In the first period t, old (or existing) products are produced. In the subsequent period $t+1$, the firm can basically produce old products and new products if it decides to introduce product innovations between t and $t+1$. In that situation, the firm either exclusively produces new products if old and new products are substitutes or it produces old and new products if both are complementary to each other. The firm would produce only the existing products if it had not implemented any product innovations. In order to produce the respective output, we assume a production function that is linear homogeneous in the conventional inputs labour, capital and material. Moreover, the final output also depends on the productivity of the respective good j, at time t, captured by $\theta_{j,t}$. A firm can increase the production efficiency of the old products by, for instance, implementing process or organizational innovations. Further, mergers and acquisitions and spillover effects also affect the productivity. In contrast, the productivity of new products cannot be increased. Their productivity is either higher or lower compared to the one of the old products. These assumptions can be used to derive the following function for employment growth:

(1) $l = \alpha + y_1 + \beta y_2 + u$

Accordingly, employment growth l is influenced by three main sources: (i) efficiency gains in the production of old products, α, (ii) the growth rate of the real output of old products, y_1 and (iii) the real output growth rate of new products, y_2; u is the unobserved random disturbance. The growth in the output of old products might be induced by the firm's new products. Negative growth arises if new products are substitutes for old products (cannibalization effect), while positive growth is induced by a complementary relationship between new and old goods. Moreover, the effect of y_1 also accounts for potential business stealing effects, for demand increases due to innovation-related price reductions (compensation effect), for changes in consumer preferences as well as for policy measures and business cycle effects. So far, the analyses using that model could not disentangle the underlying effects from each other due to data limitations. This problem basically applies to our analysis as well. However, our data set allows us at least separating the business cycle effects from the other effects, which leads to a better identification.
The employment growth effect induced by new products does not only depend on the demand growth for new products (relative to the old products), y_2, but also on the relative production efficiency $\beta = \theta_{1,t}/\theta_{2,t+1}$. New products only generate higher employment growth if their production were less efficient compared to the efficiency of the old products, that is, if $\theta_{2,t+1} < \theta_{1,t}$. In contrast, relatively less labour demand is induced by new products for $\beta < 1$. In general, efficiency increases in the production of the old products, α, reduces a firm's labour demand. Harrison et al. (2014) suggest separating the different sources of efficiency improvements, which can basically be innovation-related and non-innovation-related. Rewriting the above equation yields:

(2) $l = \alpha_0 + \alpha_1 pc + \alpha_2 orga + y_1 + \beta y_2 + u$

In addition to equation (1), equation (2) disentangles the productivity effect of old products into three components: (i) α_0, (ii) α_1 and (iii) α_2. While the former effect represents the average non-innovation-related efficiency gains of the old products, the latter two effects measure the impact of process and organizational innovations. Again, controlling for organizational innovations allows us also to identify the employment effect of process innovations more precisely.
Unfortunately, we cannot estimate equation (2) since we cannot observe real output growth rates in our data. Instead, we replace the unobserved growth rates by the observable nominal output growth rates measured as sales growth. This yields the following equation (3):

(3) $l - (g_1 - \widetilde{\pi_1}) = \alpha_0 + \alpha_1 pc + \alpha_2 orga + \beta g_2 + v$

The nominal sales growth of the old products, g_1, and of the new products, g_2, are defined as $g_1 = y_1 + \pi_1$ and $g_2 = (1 + \pi_2)y_2$. The coefficient of the real output growth, y_1, is equal to one and can be subtracted from l. The variables g_1 and g_2 can be calculated by using CIS data. g_1 is defined as the total sales growth rate minus the sales growth rate due to new products. π_1 measures the unobserved price growth rate of old products at the firm level. Potential data sources usually do not have price data on a firm level. Therefore, we proxy π_1 by the price growth rate of old products at the industry level, $\widetilde{\pi_1}$. π_2 is defined as the price difference between new products at $t + 1$ and old products at t in relation to the price of the old products at t at the firm level. The problem is that this price information cannot be observed, not even on a sector level. However, substituting a real rate of change by a nominal rate of change requires price growth information to adequately estimate the effect. As a result, the estimation of β suffers from an endogeneity problem caused by measurement errors. Similar applies to the estimated effects of α_1 and α_2 even though on a much weaker scale.

4 Econometrical implementation

4.1 Data and variables

Our analysis is based on the European Commission's Community Innovations Survey (CIS). This survey rests on a common questionnaire and is biannually conducted by the national statistical offices or legalized national institutions of the European Union's member states, Iceland and Norway. The CIS applies the methodology of the Oslo Manual (see OECD, 2005). The target population covers all legally independent enterprises with more than 9 employees in manufacturing, mining, energy and water supply and selected services. The survey collects data on firms' innovation expenditures, different innovation output indicators and other business-related information as, for instance, employment and sales. The CIS covers a three-year period. For that reason, our growth variables measured at t are calculated with $t - 2$ being the reference period and not $t - 1$. Another reason is that the retrospectively required information – for instance turnover – refers to the value of t and to the value of $t - 2$ but not to the value of $t - 1$. We employ five waves of CIS data covering the years 1998-2000 (CIS3), 2002-2004 (CIS4), 2004-2006 (CIS2006), 2006-2008 (CIS2008) and 2008-2010 (CIS2010). Each wave covers about 20 member states. Table 4-1 gives an overview of different CIS waves. In total, 234,406 observations of firms operating in the manufacturing sector are available. The distribution among the CIS waves shows that the first three CIS waves exhibit the smallest sample sizes, whereas almost half of the observations are in the CIS2008 and CIS2010 waves.

Table 4-1: Distribution of CIS Sample by Waves

CIS	Observation Period	Total		
		N	%	Cum
CIS 3	1998-2000	43,640	18.62	18.62
CIS 4	2002-2004	44,993	19.19	37.81
CIS2006	2004-2006	37,479	15.99	53.80
CIS2008	2006-2008	54,996	23.46	77.26
CIS2010	2008-2010	53,298	22.74	100
Pooled	Pooled	234,406	100	

Source: CIS3, CIS4, CIS2006, CIS2008 and CIS2010, Eurostat; own calculation.

Answering the questionnaire is not mandatory in each of the participating countries. Therefore, the sample sizes between the countries differ. For instance, five countries were only taking part in one or two waves.

According to the model, the dependent variable, EMP, is defined as $l - (g_1 - \widetilde{\pi_1})$. The employment growth, l, is measured as the change in the number of employees between $t - 2$ and t. The real output growth due to old products, $g_1 - \widetilde{\pi_1}$, denotes the difference between (i) the nominal sales growth rate of old products (g_1 / SGR_OLDPD) and (ii) the growth rate of prices for old products at the industry level ($\widetilde{\pi_1}$ / PRICEGR). To calculate $\widetilde{\pi_1}$ we used producer price indices at the country-industry level as published by Eurostat.
The process innovation indicator (pc / PCONLY) is represented by a dummy variable that takes on the value one if the firm has introduced only process innovations but no product innovations. It is possible that process innovations are prerequisites for product innovations. The chosen definition of the indicator thus ensures that we identify only the efficiency improvements in the production of old products. Organizational innovations are measured by an indicator taking on the value one if the the company has introduced at least one organizational innovation. The sales growth rate due to new products (g_2 / SGR_NEWPD) is calculated as year t's sales share with new products, which have been introduced between t and $t - 2$, multiplied by the ratio of year t's sales divided by the sales of $t - 2$. Beyond the information required by the model's structural equation, employment growth is likely to be influenced by a set of other characteristics. An important determinant for employment growth is the size of firms. According to Gibrat's law, firms grow proportionally and independently of firm size. In contrast and similar to Mansfield (1962), Jovanovic (1982) took the view that surviving young and small firms grow faster than older and larger ones because of managerial efficiency and learning by doing. To control for size effects we include the dummy variables, MEDIUM – for firms with 50-249 employees – and LARGE, for firms with at least 250 employees. SMALL, builds our reference category. In addition, we control for ownership effects by including two dummy variables indicating that a firm belongs to a company group that has a domestic (DGP) and foreign headquarter (FGP), respectively. Domestic unaffiliated firms serve as reference group (DUF). A set of country and industry dummies is also included.

In order to properly examine business cycle effects, we split our estimation sample into the four phases of the business cycle. In its simplest definition, a business cycle consists of two phases: economic expansion (upturn, boom) and contraction (downturn, recession). Our analysis uses real GDP growth rates on a country level. We define two different indicators for the business cycle, see Table 4-2.

Table 4-2: Definitions of the two Business Cycle Indicators

	2-phases	4-phases
	GDP growth is…	
Upturn	increasing and positive	increasing and positive
Boom	-	increasing and positive and subsequently decreasing
Downturn	positive but decreasing or negative	decreasing but (still) positive
Recession	-	negative

4.2 Estimation approach

As described in section 3, the estimation of the relative productivity effect, β, is subject to a measurement error of the sales growth rate due to new products. Therefore, we employ an instrumental variable (IV) approach to estimate equation (3). Variables that qualify as instruments should be correlated with the sales growth due to new products (i.e. innovation success) and should be uncorrelated with the error term. In particular, the instruments have to be uncorrelated with the relative price difference of new and old products. We cannot use any lagged values because there are no firm identifiers available at Eurostat's Safecenter. Instead, we use three variables as instruments that have been found to be important in explaining innovation success and that are presumably uncorrelated with the relative price difference of new to old products. The first instrument that we use is RANGE, a binary indicator that measures whether the product innovations was aimed at increasing the product range. We assume RANGE to be correlated with the expectations of new product sales. Enlarging the range of products, however, does not imply any particular direction of the changes in prices. Our two other instruments are binary indicators taking on the value one if the firm continuously conducts R&D activities, RD, and if the firm has cooperated in innovation projects with other agents, COOP, respectively. The consistency of IV estimations depends on the validity of instruments. Therefore, we performed a Hansen J test on overidentifying restrictions for overall instrument validity and we used the difference-in-Hansen C statistic to test for exogeneity of a single instrument. It turned out that only two instruments are valid, that is, RANGE and COOP. We also checked for non-weakness of the instruments. Weak instruments can lead to a large relative finite-sample bias of IV compared to the bias of OLS (in case of endogenous explanatory variables). All first stage regressions show our valid instruments to be strongly correlated with SGR_NEWPD. Furthermore, the F-test of excluded instruments always yields a statistic clearly being larger than 10. The full regression output tables additionally display the Kleibergen-Paap LM test on underidentification as well as the F tests proposed by Cragg and Donald (1993) and Kleibergen and Paap (2006). All these tests do not indicate our instruments to be weak.

5 Econometric results

This section presents econometric results of the model described in section 3. We will start by showing basic results of the employment effect of innovation distinguished by up- and downturns. Subsequent to that, we will present the model's findings when the four phases of the business cycle are considered. In addition, we examine the employment effects for different size classes as well as different European regions. The regression tables only show the estimated coefficients for the three innovation variables (SGR_NEWPD, PCONLY, ORGA), GDP growth (GDPGR), firm size dummies (LARGE, MEDIUM) and ownership dummies (DGP, FGP). The full tables are provided in the appendix and upon request.

5.1 Employment effects during market expansions and market contractions

Our very basic results are presented in Table 5-1. We split the sample into two phases of a business cycle, that is, a growth or expansion period and a contraction period. The coefficient of the sales growth rate due to new products (SGR_NEWPD) is central in our assumption on the relationship between employment growth and innovation. The coefficient reveals the average change in employment growth as a reaction to a growth in the firm's sales caused by new products. As expected, higher new product sales translate into higher employment growth during expansion and during contraction periods. However, both coefficients are less than one. According to the underlying model, the coefficient of SGR_NEWPD refers to potential differences in the production efficiency between old and new products. A value of less than one indicates the production of new products to require less labour input compared to the production of old products.

Table 5-1: Impact of innovation on employment growth during market expansions and contractions

	Cyclical situation	
Dep. var.: EMP	Expansion	Contraction
SGR_NEWPD	**0.966*** **	**0.987*** **
	(0.021)	(0.022)
PCONLY	**-1.558** **	**-1.295* **
	(0.724)	(0.746)
ORGA	**-1.669*** **	**-0.835** **
	(0.460)	(0.401)
GDPGR	**3.673*** **	**-0.598*** **
	(0.562)	(0.138)
MEDIUM	**-1.867*** **	**-1.535*** **
	(0.451)	(0.438)
LARGE	**-3.939*** **	**-2.420*** **
	(0.637)	(0.543)
DGP	0.549	**0.950* **
	(0.722)	(0.509)
FGP	-0.123	-0.728
	(0.662)	(0.501)
Constant	**-63.590*** **	-11.981***
	(7.397)	**(2.414)**
Observations	85,718	118,395

Notes: Method:IV estimation. Weighted regression. ***, **, * indicate significance at the 1%, 5% and 10% level; robust std. err. are in parentheses.
Source: CIS3, CIS4, CIS2006, CIS2008, CIS2010, Eurostat; own calculation.

This means that the higher the sales due to new products the less additional labour demand on the firm level is induced. The coefficient for the contraction periods is even a bit larger than for the expansion periods. A t-test, however, shows that both coefficients are not significantly different from one. Thus, an increase in sales growth due to new products of 1% leads to an increase in gross employment by 1% independent of the cyclical situation. As a result, we cannot reject our first hypothesis. The coefficient of PCONLY measures the size of the gross employment effect of innovators solely focussing on process innovations. The negative coefficients among the 2 phases of the business cycle indicate that the implemented process innovations have been labour-displacing, on average. The reduction in employment growth has been even slightly larger during market expansion periods than during contraction periods. As a result, we have to reject Hypothesis 2. Organizational innovators have also had lower employment growth rates, on average. The negative effect holds for expansion and contraction periods. The effect during expansions is almost twice as large as during contractions. Thus, organizational innovators especially attempt to increase their productivity during expansion periods. The results qualitatively correspond to the results of process innovations. The findings for organizational innovators partially correspond to Bartel et al. (2008) who find that the likelihood of (labour-reducing) outsourcing increases during expansion and contraction periods and that the effect is stronger for expansion periods. Furthermore, employment growth among all firms benefits from demand growth – as measured by real GDP growth – in an upturn. The negative effect of GDP growth during contraction periods might be a bit puzzling. Note, this negative effect means that while the economy is already cooling off, higher GDP growth does not (necessarily) reduce the company's employment level but its employment growth. A relatively high GDP growth rate within a downturn period means that the downturn "has just" started. In that situation, the companies most likely anticipate a contraction period. As a result, they grow less strong to avoid a potentially upcoming situation of having high(er) wage costs and low demand. Alternatively, if companies stop "massive" hiring at the onset of an economic downturn they do not have to lay off that much employees later on. The coefficients of the size dummies (MEDIUM, LARGE) are negative during expansion and contraction periods. This finding indicates that small firms have a faster and higher employment growth than medium and large enterprises. In contrast, ownership dummies are not significant in most of the cases implying that a domestic or foreign ownership has no relevance for employment growth.

5.2 Employment effects during the four phases of a business cycle

The results of Table 5-2 largely confirm the findings of the 2-phase indicator. The coefficient of the sales due to new products is positively significant among all phases a business cycle. Successful product innovations thus increase the innovators' employment growth rate, on average. The respective coefficients differ, indeed, but a t-test shows that they are not significantly different from one. We can thus infer a stable relationship between successful product innovations and employment growth during all states of a business cycle. Accordingly, Hypothesis 1a cannot be rejected. In contrast to product innovations, the effects of process innovations do differ from Table 5-1. Process innovations as well as organizational innovations lead to reduced labour demand during upturns and downturns but not during booms and recessions. The results for both types of innovators present first evidence that process and organizational innovations only significantly affect employment growth if competitive pressure is rising. Alternatively, they only seem to affect labour demand if the economy is in a transition period. As already stated in section 2.2, there presumably are no significant effects during booms and recessions because the innovators either do not focus that much on efficiency increases and do not reduce the prices, respectively. Therefore, Hypothesis 3a - Hypothesis 3d cannot be rejected. Moreover, affiliates of foreign multinational firms (FGP) significantly reduce their labour demand during recessions compared to domestically-owned firms. An explanation could be that foreign-owned firms are more exposed to fluctuations of the world market via exporting. In addition, the negative coefficient might also imply that multinational firms rather prefer to lay off employees abroad than at home during recessions.

Table 5-2: Impact of innovation on employment growth during all four phases of a business cycle

	Cyclical situation			
Dep. var.: EMP	Upturn	Boom	Downturn	Recession
SGR_NEWPD	**0.984*** **	**0.965*** **	**1.002*** **	**0.976*** **
	(0.024)	(0.029)	(0.025)	(0.026)
PCONLY	**-1.747** **	-0.268	**-1.835* **	-0.367
	(0.853)	(1.391)	(0.941)	(1.027)
ORGA	**-2.207*** **	0.601	**-1.373** **	-0.567
	(0.467)	(0.738)	(0.617)	(0.490)
GDPGR	**3.641*** **	2.816	**-0.600*** **	-0.017
	(0.556)	(1.811)	(0.175)	(0.278)
MEDIUM	**-3.080*** **	-0.006	**-1.255** **	**-2.019*** **
	(0.460)	(0.865)	(0.596)	(0.496)
LARGE	**-4.718*** **	**-3.542*** **	**-1.351* **	**-3.979*** **
	(0.609)	(1.284)	(0.787)	(0.659)
DGP	**-1.472* **	**3.213*** **	0.567	**1.290* **
	(0.791)	(1.163)	(0.648)	(0.661)
FGP	-1.130	1.034	0.124	**-1.805*** **
	(0.804)	(1.147)	(0.659)	(0.631)
Constant	**-67.186*** **	**-33.372** **	**-15.091*** **	**3.049* **
	(7.291)	(15.808)	(2.647)	(1.654)
Observations	67,521	15,863	67,200	51,195

Notes: Method:IV estimation. Weighted regression. ***, **, * indicate significance at the 1%, 5% and 10% level; robust std. err. are in parentheses.
Source: CIS3, CIS4, CIS2006, CIS2008, CIS2010, Eurostat; own calculation.

The results concerning the GDP growth support the implications of Table 5-1. While higher GDP growth leads to higher employment growth during upturns, the opposite relationship holds during downturns. In particular, firms anticipate or adjust to an upcoming economic downturn when the GDP growth is already declining but still relatively high. Firms then rather start to gradually decrease additional job creation. The lower the GDP growth rate is the lower is the additional job destruction. When it comes to a recession the GDP growth does not significantly affect the employment growth rates anymore, on average. The same applies for boom periods. Higher or lower GDP growth does not change employment growth. It could be that during a period of high and stable product and labour demand firms reach their capacity of sustainable growth. Moreover, as in the case for downturns, companies most likely refrain from hiring “too many” people. The national labour markets of EU countries are relatively well protected against dismissals. For instance, the majority of the EU countries, which are also members in the OECD, have rather strict employment protection laws (see OECD, 2013). Thus, it is not easily doable for companies to lay off employees.

5.3 Employment effects during the four phases of a business cycle for different European regions

Since our dataset covers 26 countries and the period 1998-2010, we assume differences of employment effect to exist across different European countries. For instance, the cyclical dependency of employment growth could be much more pronounced in economic weaker regions as Southern Europe compared to economic more robust regions as Western European countries. Unfortunately, CIS data provided at the Eurostat's Safecenter does not allow to perform a comparative analysis at the EU member states level for all countries since not all countries are observed in all phases of a business cycle (see section 4.1). As an alternative, we aggregate EU member states into three groups: North-west Europe, South and East Europe. The three regions comprise the following countries:

- **North-west Europe**: Belgium, Germany, Denmark, France, Finland, Ireland, Luxemburg, the Netherlands, Sweden, Iceland and Norway
- **South Europe**: Cyprus, Spain, Greece, Italy, Malta and Portugal
- **East Europe**: Czech Republic, Estonia, Latvia, Lithuania, Slovakia, Slovenia, Romania, Hungary, Bulgaria and Croatia

The findings at the European regional level basically confirm our previous estimated effects for product innovations, see Table 5-3. Higher sales growth rates due to new products are associated with significantly higher employment growth across all phases of a business cycle and across all regions. In South and East Europe, the coefficient of new product sales is not significantly different from one indicating the same production efficiency between old and new products. In North-western European countries, however, the coefficient is significantly smaller than one during booms, downturns and recessions. The estimated value ranges between 0.92 and 0.95. This implies that product innovators in North-western European countries increase the efficiency of the production of the new products compared to the old products. During upturn periods the production of old products is slightly more efficient than the production of new products. Both, process and organizational innovations play only a minor role for employment growth in North-western European countries. The coefficients of organizational innovations are not only insignificant but also rather small. The effect of process innovations is only significant for the downturn case. The pattern is more mixed in the Southern and Eastern European countries. In both regions organizational innovations have significantly increased the production efficiency and thus reduced employment growth rates. The effect of process innovations is also mixed. While in Eastern European countries they have significantly decreased employment growth during downturns and recessions, in South Europe they have had no effect on employment growth at all.

Table 5-3: Impact of innovation on employment growth by region

	Region: North-west Europe				Region: South Europe				Region: East Europe			
Dep. var.: EMP	Upturn	Boom	Downturn	Recession	Upturn	Boom	Downturn	Recession	Upturn	Boom	Downturn	Recession
SGR_NEWPD	**1.010*****	**0.944*****	**0.950*****	**0.916*****	**1.021*****	**1.161*****	**1.051*****	**1.150*****	**0.968*****	**1.002*****	**0.943*****	**0.963*****
	(0.038)	(0.040)	(0.032)	(0.048)	(0.029)	(0.096)	(0.043)	(0.118)	(0.034)	(0.025)	(0.036)	(0.030)
PCONLY	-2.478	-1.841	**-2.116****	0.488	-1.098	3.358	-0.502	1.627	0.041	0.215	**-4.750***	**-2.368****
	(2.270)	(1.806)	(0.920)	(1.705)	(0.897)	(2.599)	(1.322)	(2.213)	(1.668)	(2.583)	(2.466)	(1.089)
ORGA	0.045	-0.618	0.166	-0.850	**-2.718*****	0.746	**-2.559*****	**-2.606****	**-4.780*****	-1.174	-1.450	**-1.296***
	(0.842)	(0.921)	(0.621)	(1.171)	(0.619)	(1.446)	(0.833)	(1.249)	(1.241)	(1.175)	(1.330)	(0.701)
GDPGR	**-1.262*****	**1.069***	0.241	-1.192	-2.045***	0.535	-0.205	**-1.142*****	**5.388*****	0.807	-0.087	**-0.407*****
	(0.392)	(0.571)	(0.386)	(1.698)	(0.331)	(2.874)	(0.217)	(0.333)	(0.667)	(0.645)	(0.173)	(0.073)
MEDIUM	**-3.383*****	-0.988	**-1.372****	-0.636	**-2.090*****	0.089	**-2.968*****	-1.414	**-5.489*****	**2.684****	1.553	**-5.032*****
	(0.820)	(1.123)	(0.611)	(0.585)	(0.669)	(1.509)	(0.848)	(1.132)	(0.939)	(1.280)	(1.388)	(0.530)
LARGE	**-6.018*****	**-4.391*****	-0.822	**-1.911****	-2.299**	-2.945	**-4.162*****	-1.729	**-7.636*****	1.428	1.628	**-8.290*****
	(1.110)	(1.481)	(1.051)	(0.759)	(0.969)	(2.377)	(1.051)	(1.345)	(1.197)	(1.639)	(1.470)	(0.679)
DGP	1.709*	**4.469*****	0.257	**1.516****	**-2.656****	0.576	1.102	0.458	1.491	-1.473	1.605	**1.574***
	(0.883)	(1.222)	(0.781)	(0.766)	(1.325)	(2.709)	(1.070)	(1.291)	(1.375)	(2.050)	(1.715)	(0.837)
FGP	0.951	1.644	1.066	0.411	-0.850	-2.362	-0.032	**-3.183****	1.307	0.114	**-3.396*****	**-4.056*****
	(1.011)	(1.443)	(1.324)	(0.885)	(1.545)	(2.454)	(0.970)	(1.262)	(1.796)	(1.171)	(1.247)	(0.803)
Constant	4.343	-4.624	**-4.920****	0.110	**12.657*****	-6.604	**4.858*****	-1.527	**-49.756*****	**-26.304*****	**-7.104****	**9.036*****
	(4.511)	(3.582)	(2.468)	(2.582)	(1.724)	(28.590)	(1.432)	(1.577)	(6.132)	(9.714)	(3.233)	(0.840)
Observations	13,953	9,530	11,493	12,977	26,660	5,681	25,225	19,514	26,862	2,986	30,461	18,690

Notes: Method: Instrumental variables estimation. Weighted regression. ***, ** and * indicate significance at the 1%, 5% and 10% level; robust std. err. are in parentheses.
Source: CIS3, CIS4, CIS2006, CIS2008, CIS2010, Eurostat; own calculation.

6 Employment decomposition

The models presented in the previous section only shed some light on the direction of the impact of innovations on employment growth. Therefore, we complement our econometric results with a decomposition analysis. The decomposition allows us to quantify the absolute contribution of different sources to employment growth. In particular, we are able to disentangle the employment effects of product, process and organizational innovations from effects originating from general demand and productivity trends. We follow the decomposition of employment growth proposed by Harrison et al. (2014) and Peters et al. (2013):

$$(4)\quad l = \underbrace{\widehat{\alpha_0}}_{1} + \underbrace{\widehat{\alpha_1}pc}_{2} + \underbrace{\widehat{\alpha_2}orga}_{3} + \underbrace{[1 - I(g_2 > 0)](g_1 - \widetilde{\pi_1})}_{4} + \underbrace{I(g_2 > 0)(g_1 - \widetilde{\pi_1})}_{5a}$$

$$+\underbrace{I(g_2 > 0)\hat{\beta}g_2}_{5b} + \hat{v}$$

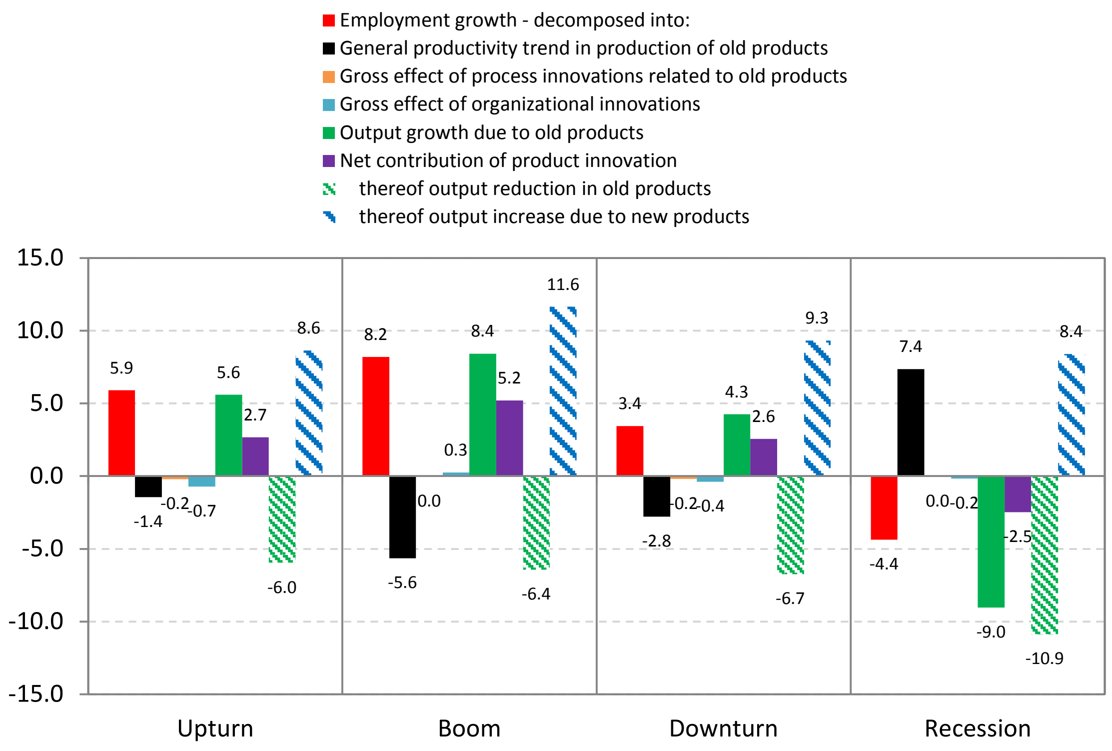
The first term, $\widehat{\alpha_0}$, measures the contribution of the general trend in productivity in the production of old products to employment growth. It accounts for all changes in efficiency and in turn in employment that are not attributable to firms' own innovations. That is, it captures, for instance, employment effects of training, improvements in the human capital endowment and productivity effects from spillovers. The general productivity trend is calculated in a way that it is industry-, country-, time-, size- and ownership-specific, since it captures mot only the effect of the constant but also of the corresponding dummy variables and changes of GDP growth. It is measured as the average effect across innovators and non-innovators. The second and the third terms capture the labour displacement effect of process innovations and organizational innovations, respectively.

In equation (4), $I(.)$ denotes an indicator function. It takes on the value one if the condition in parentheses is true and zero otherwise. Therefore, $I(g_2 > 0)$ refers to product innovators, while $1 - I(g_2 > 0)$ refers to non-product innovators. This implies that the fourth component of equation (4) captures changes in employment that are caused by the real growth of the output of old products for firms that have not implemented product innovations. A demand increase of old products can be due to a change in consumers' preferences, price reductions but also because of rivals' product innovations (business stealing effect). The cannibalization effect is captures by the term 5a. The components 5a and 5b denote the net contribution of product innovations to employment growth. This net effect depends on (i) the demand increase for new products, $I(g_2 > 0)g_2$, (ii) the relative production efficiency between old and new products, $\hat{\beta}$ (representing $\theta_{1,t}/\theta_{2,t+1}$), and (iii) possible shifts in demand for the old products, $I(g_2 > 0)(g_1 - \widetilde{\pi_1})$. The latter effect captures cannibalization effects if $(g_1 - \widetilde{\pi_1}) < 0$ and complementarity effects to the innovator's own old products if $(g_1 - \widetilde{\pi_1}) > 0$, respectively.

6.1 Decomposition: The case for all phases of the business cycle

The Figure 6-1 provides a graphical illustration of the decomposition of employment growth during all four phases of a business cycle. The five sources (i) general productivity trend in the production of old products (black bar), (ii) displacement effect of process innovations (orange bar), (iii) organizational innovations (light blue bar), (iv) output growth due to old products (green bar) and (v) the net contribution of product innovations (purple bar) sum up to total employment growth (red bar). The figure further splits the net contribution of product innovation in the increase in demand for new products (bar with blue stripes) and shifts in demand for old products (bar with green stripes).

Figure 6-1: Contribution of innovation to employment growth during all phases of the business cycle, in %



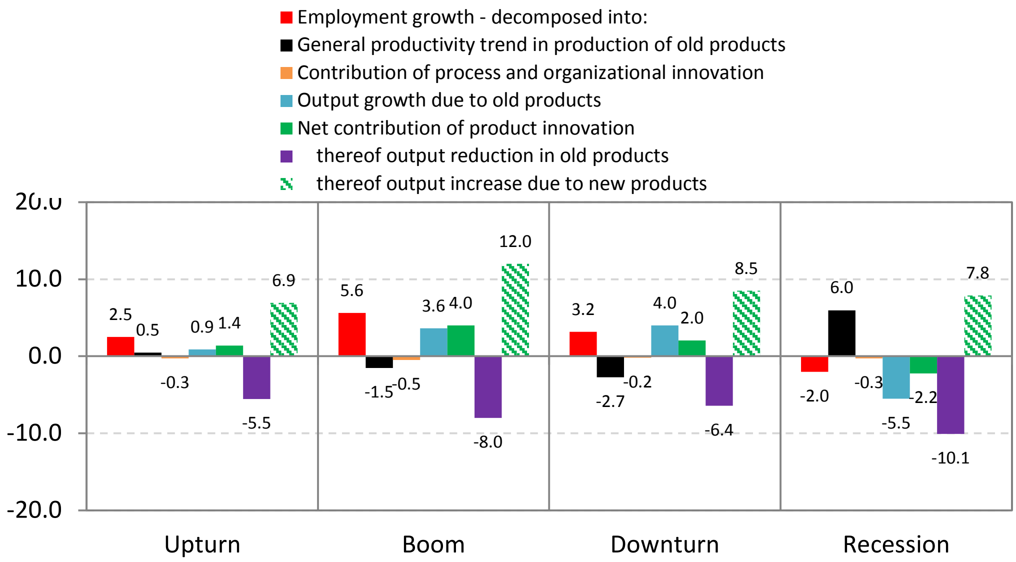
Note: Decomposition is based on the regressions of Table 5-2.
Source: CIS3, CIS4, CIS2006, CIS2008, CIS2010, Eurostat; own calculation.

The figure discloses that the net contribution of product innovations to employment growth is positively related. The stronger the economy grows the higher is the net contribution to employment growth. Therefore, we cannot reject our Hypothesis 1b. Employment has grown by 2.7% (5.2%) during upturns (booms) and by 2.6% (-2.5%) during downturns (recessions) due to the introduction of new products. This pro-cyclicality is primarily caused by the strong cannibalization effect. The introduction of new products has always led the demand for old products to successively fall. The resulting employment reduction has amounted to -6% (-6.4%) during upturns (booms) and -6.7% (-10.9%) during downturns (recessions). In contrast, the output of new products has been relatively stable and high during the periods. That output increase induced employment growth of 8.6% (11.6%) during upturns (booms) and 9.3% (8.4%) during downturns and recessions. But Figure 6-1 also reveals that – with the exception of recessions – the main source for employment growth has always been the output growth due to old products of non-product innovators. Further, that old product sales are also the source of large employment losses during recessions. Thus, it is the ability of product innovators to substitute losses due to old products by gains due to new products that keeps employment losses limited during recessions. Another factor that softens employment fluctuations over the business cycle is the general productivity trend in the production of old products. While it is relatively strong negative during upturns and booms, it is rather moderate and strikingly positive during downturns and recessions, respectively. The general trend is supposed to be positive during upturn and boom periods and negative during downturns and recessions. That means, following the (positive) productivity trend decreases employment during upturns and booms. However, following the (negative) productivity trend apparently increases employment growth during recession periods. Firms show a tendency towards labour hoarding during downswings and recession periods, which means that firms only slightly reduce their staff as demand for their products falls (Bhaumik, 2011). Labour hoarding results in a decrease of productivity during downturns and recessions. Leitner and Stehrer (2012) report that labour hoarding has been widely used during the recent crisis in Central and Eastern European countries. The displacement effects of process and organizational innovations do not affect employment growth very much. Although both effects are positive in only rare cases, the negative effects never amount to more than -0.7%. Compared to the other sources, the displacement effects are of minor importance for employment growth.

6.2 Decomposition: The case for European regions

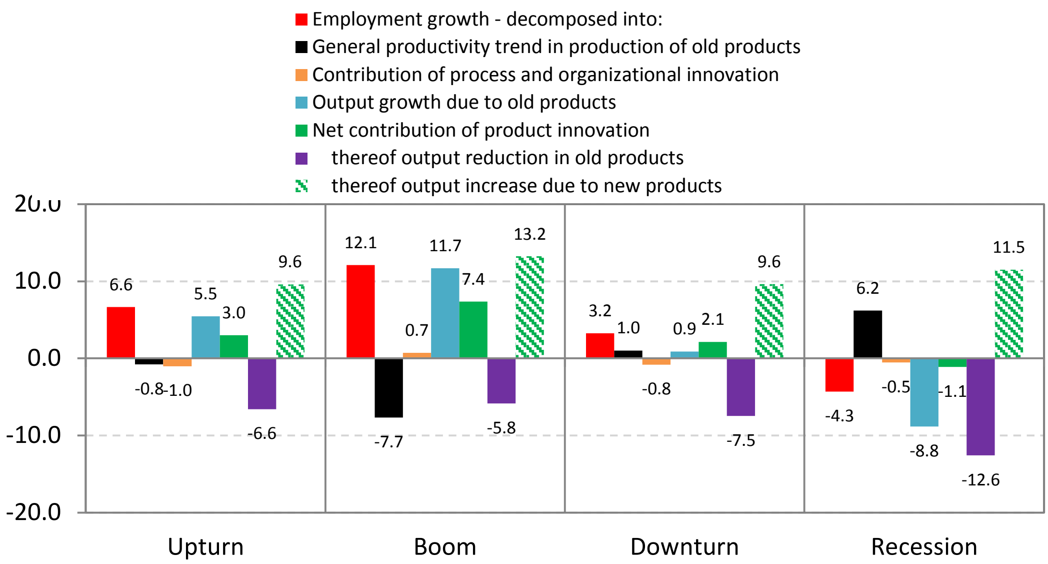
Figure 6-2, Figure 6-3 and Figure 6-4 illustrate the decomposition of employment growth for the three regions. In all these regions, product innovations have created more jobs due to demand effects than jobs has been destroyed by productivity, cannibalization and business stealing effects, except in boom periods. The net contribution of product innovations to employment growth is positive during upturns, booms and downturns across all regions. Accordingly, the highest employment effect of product innovations has been induced in South and East Europe, with growth rates ranging from 2.1% (South) to 8.6% (East). In contrast, the highest growth rate has been 4% in North-west Europe. Moreover, Table 5-3 shows that new products are produced more efficiently than old products in North-west Europe, except during upturns. Thus, Figure 6-2 implies that although new products require significantly less labour input than old products, the market acceptance of new products seems to have been strong enough to overcompensate the higher production efficiency and cannibalization effect. This implication, however, only applies to boom periods. Despite the positive contribution of product innovations, employment growth in South and East European countries is unambiguously dominated by the output growth of old products with a peak of 20.3% (East). While in most of the periods the output of old products has increased by at least 5% in both regions, in North-west Europe that growth rate has never exceeded 4%. However, the product innovations have had a stabilizing effect during recessions in both regions as well as in North-west Europe. That is, the job creation effects of product innovations have decreased and became negative during recessions but less than those of the old products. The stabilization effect has been most effective in Southern European countries. In addition, Figure 6-4 reveals a large employment growth effect of the general productivity trend during recessions. This implies that firms in Eastern European countries have hoarded more labour than other European regions and that basically supports the findings of Leitner and Stehrer (2012). The employment growth induced by that trend has amounted to 6% (6.2%) in North-west (South) Europe and to 10.3% in East Europe.

Figure 6-2: Contribution of innovation to employment growth in North-west Europe



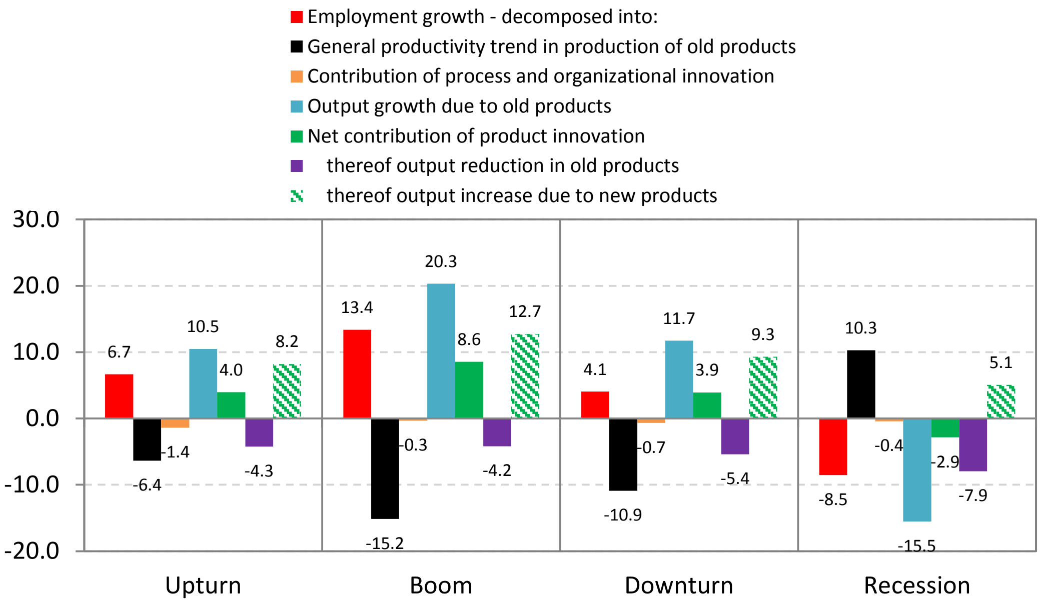
Note: Decomposition is based on the regressions of Table 5-3.
Source: CIS3, CIS4, CIS2006, CIS2008, CIS2010, Eurostat; own calculation.

Figure 6-3: Contribution of innovation to employment growth in South Europe



Note: Decomposition is based on the regressions of Table 5-3.
Source: CIS3, CIS4, CIS2006, CIS2008, CIS2010, Eurostat; own calculation.

Figure 6-4: Contribution of innovation to employment growth in East Europe



Note: Decomposition is based on the regressions of Table 5-3.
Source: CIS3, CIS4, CIS2006, CIS2008, CIS2010, Eurostat; own calculation.

7 Conclusion

We examined employment effects of different types of innovations over the business cycle with the model developed by Harrison et al. (2014). We estimated the model with firm-level data from 26 European countries covering the period of 1998 to 2010.

The estimation results indicate a race between job creation due to additional demand created by new products and job destruction due to productivity effects and the substitution of old by new products. Across all specifications and business cycle phases, product innovations always induce employment growth. In contrast, employment growth estimates of process and organizational innovations point towards significant increases in productivity – and subsequent reductions in a firm's employment growth – during upturn and downturn periods. Estimation results, however, vary considerably with the location of the firm.

A decomposition of employment growth based on the estimation results allows to quantify the absolute contributions of different sources to employment growth. Accordingly, product innovators strongly gain from new product demand during all phases of the business cycle. New product demand partially substitutes the demand for old products and lowers the employment growth induced by product innovations. Overall, the net contribution of new products is positive during upturns, booms and downturns. More importantly, employment losses during recession periods are much smaller than for non-product innovators because the output growth of new products remains on a high level compared to the output growth due to old products.

This employment-preserving effect of product innovations is a strong argument for a countercyclical public support of innovation activities. The results of the analysis suggest that a decrease in the share of innovative firms during a crisis – together with losses in old products –

is the main reason for employment losses in a recession. More public funding for innovation activities during a crisis can help firms to stabilize expectations and overcome financing restraints discussed in chapter 2.2, leading to fewer firms that postpone or abandon innovation activities. Counter-cyclical support for innovation may also be favorable because of free resources and lower opportunity cost for innovation during a recession. However, the exact timing of such measures can be tricky; the set-up of new support measures needs time; firms may have difficulties to increase their R&D efforts after substantial reductions in R&D staff; moreover, time lags in the preparation of such measures may even lead to a pro-cyclical policy reaction.

Altogether, the analysis draws a positive picture of the ability of innovation to create new employment. This puts our results in some contrast to other recent research, which points to potential negative effects of new process and automatisation technologies on employment (Frey and Osborne 2013; Brynjolfsson and McAfee 2014). It may be that potential losses from innovation are more visible than the potential benefits of new technologies from today's perspective; there may also be a tendency to underestimate benefits and overestimate losses from technological change. Thus, maybe the most important lesson policy can learn from our results is the fact that innovation creates new jobs, although this ability may only be clearly visible in hindsight.

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10 Appendix

10.1 Sample statistics

Table 10-1: Distribution of the CIS Sample by Business Cycle Phases

Observation Period	Business Cycle Phases			
	Upturn	**Boom**	**Downturn**	**Recession**
1998-2000	23,756	16016	3868	0
2002-2004	43,363	785	845	0
2004-2006	4,399	17917	15163	0
2006-2008	0	224	54772	0
2008-2010	1,945	0	0	51353
Total	73,463	34942	74648	51353
in %	31	15	32	22

Source: CIS3, CIS4, CIS2006, CIS2008 CIS2010, Eurostat.

10.2 Estimation tables

Table 10-2: Impact of innovation on employment growth during market expansions and contractions

	Cyclical Situation	
Dep. var.: EMP	Expansion	Contraction
SGR_NEWPD	0.966***	0.987***
	-0.021	-0.022
PCONLY	-1.558**	-1.295*
	-0.724	-0.746
ORGA	-1.669***	-0.835**
	-0.46	-0.401
GDPGR	3.673***	-0.598***
	-0.562	-0.138
MEDIUM	-1.867***	-1.535***
	-0.451	-0.438
LARGE	-3.939***	-2.420***
	-0.637	-0.543
DGP	0.549	0.950*
	-0.722	-0.509
FGP	-0.123	-0.728
	-0.662	-0.501
Constant	-63.590***	-11.981***
	-7.397	-2.414
Joint sign. (p-value)		
W_industry	0.000***	0.000***
W_country	0.000***	0.000***
W_time	0.000***	0.000***
R2a	0.398	0.411

RMSE	28.496	25.846
Wald-Test: β=1	0.105	0.536
Tests on Exogeneity		
SGR_NEWPD	0.000***	0.000***
Tests on instr. validity		
Sargan/Hansen J-Test	0.654	0.518
First stage results		
RANGE	23.734***	22.764***
	-0.656	-0.642
COOP	7.310***	5.422***
	-0.812	-0.614
F test on excl. Instr.	700.39***	740.69***
Tests on underident.		
Kleibergen-Paap LM test	266.525***	1826.441***
Test on weak instr.		
Cragg-Donald F test	9895.000***	14581.822***
Kleibergen-Paap F test	1134.609***	1464.345***
Weak instr. rob. inf.		
Anderson-R. Wald test	1125.380***	643.634***
Stock-Wright LM test	83.679***	70.903***
Observations	85718	118395

Table 10-3: Impact of Innovation on employment growth in different phases of the business cycle

	Cyclical Situation			
Dep. var.: EMP	Upturn	Boom	Downturn	Recession
SGR_NEWPD	0.984***	0.965***	1.002***	0.976***
	(0.024)	(0.029)	(0.025)	(0.026)
PC	-1.747**	-0.268	-1.835*	-0.367
	(0.853)	(1.391)	(0.941)	(1.027)
ORGA	-2.207***	0.601	-1.373**	-0.567
	(0.467)	(0.738)	(0.617)	(0.490)
GDPGR	3.641***	2.816	-0.600***	-0.017
	(0.556)	(1.811)	(0.175)	(0.278)
MEDIUM	-3.080***	-0.006	-1.255**	-2.019***
	(0.460)	(0.865)	(0.596)	(0.496)
LARGE	-4.718***	-3.542***	-1.351*	-3.979***
	(0.609)	(1.284)	(0.787)	(0.659)
DGP	-1.472*	3.213***	0.567	1.290*
	(0.791)	(1.163)	(0.648)	(0.661)
FGP	-1.130	1.034	0.124	-1.805***
	(0.804)	(1.147)	(0.659)	(0.631)
Constant	-67.186***	-33.372**	-15.091***	3.049*
	(7.291)	(15.808)	(2.647)	(1.654)
Joint sign. (p-value)				
W_industry	0.000***	0.000***	0.000***	0.000***
W_country	0.000***	0.000***	0.000***	0.000***
W_time	0.000***	-	0.000***	-
R2a	0.378	0.493	0.387	0.465

RMSE	29.790	23.581	28.917	21.062
Wald-Test: β=1	0.500	0.229	0.950	0.350
Tests on Exogeneity				
SGR_NEWPD	0.000***	0.004***	0.000***	0.009***
Tests on instr. validity				
Sargan/Hansen J-Test	0.904	0.197	0.058*	0.483
First stage results 1 (SGR_NEWPD				
RANGE	24.216***	22.627***	24.494***	20.830***
	(0.769)	(1.076)	(0.866)	(1.018)
COOP	7.159***	6.642***	6.643***	4.191***
	(0.845)	(1690)	(0.723)	(0.898)
F test on excl. Instr.	588.93***	232.74	436.73***	334.75***
Tests on underident.				
Kleibergen-Paap LM test	278.305***	47.723***	1320.026***	650.675***
Test on weak instr.				
Cragg-Donald F test	7521.560***	1904.171***	8392.591***	6296.530***
Kleibergen-Paap F test	830.146***	323.097***	1210.113***	462.008***
Weak instr. rob. inf.				
Anderson-R. Wald test	810.060***	407.550***	783.385***	328.914***
Stock-Wright LM test	59.581***	44.579***	85.623***	48.630***
Observations	67,521	15,863	67,200	51,195

Source: CIS3, CIS4, CIS2006, CIS2008, CIS2010, Eurostat.