A closer look at the relationship between innovation and employment growth at the firm level

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Abstract

This paper considers in detail how different types of innovation (products, processes, patents, combinations) are related to different employment growth characteristics (exit or survival, with employment upscaling or downscaling at moderate or high rates). Using Norwegian Community Innovation Survey (CIS) data collected in 2008 and merged with public employer-employee registers for the years 2004-2010, it finds that growth persists over time, and increases the probability that 'bundles' of complementary product and process innovations are introduced that strengthen employment further. Downscaling also persists, and reduces the probability that 'bundles' are introduced that could turn the negative trend. While standalone product innovations follow in the wake of rapid expansion, such have limited impact on employment beyond sustaining growth at moderate levels. Standalone process innovations, by contrast, tend to be introduced after a period of moderate growth, yet, might give rise to large subsequent expansions. These results demonstrate that innovation and employment growth are multi-dimensional characteristics of the firm, which are interlinked with each other in virtuous or vicious circles that unfolds over time.

Keywords: Innovation, employment, growth, capabilities, Norway

JEL: D21, D22, L25, O33

Introduction

The question of how technological change and firm innovation is related to employment growth has been extensively debated in the academic literature (Bogliacino and Pianta 2010; Brouwer et al. 1993; Coad and Rao 2011; Dachs and Peters 2014; van Reenen 1997). Research at the aggregate level faces the challenge that innovative activities in some parts of the economy may either stimulate or come at the expense of employment in others, due to knowledge spillovers, multiplier effects and business stealing (Aghion and Howitt 1990; Greenan and Guellec 2000; Grossman and Helpman 1991; Mastrostefano and Pianta 2009). At the firm level where the relationship is more direct, a large number of empirical studies that differ widely in terms of datasets, measures of innovation and estimation strategies largely agree that innovation in some form matter for employment, but disagree on when, how and why (Goedhuys and Veugelers 2012; Grillitsch et al. 2019; Harrison et al. 2014; Lachenmaier and Rottmann 2011).

Without ambition of direct inference to the industry or economy level, this paper seeks to disentangle the relationship between innovation and employment growth in firms. By discussing antecedent research in light of evolutionary theories and well-documented statistical properties of growth, it identifies three issues in need of special attention. The first and most fundamental reflect the practice of treating innovation as exogenous and employment as a discrete, reversible scaling response (e.g. Calvino and Virgillito 2017; Hall et al. 2008). This poorly matches work going back to Penrose (1959) suggesting the two are dynamically related. The second concerns how innovation is conceptualized theoretically and measured empirically - as a technological characteristic expressed by R&D and patents, or as a differentiated commercial phenomenon. The third concerns the practice of treating employment growth as a quantitative, single-dimensional firm characteristic. This excludes the discrete event 'exit' from the growth construct, builds survivor biases into empirical models and does not acknowledge that e.g. rapid 'gazelle' expansion or mass lay-offs are phenomena that are fundamentally different from moderate increases or decreases in employment, respectively.

As these three issues are interrelated, dealing with either one demand that the two other are also considered. To do so, the analysis here uses a dedicated empirical approach and Norwegian Community Innovation Survey data (CIS) merged with employer-employee registers covering the years 2004-2010. The former are collected by Statistics Norway on a bi-annual basis, and the CIS2008 data used here cover innovation activity and outcomes in a representative sample of firms during the period 2006-2008. The latter data are maintained by public authorities and cover all firms and all individuals aged 16 or above. Using this data, the analysis is able to demonstrate that different aspects of innovation (products, processes, patents, combinations) are associated with different intrinsic growth characteristics (exit or survival, with employment upscaling or downscaling, at moderate or high rates) in their own unique ways.

Conceptual framework

The ubiquity of fat-tailed growth distributions where more observations than in the Gaussian 'normal' exhibit particularly high and low rates indicate that underlying dynamic processes are at play (Bottazzi and Secchi 2006; Dosi et al. 2018). Evidence of such processes exist in the form of positive serial correlations of growth, found most consistently among larger firms (e.g. Coad 2007; Coad and Hölzl 2009). Thus, instead of smooth adjustments, growth is characterized by longer periods of expansion and contraction (Reichstein and Jensen 2005), meaning that success might be breeding success while failure breeds failure (Bottazzi et al. 2002; Dosi et al. 2018; Reichstein et al. 2010). Negative serial correlations have also been found as small firms with more adaptable yet weaker organizational capabilities and market positions tend to exhibit lumpy growth processes, where periods of expansions are followed by setbacks (Coad 2007; Coad and Hölzl 2009). Irrespective of whether the sign is positive or negative, serial correlations mean that growth in any one period cannot be understood independently of growth in the period leading up to it. Thus, as a baseline for the analysis here, a first hypothesis is formulated that assume growth is generally related to itself with a positive sign:

Hypothesis 1: Firms exhibit upward-pointing or downward-pointing employment growth trajectories that persist over time

Against this background, the first issue that demand attention is whether observed persistence also of innovation (e.g. Cefis and Orsenigo 2001) means that the two are dynamically related to each other. The resource-based view of the firm speaks to this by conceptualizing innovation and growth as intimately interlinked with organizational capabilities that develop cumulatively (Barney 1991; Eisenhardt and Martin 2000; Grimpe and Kaiser 2010; Leonard-Barton 1992; Penrose 1959; Wernerfelt 1984). By doing so, it aligns with evolutionary theories of the firm more generally (Ahuja and Katila 2004; Nelson and Winter 1982; Nonaka 1994; Teece et al. 1997) in proposing that ongoing innovation efforts increases the capacity to innovate further by developing specialized knowledge and supportive organizational routines, potentially leading to accelerating effects (Turner et al. 2013) or 'virtuous circles' (Bogliacino et al. 2017) of sustained innovation and growth in the current business domain or diversification into new activities (e.g. Bhardwaj et al. 2006; Neffke and Henning 2013). Supportive of such a view, Bogliacino et al (2017:478) found positive correlations of wages with R&D expenditures in Italian firms, thus echoing prior research finding low wages and high turnover of employees harmful for innovation

(Herstad et al. 2015; Kleinknecht et al. 2014). Hence, downsizing of 'production capacity' may dampen 'innovation capacity', and signal limited management attention to developing current capabilities further. Conversely, growth in employment signal management attention to capability building, and open for new employees to enter with specialised knowhow gained at prior places of employment. This might give rise to 'learning-by-recruiting' effects on firms' innovation capacities (Almeida and Kogut 1999; Herstad et al. 2015; Song et al. 2003). Based on this, a second hypothesis can be formulated:

Hypothesis 2: Upward-pointing growth trajectories increases the probability of innovation, while downward pointing trajectories decreases the probability

The second issue that demand attention is the nature of 'innovation' itself. A substantial literature exists that focuses on whether research and development input (R&D) and patenting output are associated with growth, predominantly in revenues (e.g. Bogliacino 2014; Coad and Rao 2008; Del Monte and Papagni 2003; Demirel and Mazzucato 2014; García-Manjón and Romero-Merino 2012) and occasionally in employment (e.g. Coad and Rao 2011). This focus on technology reflects a long-honoured research tradition (e.g. Crepon et al. 1998; Griliches and Mairesse 1984), as well as the limited availability, varying quality and largely cross-sectional nature of data on actual innovation such as those obtained through the Community Innovation Surveys of EUROSTAT (Mairesse and Mohnen 2010; OECD 2005), However, the widespread occurrence of non-technological innovation (Jensen et al. 2007; Parrilli and Alcalde Heras 2016) underscores a fundamental limitation: While this approach does capture 'technology for the sake of technology' (e.g. Barczak 1995), most innovations, by most firms, are excluded from the analysis (Bogliacino and Pianta 2010).

In research using instead data on actual innovation, much emphasis has been put on the difference between new products and new production processes that is the direct exposure of the former to market demand and the potential for the latter to involve substitution of labour with capital equipment (Calvino and Virgillito 2017; Hall et al. 2008). Recent research point to the importance of demand effects from new products for employment growth (Bogliacino and Pianta 2010; Dachs and Peters 2014; Lachenmaier and Rottmann 2011). By doing so, it substantiates the results of prior studies using different growth measures and data spanning from small firms in Northern England (Freel and Robson 2004) through manufacturing firms in Brazil (Goedhuys and Veugelers 2012) and business services firms in the US (Mansury and Love 2008) to Italian firms more generally (Hall et al. 2008). The evidence for process innovation effects specifically on employment are more mixed (see e.g. Lachenmaier and Rottmann 2011 for a review), spanning from positive (ibid) through neutral (e.g. Harrison et al. 2014) to negative (Dachs and Peters 2014; Hall et al. 2008) also at the level of industries (Bogliacino and Pianta 2010). However, data used in this stream of research is generally cross-sectional, meaning that growth and innovation are observed simultaneously or with limited time lags. Moreover, firms' underlying growth trajectories are not accounted for. Thus, a third hypothesis is formulated that recognizes existing evidence on the impact of product and process innovation as well as influences from the underlying trajectory as assumed in Hypothesis 1:

Hypothesis 3: Product innovations exert more consistent upward-lifting forces on the (positive or negative) growth trajectories of firms than do process innovations

Interdependencies between high-tech manufactured goods and advanced, in many cases even tailored, production equipment, and the blurred boundary between products, processes and organization that characterizes many services industries (e.g. Tether and Tajar 2008; Toivonen and Tuominen 2009), are but two reason to question the relevance of following e.g. Bogliacino and Pianta (2010) and isolate the employment growth impetuses of novel products from those of other innovations. Acknowledging this in their analysis of revenue growth, Evangelista and Vezzani (2010) found simultaneous product, process and organizational innovation necessary for Italian firms achieve *'…a true competitive advantage'* (Evangelista and Vezzani 2010). Similarly, Goedhuys and Veugelers (2012) found combined product and process innovation particularly important for sales growth in Brazilian firms. Sapprasert & Clausen (2012) conclude that organizational innovations strengthen the impacts of technological innovation on growth in revenues and employment, as later analysed also by Ballot and colleagues (2014) in their study specifically of sales performance.

These results might simply reflect that new products demand new processes and ways of organizing in order for improved price/quality ratios to stimulate demand. Yet, Piening and Salge (2014) goes beyond this and suggest that process innovations involve fundamental changes in 'the ways things are done' that trigger learning and have implications for change on a broader basis. Similarly, product innovations might be important not only due to their direct effects on market demand, but also due to learning processes triggered that might have implications for processes and ways of organizing beyond requirements here and now (e.g. Dougherty 1992; Helfat and Raubitschek 2000). Thus, learning and demand effects stemming from the interplay between product and process innovation might well be more important than elementary differences between the two.

Developing complementary product and process innovation is organizationally demanding. Different aspects of development work depend on different types of practices, knowledge and networks, contradictory concerns need resolving on an ongoing basis and potential glitches must be identified and avoided (Fleck 1997; Hoopes and Postrel 1999). Consequently, firms that innovate new products and production processes signal strong organizational capabilities and management attention to developing these capabilities further, over time. This means that 'complex bundles of complementary innovation' (Evangelista and Vezzani 2010) may be intimately interlinked with the underlying growth trajectory. Accordingly, growth impetuses from combined product and process innovation must be isolated from trend growth (Hypothesis 1) in order to substantiate that they are particularly strong:

Hypothesis 4: Combined product and process innovation exert more consistent upward-lifting forces on the underlying (positive or negative) growth trajectories of firms than does standalone product or process innovation

The third and final issue that demand attention is the nature of employment growth. Dedicated literatures exist on the specificities of new firm formation, rapid 'gazelle' growth (e.g. Herstad et al. 2013; Nightingale and Coad 2014; Senderovitz et al. 2016), as well as mass layoffs and closures (see e.g. Fackler et al. 2018 for a review and evidence from Germany). Moreover, calls have been made for research more generally to shift attention away from the average growth rate towards what is occurring on the two tails (Reichstein et al. 2010). Yet, it remains common practice to ignore discrete events (entry and exit or survival, cf. Pakes and Ericson 1998) and treat employment growth as a single-dimensional characteristic exhibited only by firms that survive in the data used, i.e. as simply 'more or less of the same' for those who remain in a position to exhibit it. Accordingly, survivor biases are built into analyses and there is limited evidence on whether innovations that do not matter on the average might still do so for specific aspects of growth (e.g. exit vs. survival, or rapid expansion). Any hypothesis formulated would therefore be arbitrary, and the issue is left open for the empirical analysis to explore rather than test.

Still, supporting the relevance of raising this issue are studies that have used longitudinal data to estimate quantile regressions (Koenker and Bassett 1978) demonstrating that marginal changes in turnover due to marginal changes in exogenous variables (commonly age and size, in addition to e.g. R&D and patents) vary between different quantiles, i.e. parts, of the sales growth distribution (e.g. Calvino and Virgillito 2017; Coad and Rao 2008; Coad and Rao 2011; García-Manjón and Romero-Merino 2012; Goedhuys and Sleuwaegen 2010). Notably, Coad and Rao (2008) found firms located in the upper tail capturing unique sales growth effects from technology. However, inferences to employment growth from results for sales cannot be directly made as firms may increase the latter while maintaining or reducing the former by raising prices rather than producing larger volumes in response to strengthened demand (e.g. Hall et al. 2008; Smolny 1998). Moreover, this focus on differentiation within quantiles leaves open the question of why firms at the outset are located where on the growth distribution, and comes with the risk of excessive attention to marginal phenomena (e.g. Grillitsch et al. 2019).

As these three issues are interrelated, the first (Hypothesis 1 and 2) and second (Hypothesis 3 and 4) are here explored empirically in the Norwegian context using a simple and transparent estimation strategy developed in response to the third, i.e. to ensure that qualitatively different aspects of growth are acknowledged. As the basis for this, a representative firm-level dataset approximating that of a panel has been constructed. The dataset is constructed to reflect the warning of Pakes and Ericson (1998) that the inclusion only of surviving firms in full-fledged panels may strongly bias results if the exclusion mechanism is related to the economic phenomena of interest. As this is clearly the case here, firm exit or survival during the period is treated as one of several intrinsic characteristic of growth.

Data, variables and methodological approach

Data

The analysis uses innovation data sampled by the governmental agency Statistics Norway in the sixth round of the Pan-European (cf.OECD 2005) Community Innovation Survey (CIS2008). In contrast to many other European countries, participation in the Norwegian surveys is compulsory for sampled firms. The result is comparatively large data sets, which are not plagued by non-response biases. The full CIS2008 consists of 6029 enterprises in natural resource-based, manufacturing and knowledge intensive services industries, and provide information on their innovation activities and outcomes during the reference period 2006-2008. Prior to release for research purposes, the data were thoroughly reviewed and validated by Statistics Norway.

The data used is the 4604 CIS2008 observations that were established in 2006 or earlier, and had 10 employees or more in the sampling year 2008. To preserve the full sample, the analysis utilizes only information that can reasonably be provided by all sampled firms, independently of their innovation status[1].

[1] Innovation status refers to whether firms engaged or not in innovative activities during the reference period, with or without specific outcomes (OECD 2005:58-59; OECD 2018:80-81). Because responding is compulsory and a strict routing structure is no longer implemented, Norwegian firms that are not innovation active systematically answer ‘0’ on questions that assume such activity (e.g. questions on factors that hamper innovation and collaboration for innovation). This gives rise to tight correlations between innovation activity/outcome, and positive responses to question that in wording assume such innovation activity or outcome. Therefore, variables based on such information must be used with caution unless sample selection models in the tradition of Heckman (1979) are used where only innovation-active firms are included in the estimations of interest (see e.g. Bogliacino et al. 2017; Cassiman and Veugelers 2006; Herstad and Ebersberger 2015); Herstad et al. (2015).

Public business registers for the years 2004-2006 (the two-year period prior to the CIS reference period) and 2008-2010 (extending two years beyond the CIS reference period) provide information on employment. The CIS reference period itself is included in the latter because it cannot be determined exactly when, during this period, that innovations where introduced. The data have characteristics approximating those of a panel, yet deviate in three important ways. First, they include firms that were established during the years 2004-2006, i.e. firms for which only the qualitative growth characteristic that is ‘entry’ can be observed prior to innovation. Second, they include firms sampled in the CIS2008 that ceased to exist during the period 2008-2010, i.e. firms for which no other growth characteristics than discrete ‘exit’ can be observed after they innovated, or not. Third, no information is available on innovation output prior to 2006, or after 2008.

Growth

Quantitative growth rates were computed in accordance with conventions (c.f. Coad and Rao 2008) for the periods 2004-2006 and 2006 – 2010 (see Table 1). The two growth distributions are fat-tailed, with excess kurtosis of 21 (observed) – 3 (normal distribution) = 18, and 19 – 3 = 16, respectively. The rates are categorized as described in Table 1. The ordinal-scale variable GROWTH_0406 takes on the value 0 for firms that were established after 2004. Remaining firms where assigned to categories that correspond to their locations on the 2004-2006 growth distribution and span from 1 (lowest 20 per cent) to 5 (highest 20 per cent). The ordinal-scale variable GROWTH_0610 is assigned the value 0 for firms that exited the registers after sampling in the CIS in 2008. For remaining firms, categories ranked from 1 to 5 have been assigned as described above. The cut-point values where then adjusted so that GROWTH_0406=3 and GROWTH_0610 = 3 refer to the lowest levels of positive growth, and to ensure that the lower cut-point value of any category is always equal to the first observed growth rate that is higher than the highest rate in the category below.

The two ordinal-scale variables are in the regression represented by binary variables as described to the right in Table 1. Compared to the use of continuous growth measures, this allows entry (GROWTH_0406 = 0) and exit (GROWTH_0610 = 0) to be treated as integral to the growth construct and circumvents sample selection issues that would arise if only firms that existed the entire 2004-2010 were included in the estimations (Pakes and Ericson 1998). Moreover, it preserves, and makes transparent, information on qualitatively different growth characteristics (positive or negative growth, at moderate or high levels) contained in the quantitative measure (cf. Table 1).

Table 1: Construction of growth categories

Categorical variables	Observations	Corresponding quantitative growth rates		Corresponding binary variables used in regressions
GROWTH_0406		*Min*	*Max*	
0 (new firm)	389	-	-	0406_NEW
1	786	-3.624	-0.080	0406_C1
2	814	-0.081	0	0406_C2
3	950	0.002	0.143	0406_C3
4	847	0.144	0.318	0406_C4
5	818	0.319	4.982	0406_C5
	N=4604			
GROWTH_0610				
0 (exit)	253	-	-	
1	807	-4.412	-0.182	GROWTH_0610>0
2	906	-0.183	0	
3	887	0.004	0.182	GROWTH_0610>2
4	886	0.183	0.430	
5	865	0.431	7.240	GROWTH_0610=5
	N= 4604			

Quantitative growth rate 2004-2006: Log (employment in 2006) – log (employment in 2004) = log (employment in 2006/employment in 2004)
Quantitative growth rate 2006-2010: Log (employment in 2010) – log (employment in 2006) = log (employment in 2010/employment in 2006)

Innovation

The CIS questionnaire asks firms to specify whether, during the reference period, they introduced i) new or significantly improved products (goods or services) onto the market; or ii) implemented new or significantly improved production processes, support functions and/or means of storage and delivery (cf. OECD, 2005). Based on this, variables have been constructed to capture the composition of innovation output. PROD_ONLY takes on the value 1 for firms that reported product innovation, but not process innovation. PROC_ONLY takes on the value 1 for firms that reported process innovation, without introducing new products. BOTH captures product innovation in tandem with process innovations. Finally, PATENT takes on the value 1 if the firm submitted a patent application during the reference period. It is included as a measure of technological novelty and intellectual property right protection (IPR) (Herstad et al. 2015) that link the research here to contributions focusing specifically on this aspect of innovation (e.g. Coad and Rao 2008; Coad and Rao 2011; Demirel and Mazzucato 2014).

Control variables

The relationship between growth and firm size has been discussed intensively since Gibrat proposed that growth, on average, is proportional to current size (Gibrat 1931). Several studies from the post-war era found support for what has become known as Gibrat's Law (see Sutton 1997). More recent studies have found size negatively correlated with growth (e.g. Reichstein and Jensen 2005), conditional on the part of the growth distribution considered (Reichstein et al. 2010), and influencing the extent to which serial correlations of growth are observed (e.g. Coad 2007). As it is evident from this that size and growth are related, and size may affect innovation propensities, controls for size are included.

The commercial performance of the firm might influence i) selection into innovation activity, ii) the persistence of growth and ii) how it is related to innovation. Building on Bogliacino and Cardona (2014) the variable COMPERF captures the sales performance (log of sales per employee) of firms in 2006 relative to the frontier of their NACE 3-digit sectors[2]. The frontier is defined as the cut-point value for the 99th percentile, and values above are winsorized. Thus, COMPERF takes on values from 0 for firms without sales to 1 for firms at the sales performance frontier of the 3-digit sector. Similarlly, foreign market presence provides incentives to innovate due to market size and diversity, and competitive pressures (Bogliacino et al. 2017; Crepon et al. 1998; Ebersberger and Herstad 2011). This is captured by the variable FORMAR that takes on the value 1 if firms state a presence on markets outside Norway.

Formal education may influences survival and growth probabilities (Herstad et al. 2013), and innovation (Herstad 2018a; Piening and Salge 2014). Controls for the proportion of employees with higher education are therefore included as described below. Finally, the propensity to innovate, the types of innovation launched, opportunities to profit from innovations and the probability of employment growth itself are all related to industry conditions. Therefore, 14 dummy variables are included in the regressions to capture 15 industry groups[3].

Estimation strategy

Estimations have been conducted in three main stages. Reflecting Hypothesis 2, the first stage estimate whether innovation outcomes during the 2006 – 2008 reference period are associated with the growth of the firm during the period 2004 – 2006. The control variable HIGHED_04 is the proportion with higher education, and SIZE_04 the log of firm size. Both refer to 2004, i.e. the base year for

[2] The alternative of controlling for labour productivity growth in 2004-2006 and 2006 -2010 is not open, as it cannot be observed for firms established in the first period or closed down in the second.

[3] Aquaculture, Offshore Oil & Gas extraction, mining & quarrying, high-tech manufacturing, medium high-tech manufacturing, medium low-tech manufacturing, low-tech manufacturing, construction, energy & environmental services, wholesale trade, transportation & logistics services, information & communication services, financial & management services, technical & scientific services, other business services (cf. Herstad 2018a)

GROWTH_0406 computation. The second stage conduct binary estimations of whether survival (GROWTH_0610 > 0); upscaling at any level (GROWTH_0610 > 2) and high growth specifically (GROWTH_0610 = 5) in the period 2006-2010 is associated with past growth characteristics (Hypothesis 1), and the innovation outcomes PROD_ONLY, PROC_ONLY, BOTH (Hypothesis 3 and 4) as well as PATENT. This stage also tests for interaction effects between patents and commercial innovation.

In the third stage, probabilities of growth are estimated for sub-samples defined by the growth characteristics exhibited in 2004-2006. This is done to consider if these characteristics influence the effect of innovation on future growth. In the second and third stage, the control variables HIGHED_06 and SIZE_06 are used to capture education levels and size in the base year for GROWTH_0610 computation.

As growth and innovation variables are binary, logistic regressions have been estimated (see the robustness section on the alternative of estimating linear probability models). Wald's Chi2 tests of between-regression differences in coefficient estimates are reported in the right-hand columns of Tables 2 and 3, whereas supplementary within-regression comparisons of coefficients are reported at the bottom of the two tables.

Results

Employment growth effects on innovation output

Table 2 below display results for estimations of different innovation outcomes. In the estimation of PROD&PROC (Model 1), size, education level and foreign market presence are all strong determinants. None of the variables describing past growth are individually significant compared to the 0406_NEW reference. Yet, the supplementary Walds tests reveal that each of the negative estimates for the variables capturing downscaling of employment in 2004-2006 (0406_C1 and _C2) are significantly different from the positive estimates obtained for variables capturing substantial employment upscaling (0406_ C4 and _C5) during this period. Thus, the stronger past growth of mature firms is, the higher is the probability that they introduce combined product and process innovation. This is supportive of Hypotheses 2.

Table 2: Estimations of innovation output.

	Model 1: PROD&PROC=1		Model 2: PROD_ONLY=1		Model 3: PROC_ONLY=1		Model 4: PATENT=1		Walds tests of coefficient equality		
	Coeff	*SE*	*Coeff*	*SE*	*Coeff*	*SE*	*Coeff*	*SE*	*Model 1 –Model 2*	*Model 1 – Model 3*	*Model 1-Model 4*
EMPL_04	0.171	0.041***	0.062	0.044	0.116	0.051**	0.366	0.047***	2.35	0.56	11.49***
COMPERF	0.150	0.328	0.594	0.346*	0.336	0.403	0.413	0.367	0.81	0.11	0.33
FORMAR	1.023	0.103***	0.532	0.103***	0.200	0.129	1.108	0.128***	9.35**	21.18***	0.30
HIGHED_04	1.427	0.349***	1.694	0.349***	-0.753	0.558	3.034	0.377***	0.23	9.68***	10.94***
0406_NEW	*Reference*		*Reference*		*Reference*		*Reference*				
0406_C1	-0.342	0.276	-0.566	0.266**	-0.526	0.335	-1.275	0.305***	0.26	0.15	5.77**
0406_C2	-0.311	0.277	-0.493	0.264*	-0.379	0.333	-1.594	0.311***	0.18	0.02	10.52***
0406_C3	-0.082	0.268	-0.317	0.257	0.005	0.321	-1.332	0.298***	0.31	0.04	10.84***
0406_C4	0.023	0.258	-0.408	0.248	-0.234	0.316	-1.409	0.290***	1.1	0.34	14.76***
0406_C5	0.051	0.245	-0.099	0.229	-0.349	0.302	-0.784	0.267***	0.15	0.9	5.67***
Constant	-3.260	0.355***	-2.441	0.345***	-3.147	0.422***	-3.100	0.373***			
Walds Chi2 tests of coefficient equality											
0406_C1 - _C3	2.95*		2.43		8.42**		0.08				
0406_C1 - _C4	5.51**		0.67		2.14		0.71				
0406_C1 - _C5	5.86**		8.16**		0.44		6.73**				
0406_C2 - _C3	2.29		0.56		5.73**		1.7				
0406_C2 - _C4	4.62**		0.00		0.85		0.45				
0406_C2 - _C5	4.96**		4.45**		0.02		16.03***				
LR Chi2(df)	397.94(23)***		374.39(23)***		52.96(23)***		597.7(23)***				
Pseudo R2	0.114		0.109		0.022		0.199				

Note: Coefficient estimates and standard errors from logistic regressions. ***, ** and * indicate significance at the 1 per cent, 5 per cent and 10 per cent levels respectively. All regressions include dummies as control for sector characteristics.

Model 2 find that the probability of standalone product innovation is higher among young firms than among mature firms with negative 2004-2006 growth. Tested jointly, estimates the variables capturing positive past growth are not significant from the reference 0406_NEW reference. Still, the supplementary pairwise comparisons of coefficient estimates reveal that 0406_C5 is significant different from 0406_C1 and _C2, meaning that mature firms with strong past growth exhibit innovation propensities equal to new firms, and significantly higher than mature firms with negative past growth. In addition, PROD_ONLY is positively, and uniquely, associated with the commercial performance of the firm. This means that young firms and mature firms with strong past growth have particularly high probabilities of introducing standalone product innovations when they also exhibit strong sales performances.

At the outset, Model 3 suggests that it is only size that significantly influences the probability of standalone process innovation, as neither the control variables FORMAR, COMPERF and HIGHED nor the variables capturing past growth yield significant estimates. However, supplementary pairwise comparisons of the latter reveal that the estimate for 0406_C3 is significantly different from both variables capturing negative growth, and the variable capturing strong growth (0406_C5). Thus, moderate past growth gives rise to higher probabilities of standalone process innovation among mature firms.

Striking in Model 4 is the high probability of PATENT exhibited by new firms, compared to their mature counterparts for which all estimates are negative, individually significant compared the reference, and generally not significantly different from each other. The exception is again 0406_C5, for which the estimate is less negative than for mature firms with negative past growth. This suggests that new firms have a stronger emphasis on patented technology, compared to mature firms with stronger organizational capabilities. Underscoring further the higher patenting propensities of new firms is the cross-equation comparisons that find all estimates for mature firms significantly more negative in Model 4 (PATENT) than in Model 1 (PROD&PROC). From these comparisons, it is also evident that estimates for FORMAR are significantly larger in the estimation of PROD&PROC, than in the estimations of other innovation outcomes except patents. Thus, foreign markets drive complex innovation activities, and patenting.

The persistence of growth

Table 3 report estimations of GROWTH_0610 beyond the thresholds that are > 0 for survival, > 2 for growth and =5 for strong growth (cf. Table 1). In these models, the effects of growth in 2004-2006 on growth 2006-2010 are isolated from the effects on the latter from innovation. The estimates for GROWTH_0610 > 2 (increasing employment independently of level, Model 6 in Table 3) are supportive for Hypothesis 1 that predicted persistence of positive as well as negative growth, independently of innovation: 0406_C1 and 0406_C2 that capture negative growth in 2004-2006 reduces significantly the probability of upscaling in 2006-2010, compared to the reference. Moreover, pairwise comparisons reveal that estimates for 0406_C3, _C4 and _C5 that are not individually significant compared to the 0406_NEW reference all are significantly different from 0406_C1 and _C2: Growth does persist over time. Model 7 suggests that this particularly applies to strong growth, as all coefficients for growth in 2004-2006 are significantly negative compared to the 0406_NEW reference except 0406_C5 that is positive and significantly different from all other growth classes except 0406_NEW. This holds independently of size, commercial performance in 2006 and foreign market presence, the latter being an important driver specifically of high growth rates.

Table 3: Estimations of employment growth.

	Model 5 GROWTH_0610>0		**Model 6** GROWTH_0610>2		**Model 7** GROWTH_0610=5		**Walds Chi2 tests of coefficient equality**	
	Coeff	*SE*	*Coeff*	*SE*	*Coeff*	*SE*	*Model 5 – Model 6*	*Model 6 – Model 7*
PROD&PROC	0.389	0.228*	0.423	0.103***	0.293	0.132**	0.02	0.93
PROD_ONLY	0.763	0.266***	0.135	0.104	-0.072	0.142	5.55**	2.19
PROC_ONLY	0.087	0.252	0.070	0.121	0.450	0.156***	0.00	6.13**
PATENT	0.020	0.263	0.049	0.116	0.279	0.149*	0.01	2.86*
EMPL_06	0.021	0.057	-0.231	0.028***	-0.662	0.043***	17.74***	88.28***
COMPERF	0.478	0.378	0.372	0.207*	0.425	0.258*	0.11	0.04
FORMAR	0.158	0.151	0.025	0.073	0.236	0.097**	0.77	4.86**
HIGHED_06	-0.049	0.551	0.944	0.305***	0.751	0.322**	3.78*	0.36
0406_NEW	*Reference*		*Reference*		*Reference*			
0406_C1	0.387	0.251	-0.489	0.135***	-0.642	0.159***	14.01***	1.00
0406_C2	0.327	0.252	-0.381	0.136***	-1.100	0.171***	902***	18.59**
0406_C3	0.592	0.257**	-0.129	0.133	-0.957	0.164***	9.04***	25.48***
0406_C4	0.435	0.250*	-0.131	0.134	-0.654	0.156***	5.89*	11.43***
0406_C5	0.351	0.246	0.121	0.136	0.117	0.146	1.03	0.00
Constant	2.225	0.432***	1.050	0.227***	0.644	0.280		
Walds Chi2 tests of coefficient equality								
0406_C1 - _C3	0.84		12.71***		4.47**			
0406_C1 - _C4	0.03		11.93***		0.01			
0406_C1 - _C5	0.03		32.68***		33.82***			
0406_C2 - _C3	1.39		6.43**		0.79			
0406_C2 - _C4	0.01		5.94**		8.34***			
0406_C2 - _C5	0.14		22.28***		70.24***			
LR Chi2(df)	50.78(27)***		331.04(27)***		648.91(27)***			
Pseudo R2	0.025		0.053		0.146			

Note: Coefficient estimates and standard errors from logistic regressions. ***, ** and * indicate significance at the 1 per cent, 5 per cent and 10 per cent levels respectively. All regressions include dummies as control for sector characteristics

Innovation effects on employment growth

From the results reported in Table 3, it is evident that PROD&PROC is the only type of innovation output that significantly increases the probability of survival, of growth, and of strong growth. This consistent upward lift is supportive of Hypothesis 4 also because standalone innovations only have conditional effects: In the estimation of survival (GROWTH_0610 > 0), PROD_ONLY yields a positive and strongly significant estimate, meaning that standalone product innovations increases specifically the probability of survival. Yet, it does not influence the probability that firms expand (GROWTH_0610 > 2) or achieve high growth (GROWTH_0610=5). The tests reported in the right-hand columns show that the estimated effect of PROD_ONLY on the probability of survival is significantly larger than the estimated effects of PROD_ONLY on actual growth. Standalone process innovation does not significantly influence the probability of survival, nor the probability of growth in general. However, it yields a positive estimate for GROWTH_0610=5 that is strongly significant and comparable in size to the effect detected from PROD&PROC in the same regression. These results are contrary to expectations in Hypothesis 3.

In extension of this is the question of whether effects of commercial innovation on growth are contingent on technological content and IPR protection, as expressed by PATENT. In the regressions reported in Table 4, the three two-way interaction terms that can be constructed from PATENT and innovation output are included. Interaction effects are not significant and neither results nor the overall explanatory power of the models is influenced.

Table 4: Test for interaction between patent and innovation.

	Model 8 GROWTH_0610>0		**Model 9** GROWTH_0610>2		**Model 10** GROWTH_0610=5	
	Coeff	*SE*	*Coeff*	*SE*	*Coeff*	*SE*
PROD&PROC	0.274	0.242	0.392	0.113***	0.332	0.144**
PROD_ONLY	0.691	0.291**	0.184	0.115	0.026	0.157
PROC_ONLY	0.096	0.265	0.103	0.126	0.425	0.164***
PATENT	-0.314	0.369	0.160	0.210	0.540	0.256**
PATENT*PROD&PROC	0.774	0.622	0.024	0.286	-0.352	0.357
PATENT*PROD_ONLY	0.559	0.681	-0.265	0.285	-0.549	0.367
PATENT*PROC_ONLY	0.086	0.864	-0.466	0.470	0.142	0.551
EMPL_06	0.019	0.058	-0.232	0.028***	-0.661	0.043***
COMPERF	0.466	0.378	0.375	0.207*	0.439	0.258*
FORMAR	0.159	0.151	0.025	0.073	0.232	0.097**
HIGHED_06	-0.041	0.553	0.942	0.305***	0.745	0.322**
0406_NEW	*Reference*		*Reference*		*Reference*	
0406_C1	0.385	0.251	-0.490	0.135***	-0.640	0.159***
0406_C2	0.326	0.252	-0.382	0.136***	-1.100	0.171***
0406_C3	0.591	0.257**	-0.131	0.133	-0.957	0.165***
0406_C4	0.437	0.250*	-0.129	0.134	-0.657	0.156***
0406_C5	0.353	0.246	0.122	0.136	0.115	0.146
Constant	2.261	0.433***	1.045	0.228***	0.617	0.281**
LR Chi2(df)	52.34(30)***		333.13(30)***		651.92(30)***	
Pseudo R2	0.027		0.053		0.148	

Note: Coefficient estimates and standard errors from logistic regressions. ***, ** and * indicate significance at the 1 per cent, 5 per cent and 10 per cent levels respectively. All regressions include dummies as control for sector characteristics

Moderating effects of trend growth

Models 5-10 echo Hypotheses 3 and 4 in assuming that the impact of innovation on growth is independent of past growth performance. As suggested by Coad and Rao (2011), this assumption might not hold: Firms with positive trend growth might benefit differently from innovation compared to firms with negative trend growth. In response, Models 11-16, reported in Table 5, estimate the probability of GROWTH_0610 > 2 and GROWTH_0610 = 5 for subsamples of firms constructed based on growth characteristics exhibited in 2004-2006. Overall, the results indicate that employment expansion in the past does not weaken the growth impetuses that firms receive from the combined product and process innovations that they are more likely of introducing. Moreover, while downscaling reduces the probability of PROD&PROC, it is apparent from Models 13 and 14 that this is the *only* form of innovation that might dampen or turn the negative trend. Thus, evidence is provided that not only virtuous circles of employment growth and complex innovation exist that give rise to upward-pointing momentum; circles may also be *vicious,* at least as seen from the perspective of employees who depend on the firm.

New firms do not capture growth impetuses from the patent applications that they are more likely of filing; instead, benefits from patents are unique to mature firms with positive trend growth (Model 16). Positive trend growth emerge as highly persistent also in the upper tail, as coefficient estimates for strong past growth in the estimation of future growth (Models 15 and 16) are significant compared to the moderate past growth reference. Moreover, once a positive trend is established, additional lift is provided by PROD_ONLY and PROC_ONLY: PROD_ONLY increases the probability of continued growth at a moderate rate, which is notable in light of Model 2 where the probability of such innovation was found to be highest among firms with strong past growth performance. PROC_ONLY, in turn, increase the probability that firms locate in the upper tail of the growth distribution, which is notable in light of the results from Model 3 indicating that the probability of such innovation is highest among firms that experienced positive yet conservative past growth. While it cannot be determined directly from the cross-sectional innovation data used here, these results is strong indication that growth-inducing complementarities between product innovation and process innovation might also be captured over time: A period of conservative growth in the wake of successful standalone product innovation (Model 15) induces work with standalone process innovation (Model 3) to allow larger expansions (Model 16); if successful triggering work on additional standalone product innovation that support further expansion at more conservative rates.

Table 5: Estimations of growth 2006-2010 for growth 2004-2006 subsamples

Subsample:	**Only firms established 2004-2006**				**Only firms with negative growth 2004-2006**				**Only firms with positive growth 2004-2006**			
	Model 11: GROWTH_0610>2		**Model 12:** GROWTH_0610=5		**Model 13:** GROWTH_0610>2		**Model 14:** GROWTH_0610=5		**Model 15:** GROWTH_0610>2		**Model 16:** GROWTH_0610=5	
	Coeff	*SE*	*Coeff*	*SE*	*Coeff*	*SE*	*Coeff*	*SE*	*Coeff*	*SE*	*Coeff*	*SE*
PROD&PROC	1.152	0.570**	0.278	0.525	0.433	0.200**	0.614	0.293**	0.313	0.144**	0.188	0.178
PROD_ONLY	0.371	0.452	0.767	0.468	-0.016	0.204	-0.230	0.379	0.256	0.151*	-0.099	0.196
PROC_ONLY	1.167	0.569**	0.395	0.571	0.124	0.221	0.375	0.319	-0.007	0.163	0.456	0.204**
PATENT	0.531	0.745	0.057	0.751	-0.121	0.371	0.596	0.530	0.262	0.281	0.655	0.318**
PATENT*PROD&PROC	0.171	1.428	1.054	1.216	0.099	0.500	-0.758	0.750	-0.012	0.376	-0.496	0.439
PATENT*PROD_ONLY	-0.564	1.013	-0.038	1.052	0.102	0.518	-0.850	0.890	-0.420	0.376	-0.645	0.455
PATENT*PROC_ONLY	-2.290	1.735	0.549	1.747	-1.331	1.175	-0.416	1.318	-0.084	0.594	0.015	0.653
EMPL_06	-0.426	0.097***	-0.788	0.121***	-0.313	0.046***	-0.867	0.087***	-0.128	0.039***	-0.513	0.057***
COMPERF	0.229	0.558	-0.297	0.566	0.236	0.375	1.023	0.581*	0.394	0.295	0.466	0.377
FORMAR	0.222	0.269	0.149	0.299	-0.073	0.128	-0.065	0.199	0.005	0.097	0.375	0.123***
HIGHED_06	0.477	0.834	0.437	0.769	1.185	0.622*	0.760	0.761	1.061	0.400***	0.854	0.423**
0406_NEW	-		-		-		-		-		-	
0406_C1	-		-		*Reference*		*Reference*		-		-	
0406_C2	-		-		0.129	0.107	-0.474	0.164***	-		-	
0406_C3	-		-		-		-		*Reference*		*Reference*	
0406_C4	-		-		-		-		0.024	0.100	0.335	0.145**
0406_C5	-		-		-		-		0.280	0.104***	1.122	0.135***
Constant	1.795	0.737**	0.969	0.768	0.758	0.390*	0.299	0.618	0.639	0.310**	-0.919	0.407**
LR Chi2(df)	64.36(25)***		119.11(25)***		144.86(26)***		221.80(26)***		137.42(27)***		279.44(27)***	
Pseudo R2	0.128		0.232		0.067		0.176		0.039		0.109	
N	389				1600				2615			

Note: Coefficient estimates and standard errors from logistic regressions. ***, ** and * indicate significance at the 1 per cent, 5 per cent and 10 per cent levels respectively. All regressions include dummies as control for sector characteristics

Robustness, multicolinearity and alternative estimators

All reported models have been tested for multicollinearity. The highest condition number detected is 21.789, while the highest maximum variance inflation factor detected is 5.08. Both are well below the rule-of-thumb levels of 30 (Salmerón et al. 2018) and 10 (e.g. Bogliacino and Cardona 2014) respectively that indicate serious concerns.

It has been argued that linear probability models are preferable over models involving non-linear transformation of binary dependent variables (logit or probit) because the latter are susceptible to biases from unobserved heterogeneity (Mood 2009), and complicates interpretation of interaction effects (Ai and Norton 2003). All models have therefore been estimated also using the ordinary least square estimator with heteroscedasticity - robust standard errors (as adviced by Mood 2009). The results obtained are structurally consistent with those reported from the logit models and provide no grounds for alternative interpretations.

Finally, a Norwegian idiosyncrasy is the large aquaculture and offshore oil & gas sectors that are process-intensive and subjected to strict political regulation. Policy responses to the financial crisis that started at the beginning of the reference period for the CIS data used here combined with high international prices allowed booming growth in these two sectors towards 2010 (Herstad and Sandven 2017). To check whether these specific economy and period characteristics might have influenced the results, estimations have been conducted only for the manufacturing (sampled industries in the 2-digit NACE range 10-33) and knowledge intensive services industries (sampled industries in the 2-digit NACE range 58-79) in which aggregate growth during the period was more moderate (ibid). The results reported in Table A2 are fully consistent with those from the main analysis in that medium to high levels of growth in 2004-2006 increases the probability of product innovation relative to firms with negative growth in the period. PROD&PROC, in turn, increases the probability of further growth. Serial correlations of growth are also evident as in the main analysis, in that negative growth in 2004-2006 reduces the probability of growth in 2006-2010 while strong growth in the former period has a high probability of continuing in the latter, independently of whether additional momentum is given by innovation.

Conclusion

This paper aimed to provide new and more fine-grained insights into the dynamic relationship between innovation and employment growth at the firm level. First and most fundamentally, the analysis found 'virtuous' and 'vicious' circles (Bogliacino et al. 2017) playing out, over time: Downsizing in one period is associated with downsizing also in the next, and reduce the likelihood that innovations are introduced in the intermittent period that dampen or turn the downward-pointing trend. This gives reasons to warn that short-term capacity adjustments may impede long-term innovation-based growth. Conversely, upscaling in one period is not only associated with upscaling also during the next, it increases the probability that innovations are introduced that further strengthen employment, thus increasing also firms' future growth and innovation prospects.

While dampened by the share size of firms, upward-pointing momentum may take on two forms: As virtuous circles of growth and complementary innovations introduced in 'bundles', or varying albeit positive growth rates in consecutive periods with shifting emphasis on innovating new products and new processes. This is in line with recent research finding feed-back loops characterizing also the relationship between investments in R&D, wages paid and sales performance (Bogliacino et al. 2017), and evidence that strategic management of cumulative organizational learning, as suggested by evolutionary theory and the literature on momentum effects (Turner et al. 2013), lies underneath as one of the main reasons why some firms are able to maintain their position in the upper tail of the employment growth distribution, while growth laggards remain over time in the lower tails.

Second, to the authors' knowledge, this paper is the first to demonstrate in a large-scale empirical setting how characteristics of innovation that differentiate between positive and negative growth are not the same as those influencing the actual levels of each, nor the probability of survival. Accordingly, growth is not simply more or less of the same; it is a qualitatively differentiated phenomenon. Firms might survive by introducing standalone product innovations, but depend on complementary process innovation to initiate upward-pointing trajectories. Technology and IPR protection expressed as patents is not generally associated with growth; yet, it might still lift positive trend growth from moderate to high levels. As similar lifting effects are observed in the wake of standalone process innovation, growth impetuses from improved price/quality ratios more than outweigh the potential employment downside of such innovation that is substitution of labour with capital equipment.

In extension, and third, the role of broad-based organisational learning and renewal in determining the competitive position of firms is evident from the importance of combined product and process innovation for growth. Notably, such 'bundles' is the only type of output that can turn trend growth from negative to positive, allowing firms to obtain even the highest growth rates here observed. This indication that pervasive organizational change is required in such situations, and has the requisite transformative capacity, is notable in light of Coad and Rao (2011) who found downsizing high-tech manufacturing firms in the US unable to benefit from 'technology' more narrowly defined.

As for any empirical study, there are notable limitations to this. The data do not include information on innovation activity and output prior to the CIS2008 reference period, and the estimation strategy relies on the variables representing prior growth and sales performance to capture remaining *direct* effects of this on growth after innovations were observed. Similarly, observed growth may be driven by innovations that are not observed because they were introduced after CIS sampling. However, the substantive implications of these limitations are modest. Following the theoretical perspectives applied, correlations between observed (during the reference period) and unobserved (either prior to or after the reference period) innovation output are to be expected due to the underlying, yet unobserved, organizational dynamics that evolutionary theories postulate are both cause and effect of innovation. For these reasons, persistence in innovation activity is also to be expected (e.g. Cefis and Orsenigo 2001; Sapprasert and Clausen 2012). Thus, it poses a methodological problem foremost to the extent that one is seeking to precisely determine the effects of *specific innovations, introduced at a certain point in time,* on employment at a later point, and isolate these from evolving organizational capabilities.

To maintain focus on the core argumentation, inter-industry differences in the relationship between innovation output and employment have not been considered. Future research is therefore needed that explore in more detail how intertemporal growth-innovation dynamics are moderated by opportunities to profit from innovations, the cumulativeness of knowledge development, and the complexity of products and production processes at the industry level (e.g. Bogliacino and Pianta 2010; Gomez et al. 2016; Herstad 2018b). Moreover, characteristics of firms' market and technology contexts that correlate with employment performance *and* with innovation propensities may be present, which are not captured by the sector controls (or eliminated in the robustness test). If so, inter-temporal dynamics here ascribed to the strategic management of cumulative organizational learning may have their real causes in the external environment. As previous research has found country effects to be at play (e.g. Ballot et al. 2014), these limitations and the use of Norwegian data only call for future studies in other countries to challenge the results and interpretations provided: Employment growth and innovative capability are dynamically related, over time and in manners that demand conceptual and empirical attention to the multi-faceted nature of the relationship.

Compliance with ethical standards

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Appendix

Table A1: Descriptive statistics and bivariate correlations. N=4604

		Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9
1	GROWTH_0610>0	0.945	0.228	0	1	1								
2	GROWTH_0610>2	0.573	0.495	0	1	0.279	1							
3	GROWTH_0610=5	0.188	0.391	0	1	0.116	0.415	1						
4	PROD&PROC	0.133	0.339	0	1	0.019	0.036	0.033	1					
5	PROD_ONLY	0.124	0.329	0	1	0.038	-0.008	-0.008	-0.147	1				
6	PROC_ONLY	0.073	0.260	0	1	-0.002	-0.004	0.019	-0.110	-0.105	1			
7	PATENT	0.100	0.300	0	1	0.017	0.009	0.025	0.222	0.225	-0.018	1		
8	EMPL_04	3.338	1.534	0	9.924	0.041	-0.125	-0.256	0.074	0.008	0.042	0.087	1	
9	EMPL_06	3.693	1.210	0	9.885	0.023	-0.125	-0.261	0.078	0.022	0.052	0.118	0.760	1
10	COMPERF	0.786	0.232	0	1	0.023	-0.059	-0.050	0.055	0.069	-0.015	0.070	0.096	0.047
11	FORMAR	0.396	0.489	0	1	0.012	-0.013	0.029	0.226	0.172	0.029	0.248	0.085	0.145
12	HIGHED_06	0.073	0.139	0	1	-0.007	0.098	0.132	0.120	0.119	-0.013	0.182	-0.100	-0.073
13	0406_NEW	0.084	0.278	0	1	-0.040	0.052	0.142	-0.038	0.007	-0.013	0.000	-0.661	-0.159
14	0406_C1	0.171	0.376	0	1	-0.002	-0.080	-0.025	-0.016	-0.025	-0.019	-0.003	0.167	-0.036
15	0406_C2	0.177	0.382	0	1	-0.001	-0.056	-0.098	-0.025	-0.018	-0.003	-0.029	0.175	0.062
16	0406_C3	0.206	0.405	0	1	0.026	-0.001	-0.102	0.016	0.003	0.047	0.007	0.206	0.132
17	0406_C4	0.184	0.388	0	1	0.006	0.017	-0.029	0.026	-0.001	-0.002	-0.011	0.061	0.006
18	0406_C5	0.178	0.382	0	1	-0.003	0.081	0.156	0.026	0.036	-0.017	0.035	-0.137	-0.056

		10	11	12	13	14	15	16	17
10	COMPERF	1							
11	FORMAR	0.092	1						
12	HIGHED	-0.101	0.213	1					
13	0406_NEW	-0.119	0.017	0.087	1				
14	0406_C1	0.046	-0.005	-0.068	-0.138	1			
15	0406_C2	0.025	-0.044	-0.052	-0.141	-0.210	1		
16	0406_C3	0.006	0.006	-0.038	-0.155	-0.231	-0.236	1	
17	0406_C4	0.026	-0.011	0.044	-0.144	-0.215	-0.220	-0.242	1
18	0406_C5	-0.015	0.042	0.052	-0.141	-0.211	-0.215	-0.237	-0.221

Table A2: Robustness test. Only manufacturing & knowledge intensive services. N=3645

	Innovation output 2006-2008								**Employment growth 2006-2010**			
	PROD&PROC=1		PROD_ONLY=1		PROC_ONLY=1		PAT=1		GROWTH_0610>2		GROWTH_0610=5	
	Coeff	*SE*	*Coeff*	*SE*	*Coeff*	*SE*	*Coeff*	*SE*	*Coeff*	*SE*	*Coeff*	*SE*
PROD&PROC									0.417	0.111***	0.300	0.144**
PROD_ONLY									0.073	0.109	-0.062	0.150
PROC_ONLY									0.074	0.138	0.425	0.180**
PATENT									0.097	0.123	0.295	0.159*
EMPL_04/06	0.133	0.045**	0.060	0.047	0.075	0.059	0.360	0.053***	-0.259	0.032***	-0.698	0.050***
COMPERF	0.174	0.395	0.755	0.410*	0.880	0.514*	0.671	0.460	0.289	0.254	0.302	0.319
FORMAR	1.068	0.111***	0.499	0.109***	0.090	0.143	1.063	0.137***	0.019	0.080	0.188	0.107*
HIGHED_04/06	1.127	0.388***	1.897	0.381***	-0.889	0.647	3.145	0.430***	1.166	0.341***	0.817	0.363**
0406_NEW	Reference		Reference		Reference		Reference		Reference		Reference	
0406_C1	-0.158	0.297	-0.600	0.279**	-0.414	0.380	-1.386	0.327***	-0.465	0.155***	-0.523	0.185***
0406_C2	-0.170	0.299	-0.481	0.277*	-0.307	0.380	-1.701	0.332***	-0.366	0.156**	-0.929	0.200***
0406_C3	0.044	0.290	-0.399	0.272	0.134	0.365	-1.498	0.322***	-0.002	0.154	-0.794	0.194***
0406_C4	0.217	0.279	-0.478	0.262	-0.121	0.359	-1.566	0.313***	-0.073	0.154	-0.570	0.183***
0406_C5	0.166	0.266	-0.091	0.242	-0.387	0.346	-0.930	0.288***	0.177	0.154	0.326	0.170*
Walds Chi2 tests of coefficient equality												
0406_C1 - _C3	1.55		1.43		6.85***		0.35		15.95***		2.28	
0406_C1 - _C4	5.07**		0.50		1.67		0.83		11.08***		0.09	
0406_C1 - _C5	3.43*		8.47***		0.01		5.27**		28.33***		32.16***	
0406_C2 - _C3	1.71		0.24		4.1**		1.08		10.01***		0.52	
0406_C2 - _C4	5.31**		0.00		0.72		0.44		6.22**		4.05**	
0406_C2 - _C5	3.59*		5.19**		0.11		13.96***		20.0***		56.32***	

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