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Does Innovation Lead to Firm Growth? Explorative versus Exploitative Innovations

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Does Innovation Lead to Firm Growth?

Explorative versus Exploitative Innovations

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Abstract

In this paper we examine the relationship between innovation and firm growth. We implement a classification of innovations based on whether they are explorative or exploitative, taking advantage of a unique Swedish dataset for the period 1997 to 2012. The data allows us to construct each firm's innovation history. Panel regression estimations, together with an instrumental variable method, confirm a significant and positive effect of both exploitative and explorative innovation on firms' employment growth. More radical explorative innovations are shown to have a more persistent growth effect, while exploitative innovation increases labor demand in the short run. We also provide empirical findings regarding the effect of innovations distributed on size classes and different ownership structures.

Key words: Innovation, firm growth, exploration innovation**,** exploitation innovation

JEL Codes: O31, L25

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1. Introduction

Understanding how innovation influences firm growth, and how different types of innovations impact productivity, employment and competitiveness, is high on the agenda for policy-makers. As firms convert knowledge into innovations and strengthen their market position, they are likely to contribute to economic growth and welfare. A large number of countries have also stressed innovation policies as a means to promote long-term growth and build a knowledge economy, based on a qualified and well-paid work force (Herstad, 2011). Globalization and rapid technological change means a stiffening in competition that has further emphasized the importance of innovation.

Yet our knowledge regarding the relationship between innovation and employment remains surprisingly inapt. According to Harisson et al. (2014, p.2): "The consequences of innovation for employment are of particular interest, but the relationship between innovation and employment is not well-known". Taking a long-run perspective on innovation, it is clearly beneficial for growth and prosperity. But in the short- or medium-run period the aggregate effects of innovation on employment growth may go either way: one firm's success may imply another firm's decay due to business stealing effects, or that the innovative firm reduces parts of its previous production. Hence, it seems critically important to comprehend the effects at the micro-level in order to design an appropriate long-term innovation policy. The link between innovation and employment can thus, and should, be studied at different levels of aggregation (Greenan and Guellec, 2000; Coad, 2009; Mastrostefano and Pianta, 2009).[2]

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[2] See Hall et al. (2008), Dachs and Peters (2014) and Harrison et al. (2014). For surveys, see also Pianta (2006), Coad (2009) and Vivarelli (2014). Dachs et al. (2015) provides evidence that product innovations generate employment in all stages of the business cycle.

The focus we take in the current paper is to examine how different types of innovation influences employment growth at the firm level. Most previous studies categorize innovations into two main types: product and process innovations.[3] The former has been shown to generate predominantly positive (net) effects by reinforcing demand for the firms' products and strengthening its market position. The latter is associated with more ambiguous effects where the immediate result is to displace labor. However, over time demand may increase for the firm's product and the initial displacement effect be replaced by compensatory effects that expand employment. The outcome for both of these types of innovations depend on the elasticity of demand for the firm's product, whether innovations are labor- or capital-augmenting, the level of competition, entry and imitative behavior, and exits of competing firms. Often there is no sharp distinction between the two types of innovation, either they overlap or they take place in conjunction.[4]

We will implement a somewhat different classification of innovations. Rather than separating between product and process innovations, we make a distinction depending on

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[3] More recently the role of organizational innovations has also been stressed, particularly in the service sector (Evangelista and Vezzani 2010).

[4] See Dougherty (1992), Mowery (2009) and Piening and Salge (2015). Firms' ability to exploit market and technological opportunities has also been claimed to be a function of organizational capability, routines, knowledge bases, etc., as well as their technical capacity related to R&D departments, patent strategy and knowledge base (Herstad et al., 2015). This can be viewed as a Schumpeterian perspective. Also resource-based theories (Penrose, 1959; Wernerfelt, 1984) have been used to explain innovative activities. These conceptualizes firm growth as intimately interlinked with the ability of firms to exploit the resources that are continuously created through their business processes, and embedded in their workforces and organizational routines (Leonard-Barton, 1992; Wang et al., 2009).

whether innovations are *explorative* or *exploitative* (March 1991; Akcigit and Kerr, 2013). The former innovation strategy can be characterized as having a *search scope*, meaning that firms undertake R&D to create new products that deviate from their previous knowledge profile. The latter refers to firms focusing at *search depth*, implying that improvement of current products and services are emphasized, rather than changing firms' innovation strategies (Rowley et al., 2000; Hagedoorn and Duysters 2002; Katila and Ahuja, 2002). Both of these innovation types contain products and process innovation, but new or improved products dominated both strategies.[5] We believe that this measure more accurately captures firms' innovation activities, than the dichotomous classification on product and process innovations.

Obviously there are numerous pitfalls in the measurement of innovations. The most frequently used output measures of innovative activities are R&D-expenditures and patents. R&D-expenditures suffer from the apparent drawback of applying an input measure in order to approximate innovative output. Patent is a better performance variable but is also burdened with obvious drawbacks related to time lags and the fact that not all inventions can be patented.[6] More recent contributions have used data from innovation surveys, allowing for a broader group of firms to report on innovations (Evangelista and Vezzani, 2010). But also these suffers from deficiencies such as the firms' own subjective evaluations of whether innovations have occurred, limited periods of time and restricted samples of firms.

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[5] They could also be linked to Schumpeter Mark I creative destruction processes (explorative innovations) and Schumpeter Mark II cumulative knowledge accumulation patterns (exploitative) typical in oligopolistic markets (Malerba and Orsenigo 1995).

[6] See surveys by Chennells and Van Reenen (2002), Spieza and Vivarelli (2002) and Coad (2010).

Still, there is a clear tendency in the empirical literature to use R&D investments and patent output to proxy innovation (Del Monte and Papagni, 2003; Coad and Rao, 2008; Demirel and Mazzucato, 2012). We will implement patent application as our measure of innovation which is far from perfect but has the apparent advantage of being well-defined, available for a large number of firms over long periods of time and related to firms' current innovative activities. In addition, an increasing number of firms in the service sectors also apply for patents. Using data on patent application, combined with patent classification, we create a knowledge profile for each firm at the two-digit level. Based on this knowledge profile, we can distinguish the different types of innovation. A patent application is labeled as an explorative innovation if the firm did not apply for a patent in the same patent class during the last five years, otherwise it is considered as an exploitative innovation.

Applying this measure on innovation we contribute to the previous literature in several ways. First, we are able to distinguish between innovative strategies that are aimed at more disruptive and radical innovations and those more oriented towards incremental improvements. Second, we construct knowledge profiles for all firms included in the analysis which enables us to detect switches in their innovation strategies, based on patent classes. Third, we have access to data going back two decades which allows us to control for persistency in innovations. Fourth, we are able to identify both size and ownerships effects. Finally, we have a comprehensive dataset involving all firms in both manufacturing and service industries.

Our estimations support the proposition that innovation has a positive impact on firm growth. More precisely, both explorative and exploitative innovations have a positive and significant effect on firms' employment growth. Comparing the two, we find that firms engaged in explorative innovations enjoy stronger employment growth. We apply several econometric techniques and conclude that the results are robust. In addition, the results support a persistent employment growth effect, however, only in the case of explorative innovation. Finally, it should be stressed that innovation induced growth effects are particularly important for small and medium size firms, as well as young firms.

The rest of the paper is organized as follows. Section 2 reviews previous research related to the issues addressed in this paper. Then, we present the empirical strategy in section 3 and our data in Section 4 followed by the results in Section 5. The paper ends with conclusions in Section 6.

2. Previous research

The forces of globalization and rapid technological progress emphasize the need for an innovative and competitive business sector. Moreover, as larger firms tend to expand in terms of employees primarily at foreign markets, the role for small firms with potentially strong growth prospects becomes even more important in governments' strife for full employment. Since the early 1990s it has also been shown that new jobs primarily originate in smaller and new firms (Loveman and Sengenberger, 1991; Dachs et al., 2015). Presently there is basically consensus that SMEs are the main contributors of net job creation, even though the effect varies across economies.[7] Thus, Gibrat's law (Gibrat, 1931) has convincingly been rejected in numerous empirical studies, demonstrating that smaller firms seem to exhibit a systematically higher growth rates than their larger counterparts.[8]

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[7] See Lotti et al. (2003) and Braunerhjelm (2008) for surveys.

[8] See Hall (1987), Geroski (1995), Caves (1998), Almus and Nerlinger (2000), Heshmati (2001) and Audretsch et al. (2006). Coad (2009) presents an excellent survey.

Apart from creating employment, new and growing firms introduce products, processes, and business model innovations, develop new markets and change the rules of the game of their industries (Bhide, 2000). It is noteworthy that despite their modest R&D investments, small and entrepreneurial firms have been shown to account for a substantial proportion of aggregate innovation (Audretsch, 1995; Feldman and Audretsch, 1999; Cefis, 2003; Jensen et al. 2007; Herstad and Brekke, 2012). Further, new ventures are more prone to develop, use, and introduce radical, market-making products that give the firm a competitive edge over incumbents (Casson, 2002a; 2002b). An impressive share of radical breakthrough innovations has been shown to originate from entrepreneurs and small firms. Almeida and Kogut (1997, 1999) conclude that small firms innovate in relatively unexplored fields of technology, even though industry differences prevail regarding innovative activities distribution between large and small firms.[9]

The implications of innovative activities in young and small firms are that they are likely to play a distinct and decisive role in the transformation and development of knowledge-based economies. Still, the issue of how innovation and firms' employment growth are related continues to be inconclusive. Previous empirical studies implement different type of data at different aggregation levels and the overall results are ambiguous, albeit product innovation seems to have a weak positive impact on firm growth (Coad 2009).

2.1 Relating innovation to firm growth

The effects of innovation on growth have been analyzed at different levels of aggregation and using different types of growth variables: revenues, value-added or employment. Our focus is on labor growth at the firm-level. The more aggregated level that is considered, the harder it will

[9] See Rothwell and Zegveld (1982), Acs and Audretsch (1988, 1990), Baumol (2004), Ortega-Argilés et al. (2009).

be to disentangle growth stemming in innovation from growth due to industrial restructuring, entry, exits, and businesses cycles effects, to mention a few.

In the literature innovations are often categorized on product and process innovations, and more recently organizational innovations have been added. As firms come up with new products, the short run effects are to reduce competitive pressures and strengthen their market position. The consequences would be to increase firms' production and employment. Over time, and as the firm's previous products become obsolete, as well as depending on the degree of competition and the levels of entry and exit, production and employment volumes may level out or even decrease (Hall et al., 2008). Such displacement effects of innovation are however expected to be most prominent in the case of process innovations, particularly if the innovation implies that capital replaces labor. Still, also process innovations may over time lead to increases in production and employment if productivity is increased and prices lowered (Harrison et al., 2014). The empirical results of how process innovation influences employment remains mixed (Niefert, 2005).

Hence, as pointed out by Herstad and Sandven (2015), innovation output may impact firm growth in basically two ways. First, the direct market response as a specific innovation is launched which will influence the firm's incentive to adjust capacity to profit-maximizing levels. Second, the indirect effects, implying learning and accumulation of knowledge, which may translate into other types of innovations that can either reinforce or dampen the direct market response.

Andersson and Lööf (2009), using detailed Swedish data, show that innovation as captured by patent applications, is highly skewed: one third of patent applications in the manufacturing sector emanates from firms with less than 25 employees. Compared to non-patenting firms, firms engaged in patenting have more skilled labor, larger profit margin and better access to bank loans, and also belongs to the high-technology segment of industries. Similar findings are reported by Deschryvere (2014) using data on Finnish firms and Triguero et al. (2014) analyzing Spanish firms.

Using R&D as a proxy for innovation, Stam and Wennberg (2009) report that the growth effects of R&D expenditure differ across firms. It is only the strong growth performers that benefits from increased R&D-expenditures, and the effect is conditional upon other variables such as having an already established external network. Basically, R&D is shown to matter only for a limited group of new high-tech and high-growth firms.

Other studies corroborate that R&D has its most prominent effects on firms belonging to the high-tech sectors and having already displayed strong growth (Coad and Rao, 2008). Demirel and Mazzucato (2012), using a data set on U.S. pharmaceutical firms, reports that R&D-spending positively influences smaller firms' growth, but only for those being persistent innovators. Larger firms may on the other hand experience a negative effect of increased R&D lay-outs. Hence, they conclude that R&D is not always worthwhile and that it would be misleading to think it will always generate firm level growth.

Harrison et al. (2014), implementing survey data that comprises firms from both the manufacturing and service sectors, separate between those having no innovations, only process innovations or only product innovations. Controlling for a number of other variables they conclude that productivity is higher among the innovating firms and that the compensation effects dominate over displacement of labor, i.e. innovating firms grow. For the group product innovators demand is shown to fall for older products but that the decrease is outpaced by increasing demand for new products. On the other hand, for firms involved in process innovation a small negative effect is detected on employment. In the service sector they find no evidence of displacement effects resulting from process innovation.

2.2 Explorative and exploitative innovation

March (1991) introduced the concepts of explorative and exploitative activities and argued that they are fundamental for organizations learning processes. While organizational exploration can be viewed as a search for new knowledge to create new products and processes, exploitation departs from a firm's existing knowledge, technologies and products. Hence, explorative and exploitative activities rely on different organizational characteristics and capabilities within firms and are intimately linked to firms' innovation strategies (Lewin et al., 1999; Benner and Tushman, 2003; Galunic and Eisenhardt, 2001; He and Wong, 2004).

Exploitation is a learning process assumed to primarily develop the existing knowledge, but not to widening the knowledge base (Rowley et al., 2000; Hagedoorn and Duysters, 2002). Firms that choose an exploitative innovation strategy are thus likely to increase efficiency but may reduce the ability to discover new products and processes, and to adapt to changing circumstances.[10] In contrast to exploitative innovation, explorative innovation strategies can generally be characterized as a break from existing knowledge routines. Explorative innovations that strive to develop new products and processes, which are of vital importance for survival and long-term performance, also stands a larger risk of incurring excessive costs that can endanger profitability and growth (Nooteboom, 2000; Hagedoorn and Duysters, 2002). Hence, firms have

[10] It has for instance been argued that firms focusing at exploitative innovation strategies have a drawback in adapting to novel environmental requirements (Michl et al., 2013).

to make decisions under uncertainty regarding their innovation strategies, and they are also likely to change them over time (Corradini et al. 2016).

Akcigit and Kerr (2013) links the two types of innovations to growth. They conclude that smaller firms grow faster, that their R&D to sales ratio exceeds larger firms, and that the relative rate of major, explorative innovations is higher in smaller firms. Small and entrepreneurial firms are thus claimed to have a comparative advantage in explorative innovations, whereas larger firms are more preoccupied with refining existing products. Hence, small firms come up with a disproportionate share of major innovations. Still, Akcigit and Kerr do not stress how employment growth is distributed between firms adopting the two different innovation strategies, rather their focus is growth at the aggregate level.

To summarize, previous research suggests that small firms exhibit the highest employment growth and are most likely to come up with radical innovations, R&D is not always a good indicator of innovations, and that the effects of employment growth is strongest for product innovations. Similarly, explorative and exploitative innovations may be a better way to capture firms' innovations strategies. Based on the literature survey and the innovation strategy choices that firms face, we expect firms' employment growth to be i) positively related both explorative and exploitative innovative activities, ii) particularly so for firms involved in explorative innovation strategies as well as iii) for firms adopting persistent innovation strategies.

3. Econometric strategy

We embark from a standard log linear employment equation as proposed by Layard and Nickell (1986), however modified to first differences in order to eliminate firm fixed effects,

$$\Delta n_{it} = \alpha_1 \Delta n_{i(t-1)} + \alpha_2 \Delta n_{i(t-2)} + \beta_1 \Delta w_{it} + \beta_2 \Delta k_{it} + \beta_3 \Delta ys_{it} + \Delta \varepsilon_{it} \quad (1)$$

where $\Delta n_{it} = n_{it} - n_{i(t-1)}$ is the first difference of the logarithm of employment of firm *i* at year *t*. All other continuous variables are defined in the same way. We control for the nominal wage rate w_{it}, gross fixed capital k_{it} and industry demand ys_{it}. Higher demand can be expected to result in more employment. Finally, ε_{it} is the error term, expected to exhibit standard properties.

We extend the employment equation to incorporate both current and lagged measures of our two innovation measures,

$$\begin{aligned}\Delta n_{it} &= \alpha_1 \Delta n_{i(t-1)} + \alpha_2 \Delta n_{i(t-2)} + \beta_1 \Delta w_{it} + \beta_2 \Delta k_{it} + \beta_3 \Delta ys_{it} + \beta_4 Exploitative_{it} + \\ &\beta_5 Explorative_{it} + \beta_6 Exploitative_{i(t-1)} + \beta_7 Explorative_{i(t-1)} + \beta_8 Exploitative_{i(t-2)} \quad (2) \\ &+ \beta_9 Explorative_{i(t-2)} + \mathbf{X}_{\mathbf{it}}^{'}\boldsymbol{\delta} + \Delta \varepsilon_{it}\end{aligned}$$

where vector **X** contains the following control variables: $D_{Ownership}$ which refers to ownership structure while $D_{industry}$ is associated with 21 sub-industries[11] and D_{time} controls for potential time trends (annual dummies) during 2002 to 2012. Finally, D_{region} takes into account any regional

[11] See Coad (2009). The industry classifications are based on the standard Swedish industrial classification "SIC2007" which are identical to the first four levels of NACE Rev. 2. In this paper, we use the first level of SIC2007 to identify 21 industries.

specific effects.[12]

Both OLS and system-GMM techniques are used to estimate equation (2). The latter one, developed by Blundell and Bond (1998), implies that lagged variables are used as instruments to control for potential endogeneity. First, and most obviously, the lagged dependent variable $\Delta n_{i(t-1)}$ is potentially correlated with the error term $\Delta \varepsilon_{it}$ and therefore risk introduce endogeneity in the estimations. Following Lachenmaier and Rottmann (2011), we use $n_{i(t-3)}$ and earlier realizations of n_{it} as instruments for the first difference lagged dependent variable $\Delta n_{i(t-1)}$.

Second, one might consider the endogeneity of our two innovation variables. As suggested by Lachenmaier and Rottmann (2011), innovation decisions are often based on long-term considerations while employment decisions are based on more short-term considerations. If we assume that innovation decisions are made at least one period before employment decisions, then we can consider innovation decisions as predetermined. Predetermined variables can be correlated with previous error terms while endogenous variables can be correlated with both previous and current error terms. We instrument our innovation variables with their one period lagged level values, which we assume are uncorrelated with the error term.[13]

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[12] We introduce functional regions (FA-regions) as our spatial unit of measurement according to the Swedish Agency for Economic and Regional Growth (Tillväxtverket). There are 72 FA regions in Sweden based on the commuter distance to the respective regions capital.

[13] The validity of this assumption is subsequently tested using the Sargan test (Blundell and Bond, 1998).

4. Data and descriptive statistics

The data has been acquired from the Statistics Sweden's Business Register and covers all registered firms and establishments in Sweden since 1987. Data on patent classifications go back to 1997, however, the first five years cannot be used in the estimations due to the way we identify explorative and exploitative innovations. Hence, our estimations are based on data from the period 2002 to 2012.

Patent application data has been obtained from the European Patent Office's PATSTAT database supplemented with data from the Swedish Patent Office, which includes International Patent Classification (IPC) since 1997. The firms' serial ID numbers have enabled a matching between firms and patent applications. Pooling firm-level data and patent application data leaves us with a sample of 2,159,666 observations from 482,513 firms across 20 industries.

For all firms, a patent history profile is created based on the patents the firm applied for during a five-year moving window[14] prior to any given year.[15] The firm's patent history profile enables us to distinguish between patent applications categorized as either explorative or exploitative. A patent is labeled explorative if a firm applies for a patent in a patent class that is new for the firm. On the other hand, if the firm applies for a patent in the same class as it has

[14] We follow Griliches (1979, 2007) findings that knowledge capital loses most of its economic value during the first five years and use a five-year window to distinguish between explorative and exploitative innovations. As a robustness test we also employ a shorter window comprising three years.

[15] The patent applications classes are determined at the two-digit level of International Patent Classification (IPC), which results in 121 classes. A similar method had been used by Bloom et al., (2013) who use firm-level data on patenting in different technology classes to locate firms in technology space.

previously applied during a five-year moving window, the firm is labeled as exploitative. Hence, we construct the following two innovation variables:

Exploitative innovation: A dummy variable equal to one if a firm applies for a patent in year *t* in a patent class where it already has applied for a patent during the last five years; zero otherwise.
Explorative innovation: A dummy variable equal to one if a firm applies for a patent in year *t* within a patent class where it has not applied for a patent during the last five years; zero otherwise.

The wage variable (w_{it}) (measured as wage costs per employee), the gross fixed capital stock (k_{it}) and industry demand (ys_{it}) (measured as industry-aggregated gross value added) are all deflated using the producer price index. Finally, we distinguish between four different types of firm ownership in the analysis: domestically owned independent firms (DIFs), domestically owned firms belonging to a Swedish corporate group (DSC), domestically owned multinational firms (DMNEs) and foreign owned multinational firms (FMNEs)[16]. Table 1 provides the definitions of all variables employed in the analysis, while Table 2 reports descriptive statistics and Table 3 presents the pairwise correlation coefficients.

TABLE 1 HERE

[16] Ownership has been shown to influence both firms' employment growth and innovative activities, but results are inconclusive (Barba Navaretti, 2004; Geroski and Gugler, 2004; Beck et al., 2005; Ebersberger et al., 2005; Sadowski and Sadowski-Rasters, 2006; Dachs et al., 2008; Dachs and Peters, 2014).

TABLE 2 HERE

TABLE 3 HERE

We find that the two innovation variables are positively correlated (the correlation coefficient is equal to 0.46) regardless if we use the three- or the five-year window, suggesting that firms being involved in one type of innovation are likely to also pursue the other type of innovation. In addition, it is obvious that the main part of our sample consists of domestically owned independent firms (DIFs) followed by domestically owned firms belonging to a Swedish corporate group (DSCs). Together, these two types of firms comprise over 94 percent of all firms. The vast majority of firms (almost 60 percent) belong to the manufacturing, construction, wholesale, retail and professional and technical industries. Table 4 shows descriptive statistics distributed on the four ownership categories.

TABLE 4 HERE

The average annual employment growth among DIFs has been 3.1 percent, followed by DMNEs (0.8 percent), DSCs (0.8 percent) and FMNEs (0.4 percent). DIFs are small firms with an average of four employees and are also endowed with modest amounts of physical capital and are poor innovators. On average, 0.036 percent of firms belonging to this owner category had an explorative innovation and 0.038 percent had an exploitative innovation during 2002 to 2012.

The categories DMNEs and FMNEs contains the largest firms (about 95 employees on average), which also have considerably more physical capital and are more innovative. DMNEs perform better in terms of innovation output then FMNEs. In DMNEs, 1.6 percent of the firms are involved in explorative innovation and 2.8 percent in exploitative innovation; in FMNEs, 1.0 percent of the firms are involved in explorative innovation and 1.9 percent in exploitative innovation.

Looking at Figure 1, we can observe the fluctuation of the average growth rate during 2002 to 2012. Both explorative innovators and exploitative innovators enjoy a higher average growth rate of employment than non-innovators, but the growth rate has a tendency to change frequently. After the “great recession” starting in 2008, the decline in growth rate has been most pronounced for innovative firms. For non-innovators, the decrease is more smoothly from 4.1 percent in 2007 to 0.4 percent in 2009.

FIGURE 1 HERE

Comparing innovators, explorative strategies seem to be consistent with a considerably higher growth rate throughout the entire period as compared to firms adopting exploitative strategies. Both explorative and exploitative innovators have experienced the highest growth up until 2007 (10.5 percent for explorative innovators and 6.6 percent for exploitative innovators). However, they have also suffered the sharpest decline after 2008. It illustrates that even if innovation creates competitiveness, it may also expose firms to considerable risks.

5. Empirical results

The results from the regressions implementing OLS are presented in Table 5 while the system-GMM estimation results are shown in Table 6. Specification 1 and 2 include the explorative and exploitative innovation variables separately while specification 3 includes both types of innovations simultaneously.

TABLE 5 HERE

TABLE 6 HERE

The first apparent thing in Table 5 is the strong and highly significant negative relationship between current growth and the lagged employment growth variables, which could be interpreted as an indication of mean reversion, i.e. firms that have experienced high employment growth one year tend to see slower growth rates the following years and vice versa. Interestingly enough, this effect disappears when we use the more elaborate GMM estimator as shown by the overall lack of statistical significance for the lagged employment growth variables in Table 6.

Next, looking at the innovation variables in specification 1 and 2, we find that both exploitative as well as explorative innovations are associated with positive and significant effects on subsequent firm growth. This result is qualitatively equal for both the OLS and the GMM estimates, but the strength differs somewhat between the two methods. In general, the effects tend to be slightly larger when looking at the GMM results as compared to those obtained via OLS. This could potentially be due to the presence of endogeneity, making the OLS estimator both biased and inconsistent.

The strength of the positive relationship between innovation and employment growth decreases over time for both types of innovations. It even turns negative for exploitative innovations after two years as indicated by the statistically significant negative sign for the two-year lagged dummy variable for exploitative innovations. A possible interpretation of this finding is that firms that have chosen an exploitative innovation strategy, may enjoy efficiency gains already in the short term whereas it may take some time before it results in a reduced workforce.[17] Over time an exploitative innovation strategy may also hamper the firms' ability to discover new products which would further decrease the demand for new labor. Explorative innovations based on a wider search activity, is on the other hand more likely to come up with new products and processes and generate an increase in labor demand. Note that when both explorative and exploitative innovations are included in the regressions simultaneously, only the former remains statistically significant. This is, however, a likely effect of the high pairwise correlation between the two innovation variables as shown in Table 3.

Our control variables, i.e. the wage rate, the capital stock and the sector gross value added, all have their expected signs and are highly significant. Higher wage growth is associated with lower employment growth while an increasing capital stock goes hand-in-hand with stronger employment growth. Thus, it seems as if excessive labor costs make firms shed labor while capital deepening is positively associated with higher marginal productivity of labor and contributes to employment growth. Moreover, as expected there's a positive relationship between overall sector expansion and demand for labor as evident by the positive sign of the aggregate sector value added variable.

Finally, turning to the ownership variables, we see that the only category consistently differing from domestically owned individual firms in Table 5 and 6 is FMNEs. That is unexpected considering that FMNEs are believed to have a higher potential (sale organizations, access to global markets, etc.) to introduce new products more successfully into the market, which should be mirrored by higher employment growth. However, our results show that firms belonging to this category on average display a lower employment growth rate. One explanation

[17] A number of countries, including Sweden, has different safe-guards for employees implying that they cannot be dismissed from one day to the other.

could be that FMNEs adopt less labor-intensive production technologies in high wage countries such as Sweden. Potentially positive employment effects from innovation may predominantly be substantiated in foreign-owned plants outside of Sweden.

Second, the effect of innovation on employment creation is much larger in upswings of the business cycle than in downswings (Peters, 2008; Lucchese and Pianta, 2012). We have also shown that the employment growth rate dropped most for the innovative firms after the financial crisis (Figure 1). The period we have chosen for the analysis covers two economic recessions (2002–2004 and 2007–2010), but only one upswing. From a dynamic perspective, the slow-down in employment growth of foreign-owned firms might be explained by the business cycle.

In an attempt to test the robustness of our results, we use a three-year window to categorize innovations as explorative or exploitative as a complement to our baseline five-year window. As seen in the Appendix, basically all our results remain unchanged when using this alternative measure and we conclude that we have a stable and significant relationship between innovations and employment growth at the firm level.

The test statistics shown at the bottom rows in Table 6 and in the GMM-estimations in the Appendix support the validity of the system-GMM method. The Sargan test does not reject the null hypothesis that our instruments are exogenous and furthermore, the AR(2) test does not reject the null hypothesis of no second order autocorrelation at the 5 percent significance level.[18]

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[18] We have used a Heckman selection model in addition to the OLS and GMM-model to see if our results are driven by sample selection. The results from these additional regressions indicate that the effect of innovation on firm growth does not change in any substantial way when we control for firm survival. The estimation results are available upon request.

6. Conclusion

The purpose of this paper has been to empirically examine how innovation influences firm growth measured in terms of employment. Building on previous theoretical and empirical findings, we create knowledge profiles to distinguish between exploitative and explorative innovations and investigate how different types of innovation have influenced firm growth.

We apply a dynamic analysis and use first difference employment equation techniques in the regressions, where Swedish firm level data for the period 2002 to 2012 have been implemented. The results confirm significant and positive effects for both exploitative and explorative innovation on firm's employment growth. The results are shown to be robust to different estimation techniques, such as OLS regression and GMM system method, as well as different measurements for the innovation variables.

We find that explorative innovations have a more pronounced and persistent effect on employment growth than exploitative innovations. This type of innovation adheres more closely to Schumpeter's early view on the role of the entrepreneur in initiating creative destruction processes. Exploitative innovations increase labor demand only in the short-run according to our estimations.

In addition, we also investigate the relationship between employment growth and ownership structure, which is essential for understanding the employment impact of foreign- and domestically-owned firms. Among four owner types, foreign owned multinational enterprises (FMNEs) are shown to exhibit the lowest employment growth. This may reflect a higher capability of transforming innovations into higher productivity, or that innovations are primarily used in affiliates outside of Sweden, thereby not influencing local demand for labor. Multinational enterprises may also have a tendency to use less labor intensive production in a high wage country such as Sweden and move labor intensive production into low wage countries. In addition, we also control for a number of other variables that are likely to affect firm growth such as physical capital, wages, regions, industries and time trend.

The different impact of exploitative and explorative innovations for firm growth has important implications for government policies, aiming at full employment and economic growth. Business stealing effects may imply that the aggregate effects will be smaller or even negligent. The results of our study may also be affected by the time period we are studying, even though we implement time dummies. As shown by Dachs et al. (2015), the effects of innovation on growth are larger in economic booms than in busts and our data covers one upturn and two downturns.

From a policy perspective, it is important what the policymaker aims to achieve by introducing different policy measures. As shown in numerous previous studies, R&D may not be an optimal policy instrument for all firms. Size, industry and ownership influence the effect of R&D subsidies, as well as different measures to enhance innovations. Acemoglu et al. (2013) show that R&D subsidies to incumbents reduce welfare and deter entry of high-tech firms.

Appendix OLS regression result (3 years moving window)

	(1)	(2)	(3)
L1. Δ log employment	–0.257***	–0.257***	–0.257***
	(–277.15)	(–277.14)	(–277.15)
L2. Δ log employment	–0.0737***	–0.0737***	–0.0737***
	(–83.22)	(–83.22)	(–83.22)
Exploitative innovation		0.0208***	0.0121
		(2.87)	(1.51)
L1. Exploitative innovation		0.0132*	0.00831
		(1.83)	(1.08)
L2. Exploitative innovation		–0.00929	–0.0107
		(–1.42)	(–1.60)
Explorative innovation	0.0177***		0.0137*
	(2.60)		(1.87)
L1. Explorative innovation	0.0145**		0.00925
	(2.29)		(1.31)
L2. Explorative innovation	0.00881		0.00713
	(1.50)		(1.07)
Δ Log wage	–0.0178***	–0.0178***	–0.0178***
	(–32.56)	(–32.56)	(–32.56)
Δ Log physical capital	0.00331***	0.00331***	0.00331***
	(54.81)	(54.81)	(54.81)
Δ Log sector gross value added	0.00498***	0.00497***	0.00498***
	(4.28)	(4.27)	(4.28)
Ownership (base is DIFs)			
DSCs	–0.000187	–0.000173	–0.000185
	(–0.28)	(–0.26)	(–0.28)
DMNEs	0.00487***	0.00502***	0.00485***
	(3.43)	(3.53)	(3.41)
FMNEs	–0.00589***	–0.00582***	–0.00590***
	(–4.27)	(–4.22)	(–4.28)
Year dummy	Yes	Yes	Yes
Region dummy	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes
Constant	–0.0175***	–0.0175***	–0.0175***
	(–4.23)	(–4.23)	(–4.23)
Number of observations	1,173,311	1,173,311	1,173,311

Note: *** denotes 0.1% significance; ** denotes 1% significance; * denotes 5% significance. L. denotes the lag operator and, hence, L1. stands for one-year lag etc.

GMM regression result (3 years moving window)

	(1)	(2)	(3)
L1. Δ log employment	0.128	0.0787	0.0968
	(0.61)	(0.59)	(0.92)
L2. Δ log employment	0.0152	0.0200	0.0202
	(0.61)	(1.18)	(1.41)
Exploitative innovation		0.0249**	0.00663
		(2.18)	(0.52)
L1. Exploitative innovation		0.0160*	0.00552
		(1.70)	(0.52)
L2. Exploitative innovation		–0.00141	–0.00386
		(–0.16)	(–0.43)
Explorative innovation	0.0299**		0.0258**
	(2.17)		(2.38)
L1. Explorative innovation	0.0240**		0.0191*
	(2.15)		(1.87)
L2. Explorative innovation	0.0185*		0.0151
	(1.90)		(1.60)
Δ Log wage	–0.0289***	–0.0276***	–0.0540***
	(–5.07)	(–7.60)	(–12.18)
Δ Log physical capital	0.00279***	0.00285***	0.00180***
	(11.76)	(17.90)	(19.83)
Δ Log sector gross value added	0.00357**	0.00373***	0.00224
	(2.29)	(2.63)	(1.45)
Ownership (base is DIFs)			
DSCs	0.000912	0.000942	0.00112
	(1.14)	(1.21)	(1.31)
DMNEs	0.00270	0.00324*	0.00319*
	(1.40)	(1.84)	(1.70)
FMNEs	–0.00409**	–0.00407**	–0.00356**
	(–2.26)	(–2.41)	(–1.99)
Year dummy	Yes	Yes	Yes
Region dummy	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes
Constant	–0.0258***	–0.0259***	–0.0363***
	(–5.17)	(–5.39)	(–7.09)
Number of observations	1,173,311	1,173,311	1,173,311
Sargan value	15.06	54.42	81.32
Sargan p-value	0.303	0.771	0.998
AR(1)	–2.95	–4.42	–5.65
AR(1) p-value	0.003	0.000	0.000
AR(2)	0.90	1.08	1.47
AR(2) p-value	0.368	0.280	0.141

Note: *** denotes 0.1% significance; ** denotes 1% significance; * denotes 5% significance. L. denotes the lag operator and, hence, L1. stands for one-year lag etc.

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Table 1 Definition of variables

Symbol	Variables	Type	Definition
n_{it}	Log employment	Continuous	n_{it} is the logarithm of employment of firm *i* at year *t*.
Δn_{it}	Employment growth	Continuous	$\Delta n_{it} = n_{it} - n_{i(t-1)}$, the value had been winsorized at the 1 percentage level for each tail.
$Explorative_{it}$	Explorative innovation	0/1	A dummy variable equal to one if a firm applies for a patent in year t within a patent class where it has not applied for a patent during the last five years; zero otherwise.
$Exploitative_{it}$	Exploitative innovation	0/1	A dummy variable equal to one if a firm applies for a patent in year t in a patent class where it already has applied for a patent during the last five years; zero otherwise.
w_{it}	Log deflated annual wage	Continuous	The logarithm of the firm' average annual wage deflated by producer price index (PPI).
k_{it}	Log physical capital	Continuous	The logarithm of value of physical capital deflated by producer price index (PPI).
ys_{it}	Log sector gross value added	Continuous	The logarithm of the aggregate sector gross value added deflated by producer price index (PPI).
$D_{ownership}$	Ownership	0/1	Domestic-owned individual firms (DIFs), domestic-owned firms belonging to a Swedish corporate group (DSCs), domestic-owned multinational firms (DMNEs) and foreign-owned multinational firms (FMNEs).

Note: The log physical capital = ln (physical capital +0.00001).

Table 2 Descriptive statistics

Variables	Mean	Std. Dev.	Min	Max
Employment	11.3	124.9	1	23,588
Employment growth	0.027	0.305	–0.916	1.099
Explorative innovation (5 years moving window)	0.0012	0.0345	0	1
Exploitative innovation (5 years moving window)	0.0018	0.0429	0	1
Explorative innovation (3 years moving window)	0.0013	0.0361	0	1
Exploitative innovation (3 years moving window)	0.0017	0.0418	0	1
Deflated annual wage (thousand SEK)	202	142	0	33,100
Deflated physical capital (thousand SEK)	7,778	218,000	0	72,800,000
Deflated sector gross value added (thousand SEK)	139,000,000	119,000,000	437	447,000,000
Ownership:				
DIFs	0.806	0.395	0	1
DSCs	0.139	0.346	0	1
DMNEs	0.026	0.160	0	1
FMNEs	0.028	0.165	0	1
Industry:				
Agriculture, forestry and fishing	0.089	0.284	0	1
Mining and quarrying	0.017	0.128	0	1
Manufacturing	0.105	0.307	0	1
Electricity, gas, steam and air conditioning supply	0.002	0.043	0	1
Water supply; sewerage, waste management and remediation activities	0.006	0.076	0	1
Construction	0.131	0.337	0	1
Wholesale and retail trade; repair of motor vehicles and motorcycles	0.205	0.404	0	1
Transportation and storage	0.067	0.249	0	1
Accommodation and food service activities	0.040	0.197	0	1
Information and communication	0.046	0.209	0	1
Financial and insurance activities	0.001	0.036	0	1
Real estate activities	0.030	0.170	0	1
Professional, scientific and technical activities	0.124	0.330	0	1
Administrative and support service activities	0.028	0.164	0	1
Public administration and defense; compulsory social security	0.000	0.001	0	1
Education	0.022	0.147	0	1
Human health and social work activities	0.034	0.181	0	1
Arts, entertainment and recreation	0.017	0.128	0	1
Activities of households as employers; undifferentiated goods- and service-producing activities of households for own use	0.029	0.167	0	1
Activities of extraterritorial organizations and bodies	0.009	0.096	0	1
Number of observations	2,159,666			

Table 3 Pairwise correlation coefficients

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Employment	1								
(2) Employment growth	0.0011	1							
(3) Explorative innovation (5 years moving window)	0.0966	0.0008	1						
(4) Exploitative innovation (5 years moving window)	0.124	0.0005	0.4601	1					
(5) Explorative innovation (3 years moving window)	0.1048	0.0006	0.9572	0.5108	1				
(6) Exploitative innovation (3 years moving window)	0.1201	0.0005	0.4469	0.9742	0.4622	1			
(7) Deflated wage	0.0413	–0.0701	0.0352	0.0498	0.0375	0.0486	1		
(8) Deflated physical capital	0.2421	–0.002	0.0489	0.0693	0.0551	0.0653	0.0355	1	
(9) Deflated sector gross value added	0.044	–0.0202	0.0419	0.0532	0.0442	0.0517	0.1026	0	1

Table 4 Descriptive statistics by ownership type

	DIFs		DSCs		DMNEs		FMNEs	
Variables	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Employment	4.2	45.7	19.3	125.7	96.5	477.4	95.1	433.7
Employment growth	0.031	0.313	0.008	0.273	0.008	0.241	0.004	0.247
Explorative innovation (5 years moving window)	0.00036	0.01888	0.00144	0.03788	0.01610	0.12584	0.01002	0.09959
Exploitative innovation (5 years moving window)	0.00038	0.01937	0.00200	0.04463	0.02783	0.16447	0.01880	0.13580
Explorative innovation (3 years moving window)	0.00037	0.01930	0.00153	0.03909	0.01792	0.13266	0.01126	0.10552
Exploitative innovation (3 years moving window)	0.00036	0.01886	0.00189	0.04343	0.02639	0.16029	0.01790	0.13259
Deflated annual wage (thousand SEK)	181	127	266	130	349	230	371	207
Deflated physical capital (thousand SEK)	1,346	41,200	21,900	385,000	79,100	768,000	55,800	583,000
Deflated sector gross value added (thousand SEK)	129,000,000	114,000,000	166,000,000	127,000,000	217,000,000	142,000,000	209,000,000	129,000,000
Number of observations	1,741,671		300,574		57,035		60,386	

Table 5 OLS regression result (5 years moving window)

	(1)	(2)	(3)
L1. Δ log employment	–0.259***	–0.259***	–0.259***
	(–274.25)	(–274.24)	(–274.25)
L2. Δ log employment	–0.0749***	–0.0749***	–0.0749***
	(–83.62)	(–83.61)	(–83.62)
Exploitative innovation		0.0222***	0.0126
		(3.00)	(1.55)
L1. Exploitative innovation		0.0153**	0.00866
		(2.07)	(1.10)
L2. Exploitative innovation		–0.0113*	–0.0142**
		(–1.70)	(–2.07)
Explorative innovation	0.0208***		0.0167**
	(2.78)		(2.06)
L1. Explorative innovation	0.0168**		0.0117
	(2.40)		(1.53)
L2. Explorative innovation	0.0133**		0.0135*
	(2.07)		(1.87)
Δ Log wage	–0.0161***	–0.0161***	–0.0161***
	(–27.87)	(–27.87)	(–27.87)
Δ Log physical capital	0.00381***	0.00381***	0.00381***
	(59.79)	(59.80)	(59.79)
Δ Log sector gross value added	0.00606***	0.00606***	0.00606***
	(4.94)	(4.94)	(4.94)
Ownership (base is DIFs)			
DSCs	–0.000471	–0.000454	–0.000468
	(–0.67)	(–0.64)	(–0.66)
DMNEs	0.00398***	0.00417***	0.00399***
	(2.66)	(2.78)	(2.66)
FMNEs	–0.00638***	–0.00630***	–0.00637***
	(–4.39)	(–4.32)	(–4.38)
Year dummy	Yes	Yes	Yes
Region dummy	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes
Constant	–0.0275***	–0.0275***	–0.0275***
	(–6.30)	(–6.30)	(–6.30)
Number of observations	1,173,311	1,173,311	1,173,311

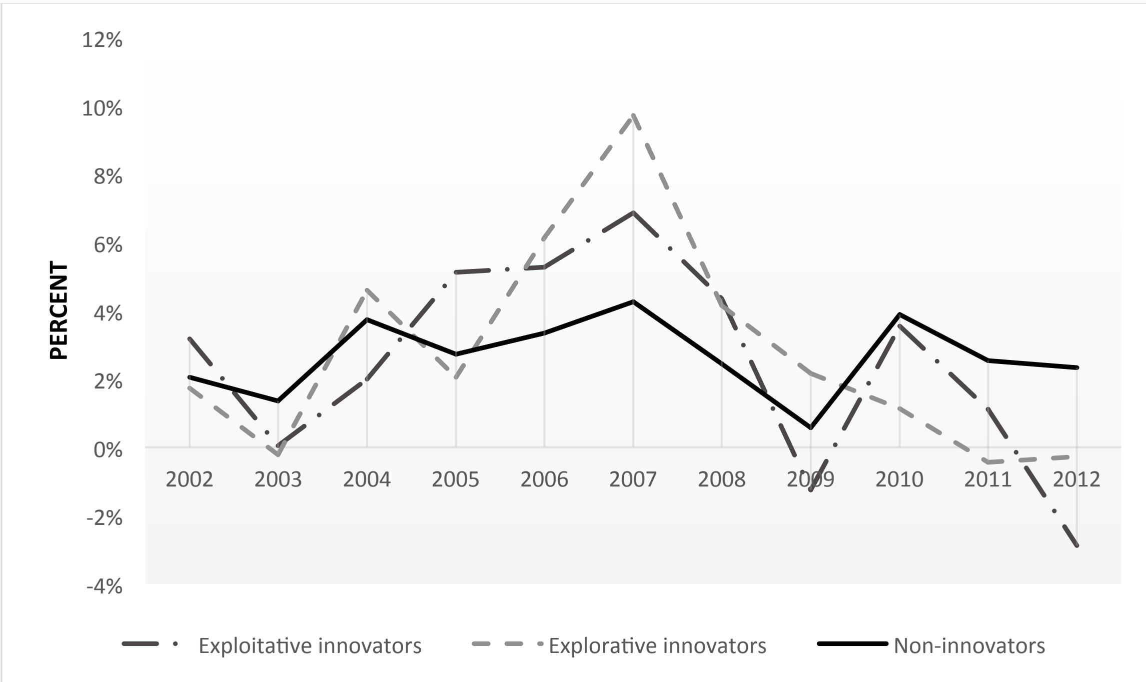
Note: *** denotes 0.1% significance; ** denotes 1% significance; * denotes 5% significance. L. denotes the lag operator and, hence, L1. stands for one-year lag etc.

Table 6 GMM regression result (5 years moving window)

	(1)	(2)	(3)
L.Δ log employment	0.103	0.126	0.0963
	(0.98)	(0.90)	(0.90)
L2. Δ log employment	0.0212	0.0162	0.0220
	(1.49)	(0.93)	(1.53)
Exploitative innovation		0.0232*	0.00309
		(1.92)	(0.24)
L.Exploitative innovation		0.0170*	0.00405
		(1.75)	(0.38)
L2.Exploitative innovation		–0.00135	–0.00597
		(–0.15)	(–0.65)
Explorative innovation	0.0347***		0.0336***
	(3.19)		(2.86)
L.Explorative innovation	0.0262***		0.0245**
	(2.77)		(2.25)
L2. Explorative innovation	0.0218**		0.0220**
	(2.49)		(2.19)
Δ. Log wage	–0.0540***	–0.0275***	–0.0537***
	(–11.92)	(–6.93)	(–11.64)
Δ. Log physical capital	0.00213***	0.00327***	0.00213***
	(22.50)	(18.77)	(22.52)
Δ. Log sector gross value added	0.00304*	0.00464***	0.00306*
	(1.88)	(3.06)	(1.90)
Ownership (base is DIFs)			
DSCs	0.000981	0.000656	0.000983
	(1.10)	(0.79)	(1.11)
DMNEs	0.00200	0.00203	0.00206
	(1.04)	(1.08)	(1.06)
FMNEs	–0.00424**	–0.00465***	–0.00424**
	(–2.31)	(–2.59)	(–2.29)
Year dummy	Yes	Yes	Yes
Region dummy	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes
Constant	–0.0514***	–0.0354***	–0.0515***
	(–9.58)	(–6.84)	(–9.63)
Observations	1,173,311	1,173,311	1,173,311
Sargan value	83.88	52.17	84.5
Sargan p-value	0.998	0.833	0.996
AR(1)	–5.72	–4.42	–5.57
AR(1) p-value	0.000	0.000	0.000
AR(2)	1.52	1.33	1.43
AR(2) p-value	0.129	0.183	0.154

Note: *** denotes 0.1% significance; ** denotes 1% significance; * denotes 5% significance. L. denotes the lag operator and, hence, L1. stands for one-year lag etc.

Figure 1 Exploration/exploitation innovation and average firm growth rate



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