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

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Abstract

A growing literature investigates 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 performance effects of innovation in general and employment effects in particular vary over the business cycle. 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. (2008, 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, net employment losses are far lower than for non-product innovators. Process and organizational innovations reduce employment growth during economic up- and downturns implying productivity gains to displace labour demand. 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.

JEL: O33, J23, C26, D2

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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 activity as well as cyclical variations in the ability of firms to transform innovation into employment growth.

So far, the literature has been focusing on the cyclicality of innovation. Most studies emphasize a pro-cyclical innovation behaviour. That is, firms invest more in R&D and innovation in upturns and booms due to higher cash-flows and better future demand expectations in prospering markets (see e.g. Hall, 1992; Himmelberg and Petersen, 1994; Harhoff, 1998; Mulkay et al., 2001; Rafferty, 2003; Barlevy 2007). However, recent studies have shown that firms behave pro-cyclical only if they are credit-constrained. On the contrary unconstrained firms behave counter-cyclical due the opportunity cost effect. Opportunity costs – in terms of forgone output – of innovative investment compared to capital investment are lower during economic downturns than during economic upturns (Bovha-Padilla et al., 2009; Aghion et al., 2010, López-Garcia et al., 2012; Aghion et al., 2012).

There is also a large literature on the effect of innovation on employment growth (for surveys see Chennells and Van Reenen, 2002; Spieza and Vivarelli, 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

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2 At the industry level, Pianta and Lucchese (2012) explicitly consider business cycle effects of innovation on employment 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 due to increased production efficiency Sample splits into different European country groups and different size classes, however, also show some interesting regional and size 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, descriptive statistics 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 (see Vivarelli, 2007, 2014 and Pianta, 2005, for an overview). 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 skill 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; Dobbs et al., 1987 or Petit, 1995, for an overview). To elaborate on that, it is necessary to separate the employment effects of product and process innovations (Hall and Heffernan, 1985; Blechinger et al., 1998).

At the firm level, product innovations might affect employment via three channels. First, introducing new products on the market generates new demand and therefore increases employment

[3] Two strands of the literature center on the impact of innovation on skills: The literature on skill-biased technological change (see e.g. Caroli and Van Reenen, 2001; Acemoglu, 2002; Bresnahan et al., 2002; Piva et al., 2005) and on routine-biased technological change (see Autor, 2006 and Autor and Acemoglu, 2011).

(*demand effect of product innovation*). Compared to existing products, these new products may be produced more (less) efficiently, 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 replace 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 increases if the new and the old products complement 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.[4] 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 demand for labour. In contrast, demand and employment rise in firms offering complements to the new products.

Despite ambiguous theoretical predictions, 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; König et al., 1995; Van Reenen, 1997; Smolny, 1998; Jaumandreu, 2003; Garcia et al., 2004; Hall et al., 2008; Peters, 2008; Lachenmaier and Rottmann, 2011; Leitner et al., 2011; Dachs and Peters, 2014; Damijan et al., 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, in particular 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), Jaumandreu (2003), Hall et al. (2008) and Damijan et al. (2014) find no significant effect of process innovations on employment. In contrast, König et al. (1995), 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.

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[4] Macroeconomic and industry level analyses have been performed, e.g. by Freeman et al. (1982), Vivarelli and Pianta (2000), Antonucci and Pianta (2002), Bogliacino and Pianta (2010) and Pianta and Lucchese (2012).

The majority of the studies have 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 are measurement problems due to the lack of a precise definition (Lam, 2005; Armbruster et al., 2008). 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. Cozzarin and Percival, 2006; Schmidt and Rammer, 2007; Polder et al., 2010).[5]

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). 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.[6] 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).

Based on this review, it is evident that demand effects play an important role for employment effects of all types of innovation. These demand effects are likely to vary with different stages of the business cycle. Likewise, productivity effects of process and organizational innovation might vary over the business cycle. The following section will develop a set of hypotheses about the employment impact of different types of innovation at different stages of the business cycle.

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 that relative productivity is not significantly affected by macroeconomic demand conditions. However, we expect the direct demand effect to vary with

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[5] Technological innovations either pave the way for organizational changes (Henderson and Clark, 1990; Deneels, 2002) or organizational innovations act as a driver and enabler for introducing technological innovations (Lokshin et al., 2009).

[6] Aquiring new firms impact employment as well (Alda and Bellmann, 2002), however, mergers and acquisitions are not counted as organizational innovation according to the Oslo manual.

the business cycle. In particular, we assume that innovators are most likely successful in selling their new products in phases of cyclical upsurge when incomes are increasing and budget constraints are less tight (see e.g. Schmookler, 1966; Shleifer, 1986; Axarloglou, 2003). Additionally, a favourable demand development may stimulate firms' willingness to take risks and incentives to introduce product innovations of higher quality; which in turn can also enlarge the direct demand effect. Furthermore, utilization of production capacities has found to be pro-cyclical (see e.g. Corrado and Mattey, 1997; Fagnart et al., 1999). As a result product innovators are more likely to expand their employment when facing increasing demand in upturns and booms since they already produce at high or full capacity. During recessions, product innovations are accordingly expected to have less of an effect on employment since direct demand effects tend to be weaker and firms are already struggling with excess capacity. Hence, we expect a positive demand effect in all phases of the business cycle but a larger (smaller) effect in booms (recessions).

Hypothesis H1a: The productivity effect of product innovations is independent of the business cycle phase.

Hypothesis H1b: 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.

In addition to the direct demand and productivity impact, indirect demand effects matter for the net effect of product innovations on employment growth. If the innovators' new and existing products complement each other, lower direct demand effects are associated with lower positive indirect demand effects in downturns and recessions as well. If new and existing products are substitutes, we expect the demand for existing products to disproportionately decline in downturn and recession periods than in upswings and boom periods. The decline may be reinforced by firms facing a tightened pressure to thin their product range during downturn and recession periods. Recently, Bernard et al. (2010), Broda and Weinstein (2010) and Bilbiie et al. (2012) showed that product creation is pro-cyclical while product destruction and drop-out rates are counter-cyclical. This means, some fraction of the sluggish demand level inherent to downturns and recessions can be attributed not only to tighter budget constraints but also to firms trimming their product variety. In total, combining all three driving forces of product innovations for employment growth, the net employment effect is ambiguous. Prior empirical evidence, however, has demonstrated that the compensation effect often outweighs the displacement effect of product innovation. We therefore expect the net effect of product innovation in general 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 H1c: The net employment effect of product innovations is largest in boom periods followed by upturn and downturn periods, and it is assumed to be smallest in recessions.

According to theory, there are two basic mechanisms involved for process innovations to increase employment growth, that is, the labour-displacing productivity effect and the labour-creating price effect. In downturns and recessions, the lack of demand may discourage the introduction of new products and may increase the competition based on costs and prices (Spiegel and Stahl, 2014). Under these circumstances process innovations play an important role in improving productivity at the cost of job losses in order to increase competitiveness (Luccchese and Pianta, 2012). In contrast, we expect that process innovators are less eager to improve productivity during boom periods when demand is high but that they have a stronger focus on improving production flexibility, adaptability to market needs and product quality which in turn are less likely to destruct jobs. Furthermore, profits are generally declining in downturns and recessions and as a consequence, depending on competition, firms might be less inclined to pass on price reductions to consumers which would imply smaller compensation effects. Combining both effects, we either expect stronger job destruction or less job creation from process innovation during downturns and recessions than during upturns and booms. This leads to the following hypotheses:

Hypothesis H2a: Labour displacement effects of process innovations are strongest during downturns and recessions, followed by upturns and booms.

Hypothesis H2b: Process innovations either lead to stronger net job destruction or less net job creation in downturns and recessions than in upturns and booms.

Similar to process innovators, organizational innovators primarily focus on lowering the production costs by increasing the production efficiency (see e.g. Lundvall and Kristensen, 1997; Greenan and Mairesse, 2003; Evangelista and Vezzani, 2011; Peters et al., 2013). An increase in efficiency induces the product price to decrease and the demand to potentially increase. This implies that the same underlying mechanisms driving the employment effect of process innovations influence the employment effect of organizational innovations. Polder et al. (2010), for instance, find a strong effect on firm productivity when organizational and process innovations have been implemented. Schmidt and Rammer (2007) find that organizational innovations strengthen the success of process innovations. Polder et al. (2010) test for potential complementarities and show that organizational innovations and process innovations are complementary. Edquist et al. (2001) do not strictly separate between process and organizational innovations. According to them, process innovations can have a technological as well as an organizational character. Lundvall and Kristensen (1997) show that with increasing competitive pressure, organizational innovators are more and more inclined to enhance the production efficiency. As we have mentioned above, the competitive pressure is probably highest during downturn and recession periods leading to decreasing labour demand. Similarly, Bartel et al. (2008) find that the likelihood for the conduction of employment-reducing outsourcing is highest not only during periods of market expansion but also during periods of market contraction. For these reasons, we assume that the business cycle effects of organizational innovations on employment growth largely correspond to the effects of process innovations.

Hypothesis H3a: Labour displacement effects of organizational innovations are strongest during downturns and recessions, followed by upturns and booms.

Hypothesis H3b: Organizational innovations either lead to stronger job destruction or less job creation in downturns than in upturns.

3 Empirical Model

We adopt the approach developed by Harrison et al. (2008, 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, 2014) 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-product framework, i.e. it is assumed that a firm can produce two different products. Furthermore, we observe a firm in two points in time t (= 1, 2). At the beginning in t=1, all existing products produced by a firm are summarized to one product bundle which we label *old product*. Between t=1 and t=2, the reference period, the firm can decide to introduce one or more new or significantly improved products. The new product can (partially or totally) replace the old one if they are substitutes or enhance the demand of the old product in case of complementarity. That is, at the end of the reference period, the firm will produce either only old products, only new products or both types of both products.

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 product j at time t, captured by $\theta_{j,t}$. For old products a firm can increase the production efficiency between t=1 and t=2 through implementing process or organizational innovations. In addition to innovation-related productivity improvements, productivity gains may be achieved through learning effects, spillovers, inputs of higher quality or mergers and acquisitions. Since by definition new products haven't been produced in t=1, firms cannot improve their productivity. However, it will be important whether the productivity of new products will be higher or lower compared to the one of old products. These assumptions can be used to derive the following equation for employment growth:[7]

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

Accordingly, employment growth l originates from 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 due to new products, $y_{2.}$; u captures an unobserved random shock to employment growth.[8] 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

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7 See Harrison et al. (2014) for more details.

8 Note: Since new products haven't been produced in t=1, y_2 cannot measure the real output growth of new products. Instead, y_2 measures the output of the new products at t=2 relative to the output of the old products at t=1 and therefore captures the real output growth rate *due to* new products.

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 the separation of 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 $\beta = \theta_{11}/\theta_{22}$. New products only generate higher employment growth if their production is less efficient compared to the production technology of the old products, that is, if $\theta_{22} < \theta_{11}$. 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. (2008, 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 $t-2$ and old products at t in relation to the price of the old products at $t-1$ 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.[9] Similar applies to the estimated effects of α_1 and α_2 even though on a much weaker scale.

In total, subtracting the proxy for the real output growth of old products, $(g_1 - \widetilde{\pi_1})$, from employment growth, l, allows us to unambiguously estimate the gross effect of process, organizational and product innovations.[10] Indeed, we cannot directly estimate the direct demand effect and the net employment effect of product innovations as hypotheses H1b and H1c imply but as you will see later in section 4.2 and section 4.4, we can descriptively show and calculate these effects, respectively. Unfortunately, this is not possible for the net effect neither of process nor of organizational innovations leaving the rejection and the non-rejection of hypotheses H2b and H3b open for future research, respectively.

4 Data and Estimation Method

4.1 Data and variables

Our analysis is based on the European Commission's Community Innovation 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.[11] 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.

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.

The CIS covers a three-year period. Hence, all growth rates are calculated between t-2 and t. 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

[9] We explain our estimation strategy later.

[10] Note: The unambiguous estimation of the gross effects crucially depends on the assumption of $\widetilde{\pi_1}$ corresponding to π_1. Failing this, would mean to estimate an attenuated gross effect of process innovations.

[11] Note: Until CIS4 (2002-2004), the survey has been conducted every four years.

half of the observations are in the CIS2008 and CIS2010 waves. One limitation of the data is that firm-level observations cannot be linked between subsequent CIS waves.

Answering the questionnaire is not mandatory in each of the participating countries. Therefore, the sample sizes between the countries differ (see Table 8-1 in the Appendix). 12 out of 26 listed countries were participating in all five waves. In contrast, five countries were only taking part in one or two waves. Within the manufacturing sector, the manufacturing of basic and fabricated metals, food and beverages as well as the textile industry hold the highest shares of observations (see Table 8-2). The vehicle industry along with the industries of chemicals, rubber and plastics as well as non-metallic mineral products, are relatively underrepresented with low shares of observations.

In accordance with the underlying 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).[12] 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 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 – taking on the value one for firms with 50-249 employees – and LARGE, for firms with at least 250 employees. Firms with less than 50 employees, SMALL, build 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 are also included (see Table 8-1 and Table 8-2).

In order to properly examine business cycle effects, we split our estimation sample into the four phases of the business cycle. In general, the business cycle describes fluctuations in economic activity that an economy experiences over a period of time. In its simplest definition, a business

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[12] Remember that our growth rates are defined as the growth between t and $t-2$.

cycle consists of two phases: economic expansion (upturn, boom) and contraction (downturn, recession). During expansions, the economy is growing in real terms, as evidenced by increases in GDP growth. A contraction is characterized by shrinking GDP growth rates. Our analysis uses real GDP growth rates on a country level, provided by Eurostat. Based on that, 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

Note: The 2-phases indicator considers a boom (recession) as upturn (downturn).

One potential issue is the time period used to calculate these indicators. Statistical offices often use quarterly data on GDP growth to define a business cycle. In empirical work, it is also common to employ one-year growth rates. The CIS data covers a three-year period, in CIS2010 for instance the period 2008-2010. Hence, we used two-year GDP growth rates, i.e. in the example above the growth rate between 2008 and 2010. Moreover, splitting the sample according to the business cycle phases would actually ignore the information about the strength of GDP growth. For that reason, we additionally include information about country level real GDP growth rates between t and $t-2$, GDPGR. This captures general demand effects. But note that firm-specific demand effects should already be covered by g_1 and g_2.

4.2 Descriptive statistics

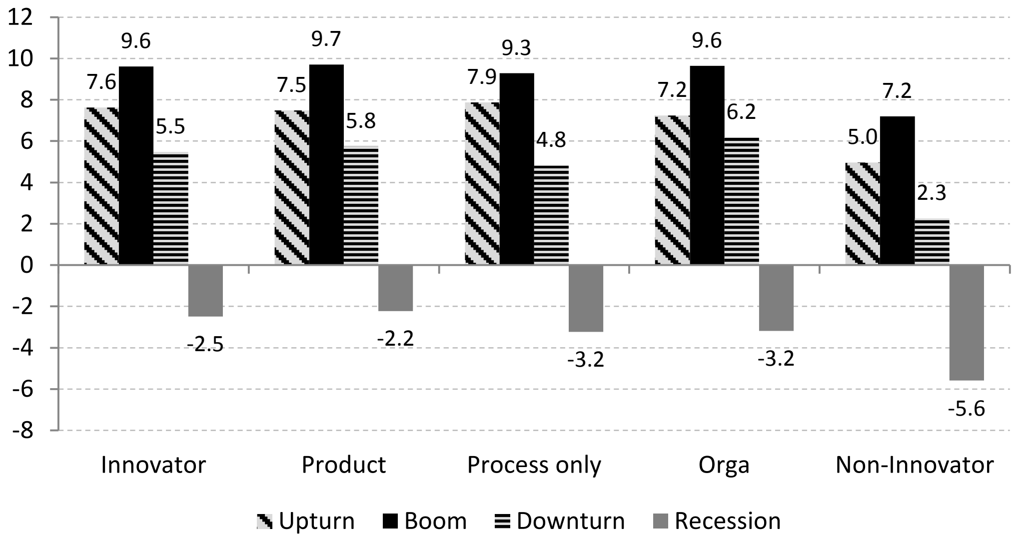
This section presents basic descriptive results on the relationship between innovation and employment growth in different phases of the business cycle. Figure 4-1 shows the mean and the median value of employment growth for the respective phase of the business cycle. As we would expect, the employment growth is highest during the boom and lowest and even negative during the recession, on average. The mean employment growth of firms has been similar during upturn and downturn periods – with regard to the median values, it actually is the same. Furthermore, the discrepancy between the mean and the median during up- and downturns indicate that the upper 50% of firms have grown faster than the lower 50% reduced employment. To elaborate on these findings in more detail we also disentangled the employment growth regarding the different types of innovators, that is, (technological) innovators, product innovators, pure process innovators, organizational innovators and non-innovators.

Figure 4-1: Employment growth in different phases of the business cycle, in %

Note: Weighted figures.

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

Figure 4-2: Employment growth by innovation status, in %

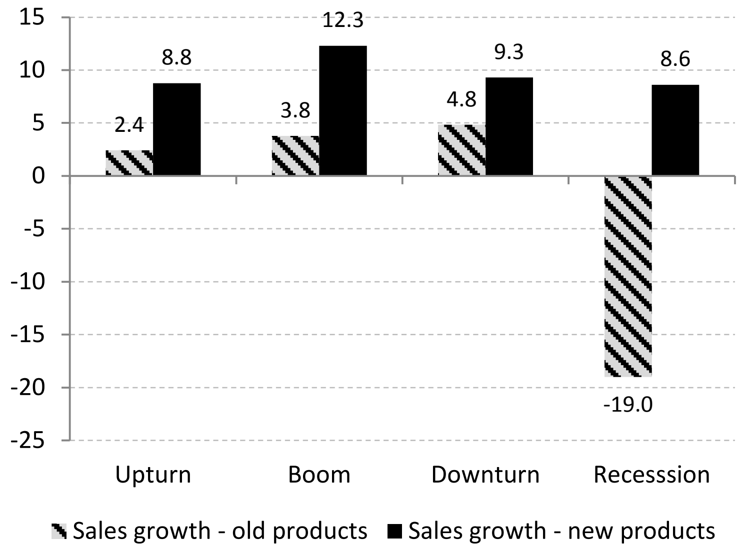


Note: Weighted figures.

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

Figure 4-2 discloses a very similar business cyclical growth pattern between various types of innovators. All groups have suffered from employment reduction during recessions and have gained from employment growth during the other periods on a very similar scale. However, product innovators seem to have been more resilient to deteriorating economic growth. During downturns their mean employment growth rate was almost 6% while the respective recession value was slightly below -2%. The values for process and organizational innovators were 5.5% and -3.2%, respectively. In contrast to innovating firms, employment growth (reduction) of non-innovators has always been significantly weaker (stronger). During economic growth periods (upturn and boom) the non-innovators' employment growth rate has been on average about 2.5%-points lower compared to the innovators. The respective value for the downturn (recession) periods amounts to about 3.3% (-3%)-points. The difference in the employment growth rates between innovators and non-innovators may be due to the innovator's superior adaptability to shocks (Meghir et al., 1996). Accordingly, innovating firms are more flexible and have lower adjustment costs for employment when faced with shocks. That means, even if they reduce their employment level during recessions, they will create more jobs compared to non-innovators during boom periods.

Figure 4-3: Sales growth due to new and old products, in %



Note: Weighted figures.

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

Figure 4-3 brings two key variables of the empirical model into focus, the average nominal sales growth of new and old products. Basically, new product sales as well as old product sales follow a pro-cyclical pattern. Nevertheless, there are notable differences. With the exception of the boom period, the growth of new product sales does not change much between upturns, downturns and recessions. The largest growth rate gap exists between recessions (8.6%) and downturns (9.3%) amounting to only 0.7%-points. Thus, new product sales are not strongly affected by changes in the macroeconomic environment. Accordingly, that difference does not support our hypothesis H1b. The direct demand effect seems to be larger in downturns than in upturns so that we have to reject H1b. A similar pattern occurs for old product sales regarding upturns, booms and downturns. However, during recessions the sales of old products have declined by 19%. Such a strong negative development could have been caused by a reduction in demand for old products due to tighter budget restrictions of consumers as well as due to a reduction in the firm's product range.

4.3 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.

4.4 Employment decomposition

The different specifications we estimated by using the previously mentioned IV regressions only shed some light on the direction of the impact of innovations on employment growth. Therefore, we complement our estimation results with a decomposition analysis. That 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 procedure 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 productivity trend in the production of old products to employment growth. It accounts for all changes in efficiency and employment that are not attributable to firms' own innovations. For instance, $\widehat{\alpha_0}$ captures 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 not only the effect of the estimated 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 effects of process innovations and organizational innovations.

In equation (4), $I(.)$ denotes an indicator function. It takes on the value one if the condition in parentheses is true and zero otherwise. Furthermore, $I(g_2 > 0)$ refers to the share of product innovators, while $1 - I(g_2 > 0)$ refers to the share of 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.

5 Econometric results

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, an 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 seem to be smaller than one indicating the production of new products to require less labour input compared to the production of old products.

Table 5-1: Employment effects of innovation during market expansions and contractions

	Business Cycle Phase	
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)
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		
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 instruments		
Cragg-Donald F test	9895.000***	14581.822***
Kleibergen-Paap F test	1134.609***	1464.345***
Weak instr. rob. inference		
Anderson-R. Wald test	1125.380***	643.634***
Stock-Wright LM test	83.679***	70.903***
Observations	85718	118395

Notes: Method: Instrumental variables estimation. Weighted regression. Robust std. err. are in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level.

A complementing 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 employment growth by 1% independent of the cyclical situation. As a result, we cannot reject our hypothesis H1a. The coefficient of PCONLY measures the size of the gross employment effect of innovators solely focussing on process innovations. The negative coefficients among the two 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 H2a. 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 largely correspond to the results of process innovations. Therefore, we cannot reject hypothesis H3a. Moreover, 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 growth due to new products is positively significant among all phases of a business cycle. Successful product innovations thus increase the innovators' employment growth rate, on average. The respective coefficients differ, indeed, but a t-test does not show them to be significantly different from one indicating a stable relationship between product innovations and employment growth during all phases of a business cycle. Accordingly, H1a 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. These findings are partially counterintuitive as we expect significant negative effects for downturns and recessions. We thus have to reject H2a and H3a. . Furthermore, as stated in section 2.2, there are presumably no significant effects during booms because the process and organizational innovators probably do not focus on efficiency increases. 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.

The results concerning the GDP growth (GDPGR) 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, laying off many employees at one time is not easy for firms.

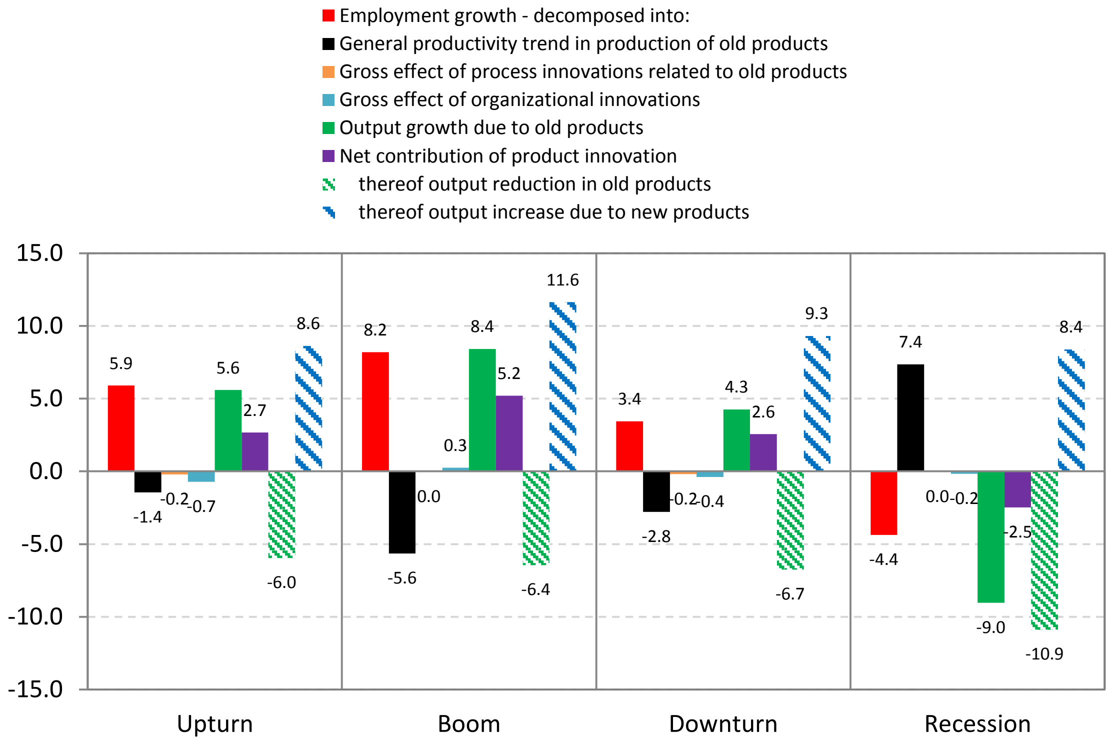
Table 5-2: Employment effects of innovation during all four phases of a business cycle

	Business Cycle Phase			
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 instruments				
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. inference				
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

Notes: Method: Instrumental variables estimation. Weighted regression. Robust std. err. are in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level.

Figure 5-1 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) productivity 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 5-1: Contribution of innovation to employment growth in 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 stronger the economy grows the higher is the net contribution to employment growth. Therefore, we cannot reject H1c. 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 5-1 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. However, old products 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 slows down employment growth during upturns and booms, it is rather moderate and strikingly positive during downturns and recessions, respectively. 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) observe frequent labour hoarding 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.

5.3 Employment effects during the four phases of a business cycle for different size classes

One of the most important differences between firms that can also explain heterogeneity in the relationship between innovation and employment growth is the firm size. Many arguments go along the discussion on specific advantages and disadvantages of small and large firms in the innovation process (see e.g. Kleinknecht, 1989; Cohen, 1995, 2010). The main argument in favour of large firms is that they have large internal financial means and access to external funds to finance innovation projects more easily. Large and diversified firms additionally have more potential applications for new knowledge (Rosenberg, 1990). Another advantage of size is specialization and a more intense division of labour between different scientific disciplines and persons of different qualifications. Data from the recent economic crisis provides evidence that innovation activities in larger firms have been less affected by the recession and support the view that large firms have advantages in the innovation process (see e.g. Paunov, 2012; Rammer, 2012; Archiburgi et al., 2013). Small enterprises, in contrast, are more flexible to react to new opportunities and are able to survive in niche markets. They primarily benefit from the personal engagement of the entrepreneur who transfers her knowledge on technologies and markets (see e.g. Carree and Thurik, 2003; Thurik, 2009 for an overview). Further, small and medium enterprises are also found to be an important driver of employment growth (see e.g. Licht and Nerlinger, 1998; Acs and Armington, 2004; Haltiwanger et al., 2013).

Table 5-3 presents the estimation results of employment growth on innovation. We split the sample into two size classes: small and medium enterprises (SME) and large firms. As we would expect, new product sales significantly contribute to employment growth across all size classes and phases of a business cycle. The effect slightly differs between the phases but the effects are not significantly different from one so that we cannot reject hypothesis H1a. Process innovations of SMEs have significantly reduced the employment growth rates during downturns only. There is no reduction effect during upturns, booms and recessions rather supporting H2a.. In contrast, large firms that have implemented process innovations reduced their additional labour demand during upturn periods. Thus, we have to reject H2a. Almost similar effects of process innovators are found for organizational innovators so that we have to reject H3a. The only difference is a significant negative effect during upturns for SMEs and a weakly significant effect for large firms during recessions.

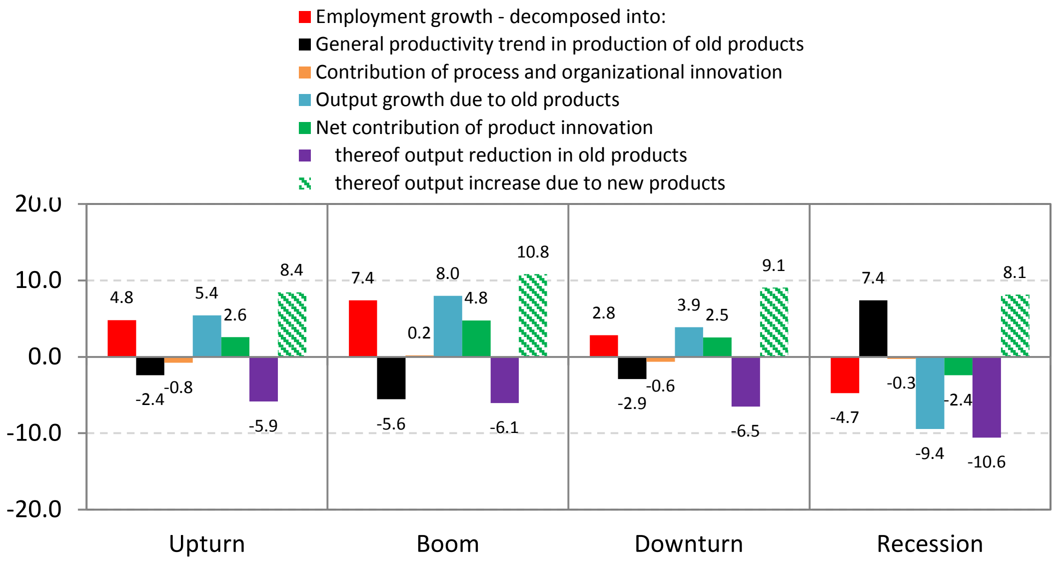
Table 5-3: Employment effects of innovation over the business cycle, SMEs and large firms

	Number of employees: 10-49				Number of employees: 250+			
Dep. var.: EMP	Upturn	Boom	Downturn	Recession	Upturn	Boom	Downturn	Recession
SGR_NEWPD	**0.989*** **	**0.965*** **	**1.010*** **	**0.971*** **	**0.953*** **	**1.015*** **	**1.025*** **	**0.994*** **
	(0.026)	(0.029)	(0.026)	(0.027)	(0.031)	(0.054)	(0.041)	(0.046)
PCONLY	-1.278	-0.453	**-1.727***	-0.547	**-2.999*** **	-0.130	0.427	0.696
	(0.821)	(1.483)	(0.981)	(1.071)	(1.107)	(2.266)	(1.177)	(1.275)
ORGA	**-2.012*** **	0.639	**-1.629** **	-0.674	**-2.871*** **	-1.710	-0.743	**-1.022***
	(0.449)	(0.703)	(0.655)	(0.509)	(0.695)	(1.049)	(0.730)	(0.560)
GDPGR	**3.774*** **	2.466	**-0.655*** **	0.169	**6.020*** **	1.134	**-0.950*** **	0.332
	(0.532)	(1.915)	(0.188)	(0.290)	(0.556)	(2.726)	(0.206)	(0.420)
DGP	-1.559*	**3.178** **	0.647	0.812	**-3.393*** **	**2.094***	**-1.717***	-1.023
	(0.835)	(1.249)	(0.674)	(0.676)	(0.963)	(1.159)	(0.935)	(0.777)
FGP	-1.559	1.059	-0.119	**-2.364*** **	**-3.209*** **	-0.289	-0.402	**-3.480*** **
	(0.970)	(1.190)	(0.780)	(0.648)	(0.995)	(1.425)	(1.113)	(0.844)
Constant	**-68.685*** **	**-30.782***	**-15.031*** **	**3.115***	**-82.340*** **	-24.260	**-23.132*** **	0.259
	(7.065)	(16.664)	(2.796)	(1.774)	(6.263)	(24.925)	(3.083)	(2.276)
Joint sign. (p-value)								
W_ownership	0.082*	0.036**	0.556	0.000***	0.001***	0.053*	0.146	0.000***
W_industry	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
W_country	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
W_time	0.000***	-	0.000***	-	0.000***	-	0.000***	-
R2a	0.387	0.474	0.386	0.467	0.620	0.640	0.554	0.554
Wald-Test: β=1	0.671	0.230	0.688	0.282	0.123	0.783	0.534	0.903
Tests on Exogeneity								
SGR_NEWPD	0.000***	0.002***	0.000***	0.023**	0.000***	0.003***	0.002***	0.029**
Tests on instr. validity								
Sargan/Hansen J-Test	0.957	0.319	0.893	0.664	0.189	0.857	0.330	0.202
First stage results 1 (SGR_NEWPD)								
F test on excl. Instr.	596.51	212.32	446.89	349.74	298.38	54.09	186.09	112.81
Tests on underident.								
Kleibergen-Paap LM test	245.537***	51.405***	1164.474***	618.394***	280.652***	40.008***	430.854***	327.493***
Test on weak instr.								
Cragg-Donald F test	6245.269***	1647.806***	7435.227***	5645.490***	822.207***	180.111***	572.785***	273.530***
Kleibergen-Paap F test	776.083***	267.749***	1005.156***	434.116***	460.893***	59.199***	401.560***	175.349***
Weak instr. rob. inf.								
Anderson-R. Wald test	757.431***	380.087***	981.495***	318.571***	449.902***	154.849***	243.982***	145.970***
Stock-Wright LM test	54.053***	42.189***	60.028***	45.979***	86.958***	42.154***	71.605***	67.936***
Observations	55,441	12,092	56,859	44,349	10,093	3,438	8,584	6,225

Notes: Method: Instrumental variables estimation. Weighted regression. Robust std. err. are in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level. .

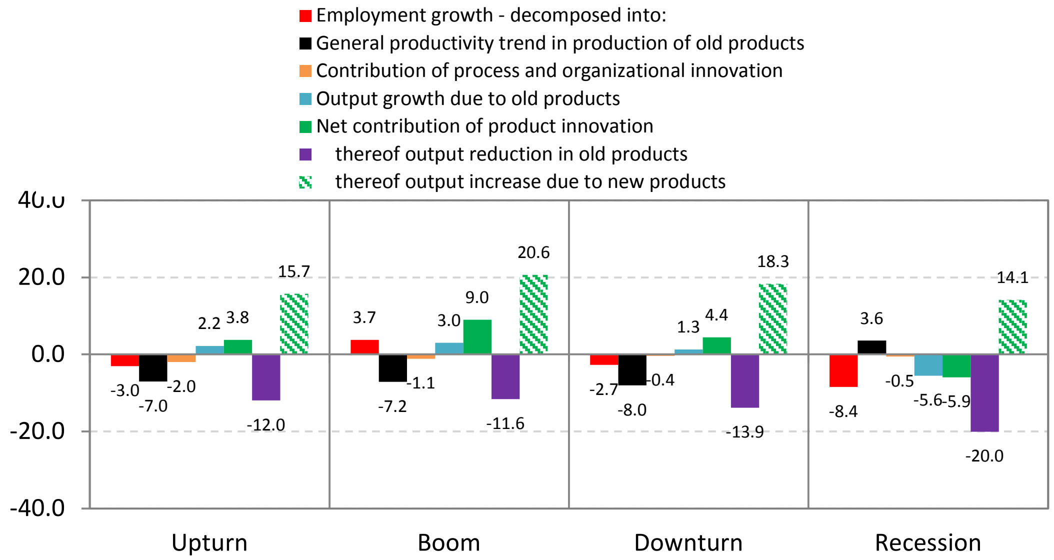
and Figure 5-2 and Figure 5-3 present the decomposition results for the different size classes. The decomposed effects for SMEs are very similar to the base case in Figure 5-1 . That is, employment growth behaves in a pro-cyclical fashion, the displacement effects of process and organizational innovations are negligible and also the general productivity trend has almost the same values. Moreover, the output growth due to old products of non-product innovators has the largest positive effect on employment growth during upturns, booms and downturns but not during recessions. During recessions, new product sales have been high enough to compensate the output reduction of old products of product innovators. However, the decomposition analysis reveals a different pattern for large firms. They generate less employment growth than SMEs despite higher sales growth from new products. Another difference is that net employment growth induced by product innovations is not strictly pro-cyclical. The net effect is lowest in recession and highest in booms, however, it is higher in downturns than in upturns, which does not support the hypothesis H1c. Moreover, large firms are considerably stronger affected by general productivity trends during upturns, booms and downturns, which overcompensates gains from new products and turn employment into negative. This could be caused by higher capital intensity, more opportunities to realize productivity gains from economies of scale, or better management practices of large firms. Figure 5-3 clearly shows that employment losses in large firms do not exist because these firms do not innovate. Instead, new product sales are a more important source for job creation in large firms than in SMEs. Employment gains from new products and also from demand growth of old products are, however, compensated by productivity gains from process and organizational innovations and general productivity increases, which are much smaller in SMEs compared to large firms. Boom periods with large demand effects are an exception.

Figure 5-2: Contribution of innovation to employment growth for SMEs, in %



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

Figure 5-3: Contribution of innovation to employment growth for large firms, in %



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

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

We also assume differences in the employment effects of innovation between different European countries. For instance, the cyclical dependency of employment growth could be much more pronounced in economically weaker Southern Europe compared to economic more robust Western European countries. Unfortunately, CIS data provided at the Eurostat's Safecenter does not allow us 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 5-4. 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. Across the regions, the coefficients of new product sales are mostly not significantly different from one indicating the same production efficiency between old and new products. There are two exceptions, (i) for the recession period for North-West Europe and (ii) the boom period for

South Europe. Both coefficients are significantly different from one but only weakly on a 10% level so that we rather cannot reject our hypothesis H1a.

For North-West Europe, process and organizational innovations play only a minor role for employment growth. 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, similar to the general case presented in Table 5-2 We have to reject the hypotheses H2a and H3a. 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. As a result, H2a and H3a have to be rejected.

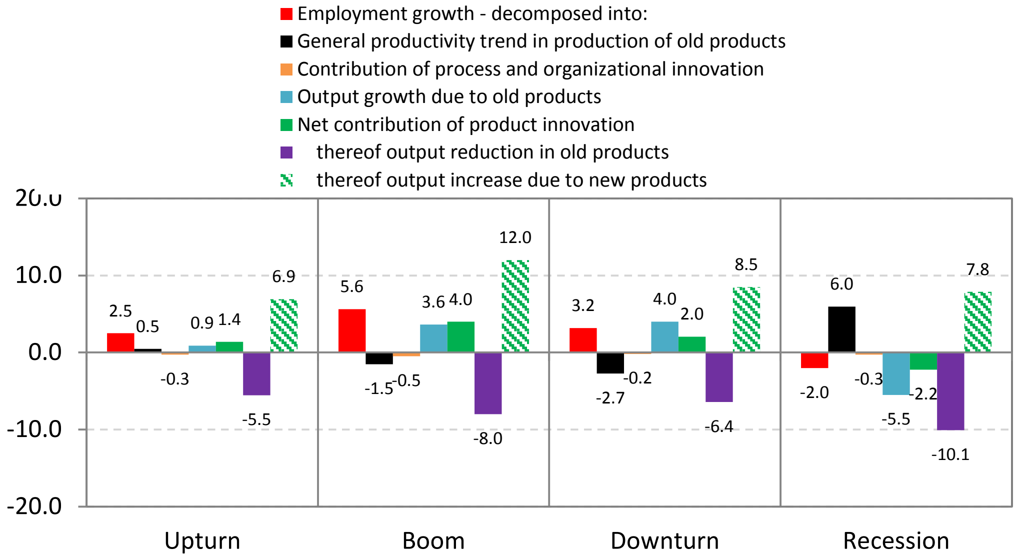
Table 5-4: Impact of innovation on employment growth by region and phase of the business cycle

	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)
W_industry	0.539	0.013**	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.176	0.15	0.000***	0.000***
R2a	0.298	0.447	0.406	0.459	0.372	0.434	0.388	0.495	0.372	0.683	0.303	0.281
Wald-Test: β=1	0.787	0.161	0.123	0.085*	0.487	0.095*	0.237	0.205	0.346	0.946	0.113	0.206
Exogeneity: SGR_NEWPD	0.001***	0.032**	0.166	0.495	0.001***	0.010***	0.003***	0.047**	0.000***	0.002***	0.003***	0.000***
Sargan/Hansen J-test	0.846	0.168	0.515	0.836	0.846	0.368	0.438	0.763	0.189	0.805	0.768	0.601
First stage results												
RANGE	16.485***	16.811***	17.797***	13.280***	21.380***	-	20.869***	-	31.294***	36.685***	36.049***	19.990***
	(1.536)	(1.374)	(1.120)	(1.184)	(1.969)		(1.0887)		(1.491)	(3.303)	(1.433)	(0.828)
COOP	4.315***	3.904**	-	4.326**	-	10.325*	-	7.700***	8.711***	6.460*	5.622***	2.728***
	(0.774)	(1.953)		(1.804)		(5.477)		(1.535)	(1.892)	(3.302)	(1.472)	(1.027)
RD	3.817***	9.779***	8.763***	6.381***	14.577***	18.675***	7.489***	17.648***	-	-	-	-
	(1.247)	(1.491)	(1.091)	(2.106)	(1.144)	(2.369)	(2.076)	(2.567)				
F test on excl. instr.	134.33***	177.68***	187.39***	211.71***	414.20***	40.67***	352.99***	119.42***	254.24***	130.19***	350.4***	498.92***
Kleibergen-Paap LM test	284.154***	22.535***	685.612***	214.264***	76.328***	34.566***	442.800***	101.199***	237.811***	199.643***	714.301***	670.698***
Cragg-Donald F test	1248.448***	889.605***	1328.781***	886.361***	2917.245***	155.677***	2927.747***	688.958***	4846.579***	574.041***	5359.603***	2935.105***
Kleibergen-Paap F test	180.370***	199.055***	468.733***	107.215***	404.853***	48.290***	411.015***	60.488***	507.825***	159.873***	601.381***	498.920***
Anderson-R. Wald test	367.699***	397.062***	236.539***	495.283***	603.132***	102.285***	576.314***	228.690***	271.812***	366.949***	322.746***	577.134***
Stock-Wright LM test	26.684***	24.612***	17.649***	25.760***	15.043***	20.481***	23.853***	15.020***	54.788***	12.868***	53.532***	453.067***
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. Robust std. err. are in parentheses. ***, ** and * indicate significance at the 1%, 5% and 10% level.

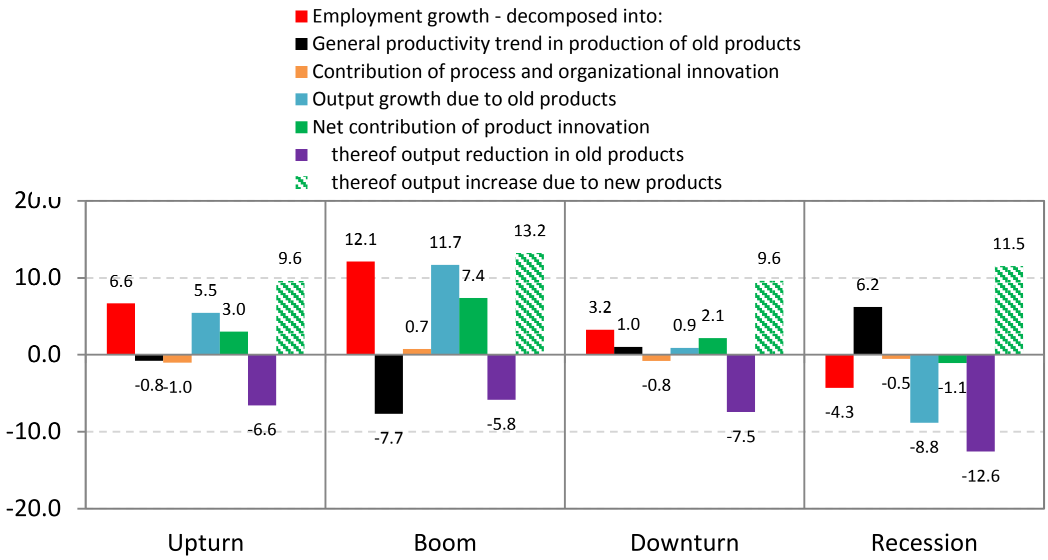
, and Figure 5-4, Figure 5-5 and Figure 5-6 decompose employment growth for the three regions. In all these regions, product innovations have created more jobs due to demand effects than jobs has been destroyed due to productivity, cannibalization and business stealing effects, except in boom periods.

Figure 5-4: Contribution of innovation to employment growth in North-West Europe



Note: Decomposition is based on the regressions of Table 5-4.
Source: CIS3, CIS4, CIS2006, CIS2008, CIS2010, Eurostat; own calculation.

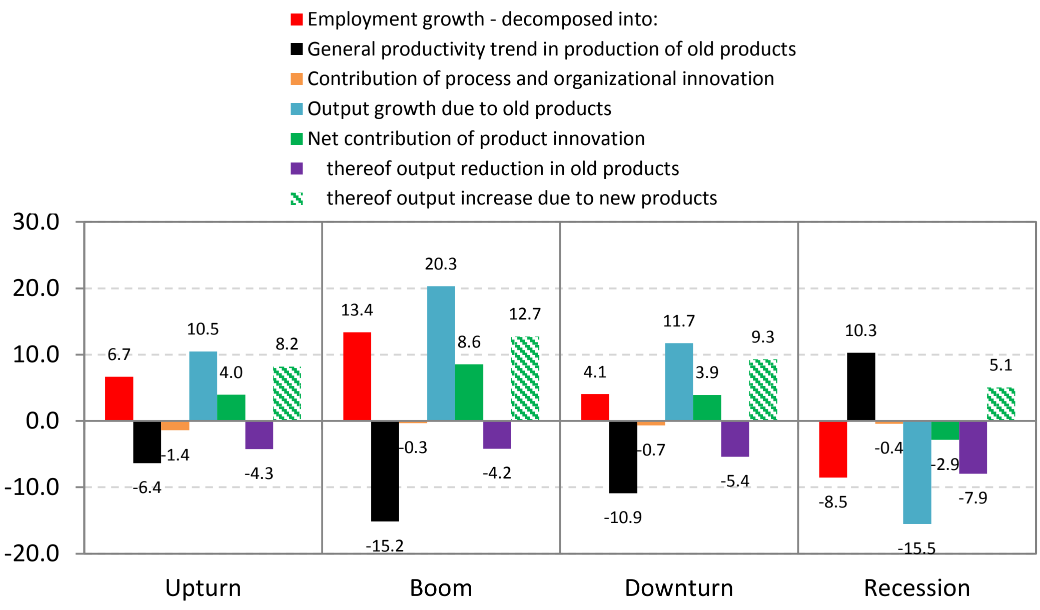
Figure 5-5: Contribution of innovation to employment growth in South Europe



Note: Decomposition is based on the regressions of Table 5-4.
Source: CIS3, CIS4, CIS2006, CIS2008, CIS2010, Eurostat; own calculation.

Across all regions, the net contribution of product innovations to employment growth is positive during upturns, booms and downturns and negative during recessions. Moreover, the net contribution is strictly pro-cyclical for Southern and Eastern European countries so that we cannot reject H1c. However, we have to reject H1c for North-West Europe since the net contribution is larger during a downturn than during an upturn. 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 5-4 shows that new products are produced more efficiently than old products in North-west Europe, except during upturns. Thus, 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, 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 5-6: Contribution of innovation to employment growth in East Europe



Note: Decomposition is based on the regressions of Table 5-4.
Source: CIS3, CIS4, CIS2006, CIS2008, CIS2010, Eurostat; own calculation.

6 Conclusion

We examined employment effects of different types of innovations over the business cycle with the model developed by Harrison et al. (2008, 2014). We estimated the model with firm-level data from 26 European countries covering the period of 1998 to 2010. Descriptive statistics reveal that employment in innovative firms grows faster than in non-innovative firms in all phases of a business cycle. The employment growth gap between innovators and non-innovators even widens during economic downturn and recession periods.

The estimation results indicate a race between job creation due to additional demand created by new products and job destruction due to productivity gains. 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 firm size class and the location of the firm.

A decomposition of employment growth based on the estimation results allows us 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 for product innovators 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 counter-cyclical 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 section 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.

The decomposition analysis for small and medium enterprises and large firms indicate that SMEs are very important for the economy's employment growth. They have relatively high employment growth rates, except during recessions. In contrast, large firms lose more employment from higher productivity than they gain from product innovations, which leads to mostly jobless growth. This may justify special programs to support innovation in SMEs, if policy sees innovation mainly as an instrument to promote jobs growth. However, from an efficiency point of view it seems that higher employment effects of innovation in SMEs are rather a sign of the considerable benefits large firms can yield from economics of scale.

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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8 Appendix

8.1 Sample statistics

Table 8-1: Country Coverage and Distribution of CIS sample by Country

Country	Country	Wave					Manufacturing	
		1	2	3	4	5	N	%
Belgium	BE	+	-	-	-	-	652	0.3
Bulgaria	BG	+	+	+	+	+	26,716	11.4
Cyprus	CY	-	-	+	+	+	1,217	0.5
Czech Republic	CZ	+	+	+	+	+	11,726	5.0
Germany	DE	+	-	-	+	+	5,727	2.4
Denmark	DK	+	+	+	-	-	1,445	0.6
Estonia	EE	+	+	+	+	+	4,557	1.9
Spain	ES	+	+	+	+	+	52,306	22.3
Finland	FI	+	-	-	-	-	900	0.4
France	FR	+	+	-	+	+	26,560	11.3
Greece	GR	+	+	+	-	-	1,568	0.7
Croatia	HR	-	-	-	-	+	1,212	0.5
Hungary	HU	+	+	+	+	+	9,581	4.1
Iceland	IS	+	+	-	-	-	318	0.1
Italy	IT	+	+	-	+	+	25,930	11.1
Lithuania	LT	+	+	+	+	+	3,567	1.5
Luxembourg	LU	+	+	+	+	+	765	0.3
Latvia	LV	+	+	+	+	+	2,615	1.1
Malta	MT	-	-	+	+	-	472	0.2
Netherlands	NL	+	-	-	+	+	5,813	2.5
Norway	NO	+	+	-	-	+	3,931	1.7
Portugal	PT	+	+	+	+	+	11,629	5.0
Romania	RO	+	+	+	+	+	18,479	7.9
Sweden	SE	+	+	+	+	+	8,150	3.5
Slovenia	SI	+	+	-	+	+	4,055	1.7
Slovakia	SK	+	+	+	+	+	4,515	1.9
Total		23	19	16	19	20	234,406	100.0

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

Table 8-2: Distribution of CIS Sample by Industry

Industry	Variable	Nace Rev. 1.1.	Nace 2	Observation		
				N	%	Cum
Food / beverages / tobacco	FOOD	15-16	10-12	32,810	14.00	14.00
Textile / wearing apparel / leather	TEXT	17-19	13-15	32,085	13.69	27.68
Wood / paper / printing	WOOD	20-21, 22.2-22.3	16-18	26,932	11.49	39.17
Chemicals	CHEM	24	20-21	12,654	5.40	44.57
Rubber / plastics	PLAS	25	22	12,959	5.53	50.10
Non-metallic mineral products	NONM	26	23	13,662	5.83	55.93
Basic and fabricated metals	BASM	27-28	24-25	33,006	14.08	70.01
Machinery	MACH	29, 33.3	28, 33	23,854	10.18	80.19
Electrical engineering	ELEC	30-32, 33.2, 33.4-33.5	26-27	17,692	7.55	87.73
Vehicles	VEHI	34-35	29-30	11,352	4.84	92.58
Nec	NEC	36, 33.1	31-32	17,400	7.42	100.00
Total				234,406	100	

Note: Up to CIS2006 the industry classification was based on NACE Revision 1.1, since CIS2008 NACE Revision 2 has been used as industry classification system.

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

Table 8-3: Distribution of the CIS Sample by Business Cycle Phases

Observation Period	Business Cycle Phase			
	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 and CIS2010, Eurostat; own calculation.