The Role of Regional Context on Innovation Persistency of Firms

Sam Tavassoli (sam.tavassoli@rmit.edu.au)
RMIT University, Australia & CIRCLE, Lund University, Sweden
Charlie Karlsson (charlie.karlsson@ju.se)
CESIS, KTH, & Jönköping International Business School, Sweden

Papers in Innovation Studies
Paper no. 2017/11

This is a pre-print version of a paper that has been submitted for publication to a journal.

This version: August 2017

Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
Lund University
P.O. Box 117, Sölvegatan 16, S-221 00 Lund, SWEDEN
http://www.circle.lu.se/publications

WP 2017/11

The Role of Regional Context on Innovation Persistency of Firms

Sam Tavassoli, Charlie Karlsson

Abstract: This paper analyses the role of regional context on innovation persistency of firms. Using five waves of the Community Innovation Survey in Sweden, we have traced firms' innovative behaviour from 2002 to 2012, in terms of four Schumpeterian types of innovation: product, process, organizational, and marketing. Employing transition probability matrix and dynamic Probit model and controlling for an extensive set of firm-level characteristics, we find that certain regional characteristics matter for innovation persistency of firms. In particular, those firms located in regions with (i) thicker labour market or (ii) higher extent of knowledge spillover exhibit higher probability of being persistent innovators up to 14 percentage points. Such higher persistency is mostly pronounced for product innovators.

Keywords: location; innovation; persistence; product innovations; process innovations; market innovations; organizational innovations; firms; Community Innovation Survey

JEL: D22; L20; O31; O32

The Role of Regional Context on Innovation Persistency of Firms

Sam Tavassoli [a,b*] and **Charlie Karlsson** [c,d]

[a] School of Management, RMIT University, Melbourne, Australia
[b] Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE), Lund University, Lund, Sweden
[c] Centre of Excellence for Science and Innovation Studies (CESIS), KTH, Stockholm, Sweden
[d] Jönköping International Business School, Jönköping, Sweden

*Corresponding author: Sam Tavassoli: sam.tavassoli@rmit.edu.au

Abstract

This paper analyses the role of regional context on innovation persistency of firms. Using five waves of the Community Innovation Survey in Sweden, we have traced firms' innovative behaviour from 2002 to 2012, in terms of four Schumpeterian types of innovation: product, process, organizational, and marketing. Employing transition probability matrix and dynamic Probit model and controlling for an extensive set of firm-level characteristics, we find that certain regional characteristics matter for innovation persistency of firms. In particular, those firms located in regions with (i) thicker labour market or (ii) higher extent of knowledge spillover exhibit higher probability of being persistent innovators up to 14 percentage points. Such higher persistency is mostly pronounced for product innovators.

Keywords: location, innovation, persistence, product innovations, process innovations, market innovations, organizational innovations, firms, Community Innovation Survey

JEL Codes: D22, L20, O31, O32

1. Introduction

Innovation[1] is not a general characteristic of firms. Many firms never innovate; some firms innovate now and then, while many other firms are persistent innovators (Tavassoli & Karlsson, 2015). Persistence of innovation has become an important topic in applied industrial economics since the seminal paper by Geroski et al. (1997), which has sparked empirical investigation of persistency in various types of innovation (Cefis & Orsenigo, 2001; Peters, 2009; Raymond et al, 2010; Clausen et al, 2012; Gartner & Hecker, 2013; Tavassoli & Karlsson, 2015). The main finding is that innovation persistency exists and being a product innovator is the strongest persistent behaviour among innovative firms. However, the determinants of innovation persistency of firms are still to be investigated.

The literature suggests two groups of explanatory factors, which are critical for innovation persistence of firms (Antonelli et al, 2013). The first group of factors builds upon the resource-based view of the firm and relates innovation persistence to intrinsic characteristics and endowments of firms (Langlois & Foss, 1999)[2]. The second group concerns the external context in which innovation happens (Tavassoli, 2014; Feldman and Tavassoli, 2015). Here the starting point is that innovation persistence is a path-dependent process, where innovation by a firm in one period increases the probability that it will also make an innovation in the next period. However, this probability is not stable over time and it can be influenced by external events. The external events can come from product, labour, input markets, and the external knowledge production activities. The signals may be transmitted via markets, via spillover from other economic agents, or via labour mobility. Such signals may be transmitted over long distance but will mostly come from within the region where the firm is located (Andersson and Karlsson, 2007). This implies that the spatial context influences the probability that a firm, which is innovative in one period, will likely be innovative in the next period too. Therefore, the richer and more developed the local spatial context, the higher the probability that firms will react creatively on external events and continue to introduce innovations. In line with Antonelli et al (2013), we argue that external knowledge (in particular from a firm's own region) is a key factor in determining path-dependent innovation persistence driven by

[1] By "innovation", we refer to the deliberate and intentional result of the willingness and ability of firms to generate new ideas and knowledge and implement them in the form of new products, production processes, organizational and/or markets solutions (Fagerberg, et al., 2005).

[2] Firms vary in terms of their initial conditions concerning innovation, learning capabilities, and routines as well as in their capacity, resources, competence and routines in developing these learning capabilities and routines over time

processes characterized by contextual and conditional feedbacks (Beaudry & Swann, 2009). In this paper, we will focus on such local spatial context as the determinant for innovation persistency of firms[3].

Locations (regions) is critical for innovation persistency of firms (Tavassoli & Tsagdis, 2014). This is because locations are characterised by varying degree of "slowly changing factors" that enforce the path-dependency in innovation persistency of firms. Such slowly changing factors are the volume and type of knowledge production, local and interregional links and arenas for knowledge interaction, transfer and diffusion, the supply of knowledge agents, i.e. knowledge-intensive business services, universities and research institutes and their knowledge handlers, which influence the knowledge generation processes among firms. Regions with these characteristics offer different types of increasing returns in the form of dynamic and interactive economies of scale and scope that foster knowledge accumulation and learning dynamics, which promotes innovation persistence (Colombelli, & von Tunzelmann, 2011). Indeed, firms cluster to get access to the right supply of knowledge and in particular new knowledge (Baptista & Swann, 1999). Empirical findings indicate that the higher the ability of firms to use external knowledge as an input in their own innovation processes, the higher their rate of innovation (Fritsch & Franke, 2004), indicating the positive effects of knowledge flows and spillover.

Against the above background the purpose of this paper is to empirically analyse the effect of three locational factors (i.e. labour market thickness, specialised supplier thickness, and knowledge spillover) that can contribute to explain variation of firm's persistence in introducing four Schumpeterian innovation types (product, process, organizational and market innovations). Using a balanced panel of firms participated in five waves of Community Innovation Survey (CIS) in Sweden over the period 2002-2012, we find that those firms located in the regions with thicker labour market or higher extent of knowledge spillover exhibit higher probability of being persistent innovators. Such higher persistency is mostly pronounced for product innovators.

We contribute to the innovation literature and in particular innovation persistency literature as follows. First, by incorporating various regional factors (as the external context) in order to

[3] Interestingly, the critical role of location for innovation persistence has not been a major research question in most of the earlier research on the determinants of innovation persistence. An exception is Antonelli, et al. (2013), who found that the external conditions, i.e. the quality of local knowledge pools and the strength of Schumpeterian rivalry, along with internal conditions (the level of dynamic capabilities, as proxied by wage levels and firm size) exert a specific and localized effect upon the persistent introduction of innovations.

explain the variation in innovation persistency of firms located in different regions. To out best of knowledge, this is one of the very few study of this kind. Second, by moving beyond commonly used technology-related innovation and instead incorporating four types of innovation based on actual Schumpeterian classification, i.e. product, process, marketing, and organizational innovations in an economy-wide empirical setting. And third, by moving beyond the usual manufacturing sector and including the service sector in the analysis as well.

The rest of the paper is as follows. Section 2 provides the theoretical reasoning for existence of innovation persistence due to regional factors by discussing two mechanisms, i.e. slowly changing regional characteristics (2.1) and path-dependency (2.2.), and eventually hypotheses development concerning the role of various regional factors for persistency of firms (2.3). Section 3 describes the data. Section 4 elaborates the empirical strategy. Section 5 reports the empirical results and Section 6 concludes.

2. Location and Innovation Persistence

It is well established in the literature that the innovation behaviour of many firms is characterized by persistence and that this prevails for product, process, organizational as well as market innovation but to a varying degree (Ganter & Hecker, 2013; Tavassoli & Karlsson, 2015). At a general level, innovation persistence has been explained by a firm's internal learning effects and knowledge accumulation from earlier innovation processes through positive feed-back mechanisms generating dynamic scale economies (Geroski, Van Reenen & Walter, 1997). However, we argue that innovation persistence is also stimulated by factors external to the firm and, in particular, factors related to the region where the firm is located, i.e. to its innovative milieu.

In order to formally show the role of the innovative milieu in a region for innovation persistency of a firm located in that region, we start with the classic knowledge production function (KPF). The KPF relates the innovation outputs to the innovation inputs (Griliches, 1979; Crépon, Dueget & Mairesse, 1998; Baum et al., 2017):

$$Y_i = A_i H_i^{\alpha} K_i^{\beta} \quad (1$$

where Y_i is a measure of the innovation outcome in firm i (for simplicity, let us assume it is a binary measure), A_i measures the overall labour productivity of the innovation activities in firm i, H_i is the human capital input in innovative activities in firm i, and K_i represents all other internal innovation inputs in firm i. Here a clear distinction is made between the innovation output and the innovation inputs. The basic underlying idea is that the different internal and external innovation inputs (human capital, R&D investments, ICT investments, various knowledge generation sources, etc.) generate knowledge, which may manifest itself in the form of an innovation output (Antonelli & Colombelli, 2015).

Then conditional on being innovative in time t ($Y_{i,t} = 1$), a firm i may persist to innovative in the subsequent period as well, which can be formally stated as below:

$$Y_{i,t+1} = Y_{i,t}^{\rho} \qquad (\rho: \rho^{r1}, \rho^{r2}, \ldots \rho^{rn}) \qquad (2$$

where ρ shows the magnitude of the persistency. While previous research generally shows that ρ is significantly different from zero (Ganter & Hecker, 2013; Tavassoli & Karlsson, 2015), our argument is that such effect also depends on the regional context, where firm is located. This implies that if we break down the ρ depending on where the firms is located, then the ρ^{r1}, ρ^{r2}, $\ldots\rho^{rn}$ should not show equal magnitude to each other. Here *r1, r2, …rn* refer to the spectrum of a given regional characteristic in which firm i is located in that region.

In the sequel, we discuss why we think so by elaborating on two sources of innovation persistence related to regional characteristics, i.e. (i) slowly changing regional characteristics and (ii) path-dependency.

2.1 Slowly Changing Regional Characteristics and Innovation Persistence

Based on location theory, those regional characteristics that are durable or semi-durable, i.e. that only change slowly, are the ones that shape the production and innovation possibilities of regions, and thus their development trajectories (Johansson & Karlsson, 2001). Some of these characteristics are spatial in nature, while others are created by various types of investments over time as well as by income growth. Examples of semi-durable regional characteristics of regions are buildings, roads, airports, production facilities, and supply of labour with its education and skills, producer service firms, universities, and R&D institutes. These durable and semi-durable, i.e. sticky, regional attributes not only characterize the production milieu of regions but also their start-ups rates and innovation milieu (Andersson & Koster, 2011).

In pure versions of endogenous growth theory (Romer, 1990), it is assumed that all new knowledge is immediately available to all economic agents to be used as an input in future knowledge production. This is of course misleading. In fact, the most realistic assumption is that there exist frictions that retard the diffusion of new knowledge. Frictions appear, in particular, when knowledge is complex (Beckmann, 1994) and/or tacit (Polanyi, 1966), which implies that knowledge is sticky (von Hippel, 1994). The strength of the frictions varies with the geographic and other communication distances between economic agents. Under such circumstances, the face-to-face interaction is essential for the transfer of knowledge between economic agents to calibrate their coding, decoding and interpretation (Johansson & Karlsson, 2009).[4]

Furthermore, the stickiness of knowledge implies that knowledge can be shared by firms in the economic environment of a functional region with little risk that the knowledge diffuses outside the region at least in the short run (Antonelli, et al., 2003; Andersson and Karlsson, 2007). An implication of this is that innovation activities in a functional region will benefit from new knowledge developed in other functional regions only to a limited extent in the short run. This implies that firms that invest in knowledge production are mainly referred to use their own internal knowledge stock and the knowledge stock in the functional region where they are located (Tavassoli & Carbonara, 2014).

Many of the external factors and not least knowledge generation capacity that influence innovation activities of firms are rather fixed in time and fit with the concept of a slowly changing innovation milieu. There is plenty of evidence that regional supply-side conditions, such as the education level of the labour force, ongoing innovation activities, industry structure, presence of knowledge-intensive supplier services and research universities influence the rate of innovation in a region. The processes that typically change these characteristics move slowly and therefore these characteristics can be seen as defining a region's innovation milieu together with prevailing demand-conditions that also change slowly. Thus, if these characteristics stimulates innovation in one period, we can expect that they also will do it in subsequent periods. This simply means occurrence of innovation persistency for firms.

An exception to such slowly changing regional factors can be the educated and skilled labours, which are, in principle, a mobile production factor. However, the rate of inter-regional mobility is rather low in this group and research has consistently shown that they are typically

[4] We must acknowledge that over time new communication technologies can modify the role of geographical proximity in such calibrations (Teece, 1981). However, casual observation of the continued and increased use of, e.g., trade fairs, scientific conferences and business travel, indicates that the new communication technologies still have a long way to go to substitute the role of face-to-face interactions for such calibrations.

concentrated in a limited number of human capital-intensive regions (Glaeser, et al., 2003). This implies that the experience, knowledge and competence of the labour force in a region can be again considered as a semi-durable attribute from an aggregated perspective. Furthermore, the innovation milieu of a region is also determined by agglomeration economies, such as urbanization, specialisation, and diversity (Tavassoli & Carbonara, 2014). Such place-specific economies of scale typically evolve over time through self-organized self-reinforcing processes and constitute a semi-durable attribute (Krugman, 1996).

Innovation processes in firms in different regions are in this sense also governed by durable and semi-durable regional characteristics as inputs in the knowledge production function. This implies that persistence in innovation at the firm level is a function of supply of the regional characteristics making up the regional innovation milieu. Thus, the ability of firms to be persistent innovators is dependent of their location. The reason is that innovation requires both internal knowledge investments and learning, and the acquisition of external tacit and codified knowledge as well external innovation capabilities. This is in turn because new knowledge is generated through the recombination of existing bits of knowledge in a cumulative and interactive process (Weitzman, 1998). Thus, efficient innovation is dependent upon firms' access to and ability to absorb external knowledge (Love & Roper, 2009).

To sum up, firms innovation dependent on not only internal but also external knowledge. The external knowledge comes from innovation milieu, which has particularly durable and sticky characteristics. If such characteristics stimulates innovation in one period, we can expect that they also will do it in subsequent periods, which implies the occurrence of innovation persistency for firms located in such regions.

2.2 Path-Dependence and Innovation Persistence

Variations in firm's innovation persistence based on firm's regional context is also generated by path-dependence in regional innovation processes, such that innovation activities in one period in a region are partly a response to innovation activities in previous periods. Our arguments for path-dependence in regional innovation activities are in line with two general reasons for path-dependence: institutional hysteresis and dynamic increasing returns (Martin & Sunley, 2006; Andersson & Koster, 2011). Institutional hysteresis refers to formal and informal institutions being both the products and the determinants of economic behaviour and exchanges (North, 1990). Dynamic increasing returns refer to positive feed-back mechanisms and the emergence of traded and untraded externalities (Arthur, 1994). Thus, the general argument for regionally path-dependency generating innovation persistence at the firm level is the existence of a slowly changing institutional context that is more conducive to innovation and the existence of feed-back mechanisms in innovation dynamics.

The path-dependency is also closely related to firm's response to innovation opportunities. The existence of innovation opportunities is considered as an exogenous factor but the recognition of the innovation opportunities is endogenous and depends on the characteristics, experiences and attitudes of the firm. Not all firms spot the existing innovation opportunities but innovation experience can be assumed to be important for the recognition of innovation opportunities (Tavassoli & Tsagdis, 2014). This means previous innovation experience leads to higher recognition of innovation opportunities external to the firms (coming from the region). This implies that recognition of innovation opportunity is a regionally path-dependent phenomenon, which eventually can lead to higher chance of introducing innovation again in the future, i.e. innovation persistency.

In other words, there are at least three aspects of innovation that are relevant in explaining the existence of response mechanisms in innovation dynamics and hence innovation persistency. First, the availability of innovation opportunities, which are exogenous to firms, is important, since it defines the scope for innovation in a region. Second, the recognition and grasping of innovation opportunities by firms need to be taken into account. Third, the preference for innovation by different firms influences the decision whether to turn the innovation opportunity to an innovation or not. Both the latter aspects are endogenous to each firm. Generally, the first two aspects relate to dynamic increasing returns whereas the third aspects relate to institutional hysteresis.

A high level of innovation activities in a region increases the number of innovation opportunities. When firms act upon such innovation opportunities and generate innovations, they create further opportunities for innovation. In line with Schumpeter (1934) an innovation is defined as a recombination of existing knowledge and resources. This implies that with each innovation, the number of possible new combinations increases in a non-linear fashion. The growth of the number of new combinations can be interpreted as path-dependence in the process itself. On this basis we argue, that a high frequency of innovation creates economic diversity and opportunities in the region, which leads to further innovation by innovating firms thus resulting in persistence in innovation at the firm level.

The recognition and acting upon innovation opportunities are inherently processes at the firm level. However, the regional context in which these innovation process manifests themselves is important in shaping the responses from individual firms. Therefore, regional differences can be anticipated in the assessment of innovation opportunities by firms and in the propensity of firms to actually pursue an innovation opportunity and generate an innovation. An important argument in explaining regional differences in such innovation talent is innovation learning and the role of innovator role models. Innovation talent is not innate in firms and we can expect that when more innovating firms are active in a region, firms will have greater opportunities to acquire and preserve innovation skills. Thus, the accumulation of innovation skills in a firm is partly a function of the regional environment in which they operate. A region's history of innovation activities is an important characteristic here as innovation learning depends on the regional innovation intensity. Innovator role models may also have a positive impact on the propensity of firms to innovate. Role models not only assist in developing innovation skills but they also signal that innovation is highly valued in the region. The recognition of innovation opportunities is also influenced by the availability of innovator role models (Gemünden, et al., 2007; Goepel, 2012). A wide availability of innovator role models in particular in the form of persistent innovators may generate demonstration effects that stimulate other firms not only to innovate but also to become persistent innovators.

Previous innovation activities may also reinforce and adapt existing formal and informal institutions that supports innovation in general and persistent innovation in particular, i.e. the institutional hysteresis argument. Generally, one can expect that regions that for whatever reason have high rates of innovation and innovation persistence over an extended period may develop a positive climate towards innovation involving both formal and informal institutions but also social capital and values and beliefs that support innovation.

To sum up the Section 2.1 and 2.2, our basic argument in this paper is that innovation persistence among firms are influenced not only by internal firm characteristics, as shown in previous studies, but also by the characteristics of region in which they are located. This is mainly due to (i) the slowly changing regional characteristics that shape the innovation milieu and hence innovation persistency of firms located in these milieu, i.e. sticky innovation factors and (ii) the existence of response mechanisms where innovation activities in earlier period influences innovation opportunity and innovation recognition in the current period, i.e. path-dependence[5].

In the following section, we will dig into three particular characteristics of region (or forces of agglomeration) that exerts an influence on the probability that firms over time can be persistent innovators (Moretti, 2012; Karlsson, Johansson & Stough, 2012): (i) thickness of regional labour markets, (ii) thickness of regional supply of specialised business service provider, and (iii) availability of knowledge spillover in the region.

2.3 Hypotheses

2.3.1 The thickness of regional labour markets and innovation persistence

The attribute of regional labour markets is one prominent example of a slowly changing regional characteristic, which is assumed to influence the external conditions for innovation persistence (Section 2.1). Thick and diverse labour markets – those with many employers and employees – are particularly attractive to innovative firms because they make it easier to recruit the specialized skills needed in the innovation process and to come close to an ideal match between the jobs to be filled and the competence profile of the people in the regional labour force (McGuirk & Jordan, 2012). High-skilled employees in thick labour markets tend to be more specialised than employees in thin labour markets but also more experienced, since employees in thick labour markets change jobs more often than employees in thin labour markets. The easier it is for innovative firms to recruit exactly the right kind of high-skilled and specialised labour, the lower the costs for these firms to be persistent innovators. The time to fill vacancies is also normally shorter in thick labour markets. The better matching in the labour market in regions with thick labour markets tends to make innovative firms in such labour markets more productive and more innovative that tends to result in higher profits, which makes it easier for firms to finance persistent innovation. Higher productivity makes it easier for these firms to pay higher salaries, which attracts skilled labour to stay in and move to thick labour markets (Antonelli, et al., 2013).

[5] It is worthy to note that certainly we have a classic chicken and egg problem here; since we do not know exactly if persistent innovators chose certain locations or if firms located in certain regions tend to become persistent innovators. Therefore, one can have inference only about the association between locational factors and innovation persistency, while causal inference will be difficult.

In thick labour markets, it is possible for innovative firms to locate close to other innovative firms and by clustering close to each other these firms become more productive and more creative, which will tend to stimulate innovation persistence. Such innovation clusters have a clear advantage in attracting even more high-skilled people, which increases the regional supply of such people. Firms and workers that join an innovation cluster enjoy private benefits in terms of higher productivity and creativity. However, they also generate a benefit for all innovative firms and employees in the cluster, which are made more productive and more creative by new entrants making it easier for these innovative firms to continue to be persistent innovators. This leads to our first hypothesis:

H 1: *The probability that a firm will be a persistent innovator increases if it is located in a region with a thick labour market.*

2.3.2 Specialized business service providers and innovation persistence

Another regional characteristic that only change slowly is the regional supply of specialized business services (referring to the Section 2.1). Specialized and knowledge-intensive business service providers in advertising, legal services, technical and management consulting, financial services, logistics services, etc. are particularly important to innovative firms (den Hertog, 2000; Stambach, 2001; Segarra-Blasco, 2010; Johansson & Lööf, 2015). These services enable innovative firms to focus on what they are good at, i.e. innovation, without having to worry about secondary functions. From the viewpoint of the specialized business service providers, geographical proximity to clients is crucial as well. They need to be close to actual and potential clients to assess their needs and demonstrate how they can help. This is critical for firms developing new and innovative products and not least for persistent innovators.

Specialized business service producers are one important factor that keeps innovative eco-systems together. Here there are "amplified" advantages for innovative firms due to thick specialized service markets. First of all, a region with thick specialized service tend to stimulate productivity and creativity in innovative firms and reduce the costs for them to be persistent innovators. Furthermore and over time, such thick specialized service region with many innovative firms tend to attract more specialised service producers leading to a larger and more specialised service producers and lower delivery costs, which further will enhance innovation persistence.

Among all specialized service providers in a region and an innovation eco-system, possibly the most important part is access to specialized finance and not least venture capital. A strong and diverse financial system in a region makes it easier for firms to continue to be persistent innovators, since they can more easily access to the necessary external financing of their investments in innovation. The discussion in this subsection leads us to the following hypothesis:

H 2: *The probability that a firm will be a persistent innovator increases if it is located in a region with a thick specialized service market.*

2.3.3 Knowledge spillover and innovation persistence

In this sub-section, we claim that firms located in regions offering good opportunities for knowledge spillover have a higher probability of being persistent innovators, which is in line with the path-dependence argument above (Section 2.2). This claim is built upon a simple fact: New ideas and knowledge are rarely born in a vacuum. They are created through new combinations of existing ideas and knowledge, which diffuse within circles of friends, colleagues, researchers and innovators. Earlier research shows that social and professional interactions among creative and innovative knowledge workers living and working in geographical proximity tend to generate learning opportunities that enhance creativity, innovation and productivity. Interacting with smart people tend to make us smarter, more creative and innovative and ultimately more productive and able to produce an output with a higher quality. We can say that the smarter the people, the stronger the effect. Good opportunities for knowledge flows and interactions between smart people represents a crucial advantage for innovative people and firms and increases the probability that firms will be persistent innovators.

The opportunities for knowledge flows and interactions are dependent upon location (Baptista & Swann, 1998), since knowledge is subject to a significant degree of "home bias", for example, in the sense that innovators are substantially more likely to cite other innovators living nearby than innovators living far away (Jaffe, Trajtenberg & Henderson, 1993). The magnitude of the "home bias" is substantial. Excluding intra-firm citations, citations are twice as likely to come from the inventors' place of residence as from other places. This implies that researchers and inventors tend to be more familiar with knowledge generated by those who live (and work) near them. The reason is probably that they share information, ideas and knowledge through informal and formal observations, networks and interactions (Breschi, et al., 2003). Interactions taking place both inside and outside the work place. In addition, the free and unstructured interactions generate new ideas and knowledge in mysterious and unpredictable ways. Hence, geographical space matters for the diffusion and generation of knowledge. Since it takes time for knowledge to reach places that are more distant despite mobile phones, the Internet and air travel, firms that are located in regions offering good opportunities for knowledge spillover are more likely to be persistent innovators than those firms that reside in locations with poorer options for knowledge spillover.[6]

It is obvious that innovative firms that are located close to other innovative firms have substantial advantages. Having innovative neighbours, including competitors, increases the creativity and innovativeness of firms and their employees. By being located close to each other innovative firms and their employees foster each other's creative and innovative spirit and become more successful. This implies that location is very important for innovative firms and that a location in a region and in particular an innovation eco-system offering good opportunities for knowledge spillover increase the probability that a firm will be a persistent innovator. We are now able to formulate our third hypothesis:

H 3: *The probability that a firm will be a persistent innovator increases if it is located in a region offering good opportunities for knowledge spillover.*

3. Data

The innovation related data in this study comes from five waves of the Swedish Community Innovation Survey (CIS) in 2004, 2006, 2008, 2010, and 2012. The CIS 2004 covers the period 2002-2004 and CIS 2006 covers the period 2004-2006 and so on, hence using the five ways, provide us with information about innovation activities of firms over a ten years period, i.e. from 2002 to 2012. In all five waves, there is information concerning product and process innovations as well as to innovation inputs (e.g. R&D investments). In the last three waves, there is also information concerning the marketing and organizational innovations. The survey consists of a representative sample of firms in industry and service sectors with 10 and more employees. Among them, the stratum with 10-249 employees has a stratified random sampling with optimal allocations and the stratum with 250 and more employees is fully covered. The

[6] Information and telecommunication technologies are excellent means to transmit routine information but new ideas and knowledge is normally not generated by means of mediated communication.

response rates in the five waves vary between 63% and 86%, in which the later CIS waves having higher response rates compared with the earlier ones.

We choose CIS data in order to investigate the innovation persistency (and the role of location) for fowling reason: (i) it allows to measure the innovation output of firms over consequent period of time, hence makes it possible to investigate the persistency or lack of it (ii) it allows to measure various types of innovation output, including technological (i.e. product and process) and non-technological (marketing and organizational) innovations (ii) empirical literature in innovation persistency has considerably moved away from patent data, as an intermediate measure of innovation, (Geroski et al 1997; Cefis and Orsenigo, 2001; Cefis, 2003) toward using CIS data, as a more direct measure of innovation output, (Peters, 2009; Raymond et al, 2010; Clausen et al, 2012; Ganter and Hecker, 2013; Tavassoli and Karlsson, 2015) in recent years.

There are 21,105 observations in total, after appending all five waves of CIS. Then we construct a balanced dataset consists of 2,870 observations, corresponding to 574 firms who participated in all five waves of CIS[7]. Then we merged the innovation-related data with other firm-characteristics data (e.g. export, import, ownership structure) coming from registered firm-level data maintained by Statistic Sweden (SCB). Finally, we regionalised the firm-level data with the location of each firm in order to be able to analyse the role of various regional context on firm's innovation persistency.

An empirical issue to use firm level CIS data in regional studies related to those firms that have multiple plants in various regions. The question here is to which region one should allocated the observed firm level information[8]. Of course this is a challenge when using the CIS since this survey is on the firm level and there is no perfect way to solve it. In order to deal with this as much as possible, we follow an approach in a recent paper by Wixe (2016), which also used the Swedish CIS data and dealt with the regionalisation of the data. The approach is as follows: for firms with multiple establishments, we have used only the largest one (which is almost always the main unit) and assumed that if the firm as such is innovative, so is the largest establishment. The geographic location is thus the location of the largest establishment which

[7] We also constructed an unbalanced dataset consists of 16,166 observations, corresponding to 4,958 firms participated in at least two consecutive waves (2,488 firms participated in two waves, 1,534 firms in 3 waves, and 936 firms in 4 waves). The result of using unbalanced panel is similar to balanced panel.

[8] In an ideal case, one should use the establishment/plant level data when planning to use regional variables. However, the CIS survey is conducted and provided at the firm level and not at the plant level.

is a correct and not assumed location. For the ”firm”-level variables concerning human capital these are based on only the employees working at this establishment and not all employees in the firm. Variables that are only reported at the firm level, such as physical capital, can be distributed to the establishments based on their share of employees in the firm.

The definition of all variables is reported in the Appendix 1 and descriptive statistics is presented in the Table 1. The correlation matrix is reported in the Appendix 2. There is no high correlation between explanatory variables. Moreover, the mean VIF score considering all variables is 1.98 and each variable get a VIF score of below 3.1. These evidence imply that multicollinearity is rather mild and may not bias the regression analyses results in the subsequent sections.

[Table 1 about here]

4. Empirical Strategy

4.1 Regional factors

As elaborated in literature review, we want to investigate the effect of three regional factors on the extent of innovation persistency of firms. These factors are: (i) labour market thickness, measured as total number of employees in the region minus firm’s own employment[9], (ii) service provider thickness, measured as total number of employment in Knowledge Intensive Service (KIS) sectors minus firm’s own employment if firm belongs to KIS sector[10], and (iii) the extent of knowledge spillover, captured by number of innovative firms in the region. Here an innovative firm is identified if it successfully introduced at least one out of four types of Schumpeterian innovation outputs, i.e. product, process, organizational, or marketing innovations (see Appendix 1 for their exact definitions). The main idea here is that the more innovative firms in the region, the more possibilities of knowledge spillover.

We will investigate the innovation persistency of firms over the spectrum of the above mentioned three regional factors. In order to do so, for each of the three regional factors, we split the total number of firms into three groups, based on equal quantile values of each of the regional factors (see Table 1 for the cutting points for the percentile 33% the percentile 66%).

[9] We also used the density measure for labor market thickness, as “total number of employees in the region minus firm’s own employment divided by square kilometers area of given municipality”. The main result stayed the same.

[10] We also used the density measure for service provider thickness, as “total number of employment in KIS sectors minus firm’s own employment if firm belongs to KIS sector, divided by square kilometers area of given municipality”. The main result stayed the same.

For instance, for the knowledge spillover (measured as number of innovative firms in the region), the cutting points for percentile 33% and percentile 66% is 7 and 45 respectively. This implies that any given region is categorized as "Low" knowledge spillover if the number of innovative firms in that region is less than 7, it will be categorized as "High" knowledge spillover if the number of innovative firms in that region is more than 45, and it will be categorized as "Medium" knowledge spillover if the number of innovative firms in that region is between 7 and 45 inclusively.

Categorising each regional characteristic across their Low-Medium-High spectrum, we will be able to run the innovation persistency regressions separately for these groups of firms (i.e. across the spectrum of a given regional characteristic). This in turns allows us to delineate the possible structural effect of regional factors on innovation persistency of firms. Next section will elaborate the specific estimation strategy that can model the innovation persistency pattern of firms.

4.2 Innovation Persistency

In order to investigate whether firms' innovation persistency exist or not (and if yes, to what extent across various regional regimes), as a first and common step, we used Transition Probabilities Matrix (TPM) (Antonelli et al, 2015). TPM reveals the information about the probability of transitioning from one state to another. In our case, "state" is the innovation status of firms in each period, i.e. being an innovator (*INNO*) or being a non-innovator (*NON-INNO*). In particular, let a sequence of random variables $\{Y_1, Y_2, \dots, Y_n\}$ be a Markov chain. Then the TPM is formulated as follows:

$$\boldsymbol{TPM} = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1d} \\ p_{21} & p_{22} & \cdots & p_{2d} \\ \vdots & \cdots & \cdots & \vdots \\ p_{d1} & p_{d2} & \cdots & p_{dd} \end{bmatrix} \quad (3$$

Where,

$$p_{ij} = P(Y_t = j \mid Y_{t-1} = i) \quad (4$$

Where p_{ij} measure the probability of moving from state *i* to state *j* in one period for the vector $\boldsymbol{Y}$. Finally, $\boldsymbol{Y}$ consists of several variables measuring different types of innovation, i.e. y_1 is product, y_2 is process, y_3 is organizational, and y_4 is marketing innovations[11]. In the context of innovation persistence, it is shown that persistency can exist in two forms of weak or strong (Cefis and Orsenigo, 2001; Roper and Hewitt-Dundas, 2008). First, there is a weak innovation persistency if sum of diagonal elements of the matrix ***TPM*** (p_{ij}, if $i = j$) is equal or bigger than 100% probability *but* not all elements of the diagonal of the matrix are equal to or higher than 50%. Second, there is a strong innovation persistency if sum of diagonal elements of the matrix ***TPM*** (p_{ij}, if $i = j$) is equal or bigger than 100% probability *and* all elements of the diagonal of the matrix ***TPM*** equal to or higher than 50%. In this paper, we will use several ***TPMs*** for not only the overall sample, but, more importantly, also for various regional regime subsamples, in which we expect differences in terms of innovation persistency.

4.3 True State Innovation Persistency

The problem with ***TPM*** is that it does not allow to identify the mechanism by which persistency is governed. Indeed, there are two mechanisms that can explain innovation persistency of firms. Innovation persistence may be the result of "true" state dependence and/or "spurious" state dependence (Heckman, 1981 a & b). True state dependence represents a casual behavioural relationship (a path-dependent process), where the decision to innovate in one period increases the probability to decide and to succeed to innovate in the following period. Spurious state dependence, on the other hand, prevails when the determinants of innovation persistency (e.g. size of firms) are persistent themselves, hence making firms to be more inclined to innovate in a persistent way. Here the observed innovation persistence is the result of the serial correlation in unobservable(s) that generate different innovation competencies and capabilities of firms, i.e. dynamic capabilities (Teece & Pisano, 1994) in line with the resource-based theory of firms (Penrose, 1959; Langlois & Foss, 1999). However, if these unobservable and serially correlated characteristics (e.g. risk attitudes or managerial skills) are not controlled for in the econometric estimations, they may generate the impression that innovation in one period drives innovation in the following period. Therefore, in reality what is observed would be the effect of unobservable characteristics of firms, and not the true persistence of innovation itself.

We employed a dynamic Probit model in order to investigate the determinants of persistency of firms' innovation, in line with previous similar studies (Peters, 2009; Ganter and Hecker,

[11] p_{ij} are unknown parameters in our case and they can be estimated by Maximum Likelihood. It can be shown that the estimated parameters of p_{ij} equals to $\widehat{p_{ij}} = \frac{n_{ij}}{ni}$, where n_{ij} is the number of observed transitions from state i to state j and n_i is the total number of state i.

2013; Tavassoli and Karlsson, 2015). Such model is able to analyse the conditional state dependence by controlling for observed and unobserved heterogeneity, hence allows us to distinguish between "true" state dependence from "spurious" one. The starting point is to assume that firm i invests in innovation activities in period t, if the expected present value of profits happening to the investment in $y*_{it}$ is positive. The latent variable $y*_{it}$ depends on the previous and realized innovation $y_{i,t-1}$, observable vector of explanatory variables $\boldsymbol{X}_{it}$, and unobservable time-invariant firm-specific elements τ_i. Other time-varying unobservable elements are captured in the idiosyncratic error ε_{it}. Such relation can be formulated as follows:

$$y_{it}^{*} = \gamma y_{i,t-1} + \beta \boldsymbol{X}_{it-1} + \tau_i + \varepsilon_{it}$$

If the latent $y*_{it}$ is positive then we observe that firm i introduces innovations, that is y_{it} = 1, and 0 otherwise. Furthermore, there are good reasons to believe that many firms in our sample do not start their innovation processes in the beginning of the period of this study, i.e. 2002. This means that the initial condition,y_{i0}, is presumably correlated with unobservable time-invariant firm-specific elements τ_i, leading to inconsistent estimators, known as initial condition problem. Moreover, it is possible that explanatory variables, X_{it}, are also correlated with τ_i (Ganter and Hecker, 2013; Antonelli et al, 2013). If these individual effects and the initial conditions are not properly accounted for, then the coefficient of the lagged dependent variable can be overestimated (Peters, 2009; Raymond et al, 2010). In order to accommodate such situation, Wooldridge modifies the original procedure of Heckman (1981a) by suggesting to model the distribution of $\{y_{i0}, \ldots, y_{iT}\}$ given y_{i0} and to use Conditional Maximum Likelihood (CML) estimator (Wooldridge, 2005). Applying this approach, the time-invariant firm-specific elements can be decomposed as:

$$\tau_i = \alpha_0 + \alpha_1 y_{i0} + \alpha_2 \boldsymbol{X}_i + \alpha_i \qquad (6)$$

Where $\boldsymbol{X}_i = \{\boldsymbol{X}_{i1}, \ldots, \boldsymbol{X}_{iT}\}$ is the vector of explanatory variables in each period from t=1 to t=T and α_i ~ $N(0, \sigma_a^2)$, which is assumed to be independent of y_{i0} and $\boldsymbol{X}_i$[12]. Plugging the equation (6) in the equation (5), the probability that firm i introduce an innovation in period t can be formulated as follows:

(7)

[12] A subtle point is that some of the subsequent studies employing Wooldridge estimator, such as Peters (2009), chose to use time-averages of covariates for the sake of reducing number of explanatory variables instead of using $\boldsymbol{X}_i = \{\boldsymbol{X}_{i1}, \ldots, \boldsymbol{X}_{iT}\}$. Such choice of using time-average is indeed a slight deviation from original estimator, strictly speaking. We did not introduce such deviation and instead we strictly followed the original Wooldridge estimator. Few other subsequent studies also strictly followed Wooldridge estimator (e.g. Tavassoli & Karlsson, 2015).

$$Prob(y_{it} = 1|y_{i0}, \dots, y_{i,t-1}, \boldsymbol{X}_{it-1}, \boldsymbol{X}_i, \alpha_i) = \boldsymbol{\phi}(\gamma y_{i,t-1} + \beta \boldsymbol{X}_{it-1} + \alpha_0 + \alpha_1 y_{i0} + \alpha_2 \boldsymbol{X}_i + \alpha_i)$$

Where y_{it} is a dichotomous variable getting value 1 if a firm i introduces innovation in year *t.* We operationalize introducing innovation in four ways: product, process, organizational, and marketing innovation. Hence, we have four different dependent variables. This way we distinguish between four types of innovation rooted in Schumpeter's definition. The parameter γ shows the effect of previous innovation on the probability of future innovation, i.e. persistency in innovation behavior. $\boldsymbol{\phi}$ is the standard normal cumulative distribution function and $\boldsymbol{X}_{it}$ composed of observable firm characteristics such as: size, innovation input, physical capital, human capital, import, export, and ownership structure (refer to Appendix 1 for exact definition of each variable).

Equation (7) has four different dependent variables, as noted earlier. Moreover, for each dependent variable, we will break down the overall sample of firms into three subsamples based on the three equal quantile value of a given regional factor (this means n=3 in Equation 2). For instance, for estimating the innovation persistency for product innovation, we grouped total number of firms into those who are located in a region that fall under the category of either (i) 0-33% value of labour market thickness (i.e. low-thick labour market), or (ii) 34-66 % (i.e. medium-thick labour market), or (iii) 67%-100% (i.e. high-thick labour market). Based on Hypothesis 1, we expect that the product innovation persistency for firms in the last group is significantly higher than the other two groups, especially in compare with the first group. The same procedure is done for investigating the persistency of process, organization, and marketing innovation.

5. Empirical Results

5.1 Innovation persistency with Transition Probability Matrices

As elaborated in the Section 4.2, we will use several ***TPMs*** for not only the overall sample, but, more importantly, also for various regional regime subsamples, in which we expect differences in terms of innovation persistency. Table 2 reports such ***TPMs.***

[Table 2 about here]

Table 2 has three parts. Part A is about labour market thickness, Part B is about specialized supplier thickness and Pact C is about knowledge spillover thickness. Each of these parts consists of twelve 2X2 TPM matrices, (four matrices for each innovation types). There are several findings worth of mentioning. First, there is always an indication of persistency in all cases (most of them time strong persistency but also sometimes the weak one). Second, when there is an evidence of weak persistency (e.g. in Part A, for marketing innovation in Low-thick labour market), it is never in the “high” category. This means thick regions in terms of labour market, specialized supplier service, and knowledge spillover are associated with strong persistency of innovation of firms, no matter which types of innovation is considered[13]. Third, within thick regions (the “High" columns in Part A to C) product innovation seems to show the strongest persistency behaviour among all four types of innovation. And finally, in the case of organizational innovation in Part B and C, it is interesting to observe that while in the overall sample and subsample of low and medium thickness of the focal regional regime the persistency is weak, it turns out to be a strong persistency only in the high-thickness subsample. All in all, based on the descriptive evidence of TPMs, there are initial indications for the positive association between thickness of regional regimes (i.e. labour market, supplier, and knowledge spillover) and innovation persistency of firms.

5.2 True Innovation persistency with Dynamic Probit Models

Tables 3 to 5 report the estimation results of dynamic Probit models in order to investigate the effect of regional factors on possible true state dependency in persistency of various types of innovations. Table 3 incorporates labour market thickness, Table 4 incorporates specialized service providers’ thickness, and Table 5 investigates the effect of knowledge spillover thickness in the region. Each table investigates the persistency on four types of innovation by incorporating the structural effect of regional factors on such persistency patterns.

[Table 3 about here]

Table 3 incorporates the effect of labour market thickness on persistency pattern of innovation. Models (1) to (3) shows the extent of persistency in product innovation for firms located in regions with labour markets thickness being low, medium, and high, respectively. Models (4) to (6) shows the extent of persistency in process innovation for firms located in regions with labour markets thickness being low, medium, and high, respectively. Similarly, models (7) to (9) shows the persistency pattern for organizational innovation, and finally models (10) to (12)

[13] However, one needs to bear in mind that TPM does not allow to delineate “true” state dependency and the findings in TPM might come from spurious state dependency. We can only be confident about true state dependency when we run a proper estimation technique in the subsequent section f this paper.

for marketing innovations. In all models, we controlled for an extensive set of firm-level characteristics as well as initial conditions.

The Table 3 shows that only those firms located in highly thick labour markets are persistent process as well as organizational innovators (significantly different than zero). As for persistency in product innovation, those firms located in both highly thick and lowly thick labour market regions are persistent innovators significantly different than zero. Furthermore, being in highly thick labour market shows higher significance level and higher estimated coefficient magnitude in compare with being in lowly thick labour market. Having said that, here we cannot rule out the counterargument in this stage (we will come back to this point later in this section when we present marginal effect). Marketing innovation is the type of innovation that labour market thickness does not matter for enhancing persistency pattern (except a weak significance for medium level market thickness, which can be neglected). Previous studies indeed show that marketing innovators are not persistent innovators anyway, mainly because these firms do not want to confuse their customers by persistently changing their marketing activities (such as packaging and pricing strategy) while the main product is the same (Tavassoli and Karlsson, 2015). Our result shows that incorporating the labour market thickness does not change that picture.

[Table 4 about here]

Table 4 incorporates the effect of knowledge intensive business service suppliers' thickness on persistency pattern of innovation. Models (1') to (3') shows the extent of persistency in product innovation for firms located in regions with knowledge intensive business service suppliers thickness being low, medium, and high, respectively. Models (4') to (6') shows the extent of persistency in process innovation for firms located in regions with knowledge intensive business service suppliers' thickness being low, medium, and high, respectively. Similarly, models (7') to (9') show the persistency pattern for organizational innovation and finally models (10') to (12') for marketing innovations.

The Table 4 shows that only those firms located in regions with highly thick business service suppliers are persistent organizational innovators (significantly different than zero). As for persistency in product innovation, similar to the Table 3, those firms located in regions with both highly thick and lowly thick business service suppliers are persistent innovators (significantly different than zero). Furthermore, being in regions with low business service suppliers thickness shows slightly higher significance level and higher estimated coefficient magnitude in compare with being in highly thick ones. Having said that, here we cannot rule out the counterargument in this stage (we will come back to this point later in this section when we present marginal effect). A for persistency in process and marketing innovations, there is not evidence that specific regional regime has any significant influence on making firm persistent innovators.

Table 5 incorporates the effect of intraregional knowledge spillover thickness on persistency pattern of innovation. In the same fashion as Tables 3 and 4, here models (1'') to (3'') shows the extent of persistency in product innovation for firms located in regions with the extent of knowledge spillover being low, medium, and high, respectively. Models (4'') to (6'') shows the extent of persistency in process innovation for firms located in regions with the extent of knowledge spillover being low, medium, and high, respectively. Similarly, models (7'') to (9'') show the persistency pattern for organizational innovation and finally models (10'') to (12'') for marketing innovations.

[Table 5 about here]

The Table 5 shows that only those firms located in regions with medium and high thickness of knowledge spillover are persistent process innovators (significantly different than zero). As for persistency in product innovation, firms located in all types of regional regimes show persistent behaviour (significantly different than zero). Furthermore, those firms in regions with medium and high thickness of knowledge spillover shows higher significance level and higher estimated coefficient magnitude in compare with those firms in regions with low knowledge spillover thickness (highly thick regime is outperforming the other two regimes). Having said that, here again we cannot rule out the counterargument in this stage (we will come back to this point later in this section when we present marginal effect). As for persistency in non-technological innovations (i.e. organizational and marketing), there is no evidence that highly thick regions are associated with higher innovation persistency.

In order to properly investigate our hypotheses, i.e. if there is systematic difference in innovation persistency of firms located in different regional regimes, we need to compare the marginal effect of the estimated coefficients in the Tables 3 to 5[14]. Figures 1 (parts A, B, C)

[14] Another option for comparing coefficient could have been performing the Seemingly Unrelated Estimation (-suest- command in STATA) and then a subsequent Wald test. However, this procedure is only applicable with the conventional OLS and unfortunately, it is not compatible with the random effect dynamic panel model

illustrates such marginal effects, as margin plots, which is calculated based on Average Marginal Effect (AME) of the estimated coefficients from the Table 3 to 5 respectively.

[Figure 1 about here]

Figure 1, Part A shows that firms located in regions with high labour market thickness are more persistent in introducing all types of innovations in compare with those firms located in regions with low labour market thickness. In the case of process and marketing innovations, there is a clear upward trend in marginal effect of persistency across regional regimes. In the case of product and organizational innovations, even though there is a drop from low to medium thickness regimes, comparing low with high thickness regimes indicates again an upward trend. in compare with less thick labour markets. To be more specific, first, the persistency in engaging in product innovation is increased by 7 Percentage Points (PP) when moving from Low (23%) to High (30%) labour market thickness. Second, the persistency in process innovation is also increased by 7 PP when moving from Low (9%) to High (16%) labour market thickness. Third, the persistency in organizational innovation is also increased by 5 PP when moving from Low (13%) to High (18%) labour market thickness. And fourth, the persistency in marketing innovation is increased by 12 PP when moving from Low (0%) to High (12%) labour market thickness. However, considering the lack of significance of coefficients for marketing innovation persistency in the Table 3, we will not consider such 12% increase in marginal effect of marketing innovation seriously. Nevertheless, by considering both estimated coefficients in the Table 3 as well comparing the magnitude of marginal effect across low to high labour market thickness in Figure 1 Part A, we can conclude that our hypothesis 1 is confirmed to a large extent, i.e. four out of three innovation types show higher persistency among firms located in thicker labour market regions.

Figure 1, Part B does not show that firms located in regions with high specialized supplier thickness are more persistent in introducing innovations in compare with those firms located in regions with low specialized supplier thickness. The magnitudes of marginal effect across low to high thickness regimes stayed more or less the same. This means even though specialized suppler matters for innovation persistency (at least in product innovation) according

---

(Wooldridge estimator), which is critical to use for the purpose of this paper. Nevertheless, we believe using marginal effect should suffice for serving the purpose of this paper, particularly because in our case the dependent (innovation) and independent variable (lagged innovation) are "the same" across compared regression models.

to significance of this variable in the Table 4, the *degree* of thickness does not matter. This implies that we are not able to confirm our hypothesis 2.

Figure 1, Part C shows that firms located in regions with high knowledge spillover thickness are more persistent in introducing all types of innovations (except organizational innovations) in compare with those firms located in regions with low knowledge spillover thickness. In the case of product, process and marketing innovations, there is a clear upward trend in marginal effect of persistency across regional regimes, while there is a slightly downward trend in the case of organizational innovation. To be more specific, first, the persistency in engaging in product innovation is increased by 14 Percentage Points (PP) when moving from Low (19%) to High (33%) knowledge spillover thickness. Second, the persistency in process innovation is increased by 10 PP when moving from Low (9%) to High (19%) knowledge spillover thickness. Third, the persistency in organizational innovation is slightly reduced increased by 4 PP when moving from Low (19%) to High (15%) knowledge spillover thickness. And fourth, the persistency in marketing innovation is increased by 3 PP when moving from Low (7%) to High (10%) knowledge spillover thickness. However, considering the lack of significance of coefficients for organizational and marketing innovation persistency in the Table 5, we will not consider marginal effects of these two types of innovation seriously. Nevertheless, by considering both estimated coefficients in the Table 5 as well comparing the magnitude of marginal effect across low to high labour market thickness in Figure 1 Part C, we can conclude that our hypothesis 3 is confirmed to a large extent, i.e. technological innovations (product and process) show higher persistency among firms located in thicker labour market regions.

6. Conclusions

This paper is one of its first kind to analyse the effect of location on innovation persistency among firms. Theoretically, we argue that innovation persistency of firms can be (at least partly) explained by regional context, due to slowly changing regional characteristics and also path-dependency. Empirically, we used five waves of the Community Innovation Survey in Sweden, which allowed us to traced the innovation behaviour of firms over a ten-year period, i.e. between 2002 and 2012. We determined how various characteristics of the regions where the firms are located can affect their innovation persistency. In analysing the persistency in innovation, we distinguished between four Schumpeterian types of innovation: product, process, organizational and market innovation. As for the regional characteristics, we investigated the effect of labour market thickness, thickness of knowledge-intensive specialized suppliers and the intra-regional knowledge spillover thickness.

Using a transition probability matrix and dynamic Probit models, we find that, in general, regional factors do matter for higher persistency of firm in various types of innovation. In particular, our results indicate that: (i) firms located in regions with a high labour market thickness have a higher probability (up to 7 Percentage Point) of being persistent product, process and organizational innovators, (ii) although the existence of knowledge-intensive service suppliers matters for innovation persistency, the thickness of such regional factor does not seem to matter, and (iii) firms located in regions with a higher knowledge spillover thickness have a higher probability (up to 14 Percentage Point) of being persistent technological innovators (product and process), (iv) persistent market innovators *cannot* be found in any regimes of regions. This is in line with the general findings of the literature that market innovators are not innovating persistently anyway (Tavassoli and Karlsson, 2015), and (v) the above finding concerning the positive association between thickness of regional characteristics and higher innovation persistency of firms is particularly pronounced for product innovators.

Our results indicate that policy-makers at the regional level can affect the extent of innovation persistence, and that regional policies can complement traditional innovation policies. In particular, results hint that innovation persistence might be influenced by the following regional policies: (i) investments in transport infrastructure that facilitates commuting and increasing the thickness of labour markets, and (ii) policies that stimulate the clustering of innovative firms, hence increasing the possibilities of knowledge spillover between such firms.

More research on these issues is needed. First, in this paper, we have assumed that being in a thick labour market or in close proximity to knowledge sources are “enough” for gaining from spillover. Recent advancement, however, suggest that localization can be also explained by social connections rather than pure externalities (Breschi and Lissoni, 2009). Future studies may incorporate such social interaction more explicitly in the empirical investigation. Second, firms do not only perform simple innovation, i.e. product, process, organizational *or* market innovation. Often firms perform two, three or four types of innovation simultaneously (Karlsson and Tavassoli, 2016) and as far as we know, there is a lack of studies to analyse the persistence in such complex types of innovation, let alone investigating the role of regional factors on persistence of complex type of innovation. For instance, a related hypothesis to be tested is that firms that are persistence in more complex types of innovation are more dependent upon the characteristics of the regions where they are located.

References

Andersson, M. & Koster, S. (2011), Sources of persistence in regional start-up rates—evidence from Sweden. *Journal of Economic Geography*, 11 (1): 179-201

Antonelli, C. (2008), *Localized technological Change: Towards the Economics of Complexity*, Routledge, London

Antonelli, C. (2011) (Ed.), *Handbook on Economic Complexity of Technological Change*, Edward Elgar, Cheltenham

Antonelli, C., F. Crespi & G. Scellato (2013), Internal and External Factors in Innovation Persistence, *Economics of Innovation and New Technology 22*, 256-280

Antonelli, C., R. Marchionatti & S. Usai (2003), Productivity and External Knowledge: The Italian Case, *Rivista Internazionale di Scienze Economiche e Commerciali 50*, 69-90

Antonelli, C. & G. Scellato (2013), Complexity and Technological Change: Knowledge Interactions and Firm Level Total Factor Productivity, *Journal of Evolutionary Economics 23*, 77-96

Antonelli, C., Crespi, F., & Scellato, G. (2015). Productivity growth persistence: firm strategies, size and system properties. *Small Business Economics*, *45*(1), 129-147.

Arthur, W.B. (1994), *Increasing Returns and Path Dependence in the Economy*, University of Michigan Press, Ann Arbor

Baptista, R. & G.M.P. Swann (1999), The Dynamics of Firm Growth and Entry in Industrial Clusters: A Comparison of the US and UK Computer Industries, *Journal of Evolutionary Economics 9*, 373-399

Baum, C. F., Lööf, H., Nabavi, P., & Stephan, A. (2017). A new approach to estimation of the R&D–innovation–productivity relationship. *Economics of Innovation and New Technology*, *26*(1-2), 121-133.

Beaudry, C. & G.M.P. Swann (2009), Firm Growth in Industrial Clusters of United Kingdom, *Small Business Economics 32*, 409-424

Beckmann, M.J. (1994), On Knowledge Networks in Science: Collabouration among Equals, *Annals of Regional Science 28*, 233-242

Boschma, R.A. (2005), Proximity and Innovation: A Critical Assessment, *Regional Studies 39*, 61-74

Clausen, T., Pohjola, M., Sapprasert, K., & Verspagen, B. (2012). Innovation strategies as a source of persistent innovation. Industrial and Corporate Change, 21 (3), 553-585.

Cohen, W.M. & S. Klepper (1996), Firm Size and the Nature of Innovation within Industries: The Case of Process and Product R&D, *The Review of Economics and Statistics 78*, 232-243

Colombelli, A. & N. von Tunzelmann (2011), The Persistence of Innovation and Path Dependence, in Antonelli, C. (Ed.), *Handbook on the Economic Complexity of Technological Change*, Edward Elgar, Cheltenham, 105-119

Czarnitzki, D. & H. Hottenrott (2010), Financial Constraints for Industrial Innovation: What Do We Know?. Faculty of Business and Economics, K.U. Leuven

David, P.A. (1993), Knowledge Property and the Dynamics of Technological Change, in *Proceedings of the World Bank Annual Conference on Development Economics*, The World Bank, Washington, D.C.

David, P.A. (2007), Path Dependence: A Foundational Concept for Historical Social Science, *Cliometrica: Journal of Historical Economics and Econometric History 1*, 91-114

Duguet, E. & S. Monjon (2002), Creative Destruction and the Innovative Core: Is Innovation Persistent at the Firm Lelvel?, Discussion Paper 02-07, Department of Economics, University College of London

Fagerberg, J., D. Mowery & R.R. Nelson (2005) (Eds.), *The Oxford Handbook of Innovation*, Oxford University Press, Oxford

Feldman, M. P., & Tavassoli, S. M. (2015). Something new: where do New Industries come from?, *The Oxford Handbook of Local Competitiveness*, 125-140.

Fritsch, M. & G. Franke (2004), Innovation, Regional Knowledge Spillover and R&D Cooperation, *Research Policy 33*, 245-255

Ganter, A. & A. Hecker (2013), Deciphering Antecedents of Organizational Innovation, *Journal of Business 66*, 575-584

Gemünden, H.G., S. Salomo & H. Hölzle (2007), Role Models for Radical Innovations in Times of Open Innovation, *Creativity and Innovation Management 16*, 408-421

Geroski, P., J. Van Reenen & C.F. Walters (1997), How Persistently Do Firms Innovate?, *Research Policy 26*, 33-48

Glaeser, E.L., J. Koloko & A. Saiz (2003), Consumer City, *Journal of Economic Geography 1*, 27-50

Goepel, M., K. Hölzle & D. zu Knyphausen-Aufseβ (2012), Individuals' Innovation Response Behaviour: A Framework of Antecedents and Opportunities for Future Research, *Creativity and Innovation Management 21*, 412-426

Griliches, Z. (1979), Issues in Assessing the Contribution of Research and Development to Productivity Growth, *Bell Journal of Economics 10*, 92-11den Hertog, P. (2000), Knowledge-Intensive Business Services as Co-Producers of Innovation, *International Journal of Innovation Management 4*, 491-528

Hannan, M.T. & J. Freeman (1984), Structural Inertia and Organizational Change, *American Sociological Review 49*, 149-164

Jaffe, Trajtenberg & Henderson (1993),

Johansson, B. & C. Karlsson (2001), Geographic Transaction Costs and Specialization Opportunities of Small and Medium-Sized Regions, in Johansson, B., C. Karlsson & R.R. Stough (Eds.), *Theories of Endogenous Regional Growth. Lessons for Regional Policies*, Springer, Heidelberg, 150-180

Johansson, B. & C. Karlsson (2009), Knowledge and Regional Development, in Capello, R. & P. Nijkamp (Eds.), *Handbook of Regional Growth and Development Theories*, Edward Elgar, Cheltenham, 239-255

Johansson, B. & H. Lööf (2015), Innovation Strategies Combining Internal and External Knowledge, In Antonelli, C. & A. Link (Eds.) *Handbook of the Economics of Knowledge*, Routledge, London, 29–52

Karlsson, C., B. Johansson & R.R. Stough (2012) (Eds.), *The Regional Economics of Knowledge and Talent. Local Advantage in a Global Context*, Edward Elgar, Cheltenham

Karlsson, C., & Tavassoli, S. (2016). Innovation strategies of firms: What strategies and why?. The Journal of Technology Transfer, 41(6), 1483-1506.

Krugman, P. (1991), *Geography and Trade*, The MIT Press, Cambridge, MA

Langlois, L.N. & N.J. Foss (1999), Capabilities and Governance: The Rebirth of Production in the Theory of Organization, *Kyklos 52*, 201-218

Le Bas, C. & G. Scellato (2014), Firm Innovation Persistence: A Fresh Look at the Frameworks of Analysis, *Economics of Innovation and New Technology 23*, 423-446

Love, J.H. & S. Roper (2009), Organizing the Innovation Process: Complementarities in Innovation Networking, *Industry and Innovation 16*, 273-290

Martin, R. & P. Sunley (2006), Path Dependence and Regional Economic Evolution, *Journal of Economic Geography 6*, 395-437

Máñez, J.A., et al., (2009), The Role of Sunk Costs in the Decision to Invest in R&D, *Journal of Industrial Economics 57*, 712-735

McGuirk, H. & D. Jordan (2012), Local Labour Market Diversity and Business Innovation: Evidence from Irish Manufacturing Businesses, *European Planning Studies 20*, 1945-1960

Moretti, E. (2012), *The New Geography of Jobs*, Houghton Mifflin Harcourt Publishing Company, New York

Nelson, R.R. (1959), The Simple Economics of Basic Scientific Research, *Journal of Political Economy 67*, 297-306

Nelson, R.R. & S.G. Winter (1982), *An Evolutionary Theory of Economic Change*, The Belknap Press, Cambridge, MA

Phillips, A. (1971), *Technology and Market Structure: A Study of the Aircraft Industry*, Heath Lexington Books, Toronto

Polanyi, M. (1966), *The Tacit Dimension*, Routledge, Kegan & Paul, London

Romer, P. (1990), Endogenous Technological Change, *Journal of Political Economy 98*, 71-102

Ruttan, V.W. (1997), Induced Innovation, Evolutionary Theory and Path Dependence: Sources of Technological Change, *The Economic Journal 107*, 1520-1529

Scellato, G. & E. Ughetto (2010), The Basel II Reform and Provision of Finance for R&D Activities, *International Small Business Journal 28*, 65-89

Segarra-Blasco, A. (2010), Innovation and Productivity in Manufacturing and Service Firms in Catalonia: A Regional Approach, *Economics of Innovation and New Technology 19*, 233-258

Strambach, S. (2001), Innovation processes and the role of knowledge-intensive business services, In: Koschatzky, K., M. Kulicke & A. Zenker, A. (Eds.), *Innovation Networks —Concepts and Challenges in the European Perspective*, Physica, Heidelberg, 53–68.

Tavassoli, S. (2014). *Determinants and effects of innovation: Context matters,* Doctoral dissertation at Blekinge Tekniska Högskola, Karlskrona, Sweden

Tavassoli, S., & Carbonara, N. (2014). The role of knowledge variety and intensity for regional innovation. *Small Business Economics*, 43(2), 493-509.

Tavassoli, S., & Tsagdis, D. (2014). Critical success factors and cluster evolution: a case study of the Linköping ICT cluster lifecycle. *Environment and Planning A*, 46(6), 1425-1444.

Tavassoli, S. & C. Karlsson (2015), Persistence of Various Types of Innovation Analyzed and Explained, *Research Policy 44*, 1887-1901

Tavassoli, S., & Karlsson, C. (2016). Innovation strategies and firm performance: Simple or complex strategies?. *Economics of Innovation and New Technology*, 25(7), 631-650.

Teece, D.J. (1981), The Market for Know-How and the Efficient International Transfer of Technology, *Annals of the American Association of Political and Social Sciences 458*, 54-67

Torre, A. & A. Rallet (2005), Proximity and Localization, *Regional Studies 39*, 47-59

Verspagen, B. & T.H. Clausen (2012), The Dynamics of Innovation Strategies, in Andersson, M., et al. (Eds.), *Innovation and Growth*, Oxford University Press, Oxford, 38-56

von Hippel, E. (1994), Sticky Information and the Locus of Problem Solving: Implications for Innovation, *Management Science 40*, 429-439

von Tunzelmann, G. & Q. Wang (2003), An Evolutionary View of Dynamic Capabilities, *Economie Appliquée 16*, 33-64

Weitzman, M.L. (1998), Recombinant Growth, *Quarterly Journal of Economics 113*, 331-360

Wixe, S. (2016). Neighbourhood related diversity, human capital and firm innovation. *Papers in Regional Science*, DOI: 10.1111/pirs.12255

Table 1-Descriptive statistics

VARIABLES	Observ.	Mean	Std. Dev.	Min	Max	P.cut#1	P.cut#2
$PROD_{it}$	2870	0.38	N/A	0	1	-	-
$PROC_{it}$	2870	0.39	N/A	0	1	-	-
ORG_{it}	1722	0.35	N/A	0	1	-	-
MAR_{it}	1722	0.34	N/A	0	1	-	-
$SIZE_{it}$	2870	4.26	1.35	0	9.41	-	-
$INN.INP_{it}$	2866	6.58	5.99	0	21.11	-	-
$IMPORT_{it}$	2866	0.10	0.15	0	1	-	-
$EXPORT_{it}$	2866	0.22	0.31	0	1	-	-
$HUM.CAP_{it}$	2294	0.13	0.16	0	0.89	-	-
$PHY.CAP_{it}$	2866	13.71	4.70	0	23.01	-	-
$UNIN_{i}$	2870	0.31	N/A	0	1	-	-
$D.MNE_{i}$	2870	0.26	N/A	0	1	-	-
$F.MNE_{i}$	2870	0.29	N/A	0	1	-	-
$LABORMARKET_{it}$	2870	27076	34020	10	88336	2097	36403
$SUPPLIER_{it}$	2870	3230	4121	0,00	12304	23	4106
$NR\ INNOVATIVE_{it}$	2870	30.60	30.00	0	88	7	45

Note 1: P.cut#1 is the cutting point for the percentile 33% and P.cut#2 is the cutting point for the percentile 66%
Note 2: For binary variables, standard errors are not reported (N/A), as it does not have practical relevance.

Table 2-Transition Probability Matrices (TPMs) in various regional regimes

A. Labour Market Thickness

Innovation Types		All regions		Low		Medium		High	
		NON-INNO	INNO	NON-INNO	INNO	NON-INNO	INNO	NON-INNO	INNO
PRODUCT	NON-INNO	84	16	81	19	86	14	87	13
	INNO	30	70	32	68	31	69	27	73
PROCESS	NON-INNO	75	25	75	25	77	23	75	25
	INNO	44	56	42	58	48	52	44	56
ORGANIZATIONAL	NON-INNO	77	23	80	20	80	20	74	26
	INNO	53	47	56	44	53	47	48	52
MARKETING	NON-INNO	71	29	72	28	72	29	71	29
	INNO	50	50	53	47	55	45	47	53

B. Specialized Supplier Thickness

Innovation Types		All regions		Low		Medium		High	
		NON-INNO	INNO	NON-INNO	INNO	NON-INNO	INNO	NON-INNO	INNO
PRODUCT	NON-INNO	84	16	85	15	81	19	86	14
	INNO	30	70	31	69	33	67	26	74
PROCESS	NON-INNO	75	25	78	22	75	25	74	26
	INNO	44	56	45	55	46	54	42	58
ORGANIZATIONAL	NON-INNO	77	23	77	23	76	24	72	28
	INNO	53	47	53	47	56	44	48	52
MARKETING	NON-INNO	71	29	74	26	69	31	71	29
	INNO	50	50	52	48	56	44	42	58

C. Knowledge Spillover

Innovation Types		All regions		Low		Medium		High	
		NON-INNO	INNO	NON-INNO	INNO	NON-INNO	INNO	NON-INNO	INNO
PRODUCT	NON-INNO	84	16	83	17	84	16	87	13
	INNO	30	70	31	69	30	70	27	73
PROCESS	NON-INNO	75	25	74	26	76	24	74	26
	INNO	44	56	47	53	47	53	41	59
ORGANIZATIONAL	NON-INNO	77	23	83	17	78	22	71	29
	INNO	53	47	52	48	60	40	50	50
MARKETING	NON-INNO	71	29	74	26	70	30	67	33
	INNO	50	50	59	41	50	50	45	55

Note: Each of the three tables above consists of twelve 2X2 ***TPM*** matrices (four matrices for each innovation types). The table reports the estimated parameters of Transition Probabilities Matrices ($\widehat{p_{ij}} = \frac{n_{ij}}{ni}$) in terms of percentage (%). n_{ij} is the number of observed transitions from state i to state j and ni is the total number of state i. Innovations status are the "state", which can be NON-INNO: Non-Innovative or INNO: Innovative. t=2004, 2006, 2008, 2010, 2012. All figures in the above TPMs are in percentages.

Table 3- The effect of Low, Medium, and High regional labour market thickness on persistency of various types of innovation

	$PROD_{it}$			$PROC_{it}$			ORG_{it}			MAR_{it}		
Variables	(1) Low	(2) Medium	(3) High	(4) Low	(5) Medium	(6) High	(7) Low	(8) Medium	(9) High	(10) Low	(11) Medium	(12) High
$PROD_{it-1}$	0.503**	0.282	0.639***									
	(0.218)	(0.229)	(0.228)									
$PROD_{i0}$	0.532**	1.191***	0.648***									
	(0.207)	(0.296)	(0.244)									
$PROC_{it-1}$				-0.047	0.278	0.357**						
				(0.198)	(0.176)	(0.156)						
$PROC_{i0}$				0.672***	0.170	0.117						
				(0.187)	(0.146)	(0.134)						
ORG_{it-1}							0.304	0.037	0.437**			
							(0.301)	(0.338)	(0.179)			
ORG_{i0}							-0.153	0.192	0.025			
							(0.243)	(0.304)	(0.184)			
MAR_{it-1}										-0.021	0.458*	0.253
										(0.359)	(0.189)	(0.190)
MAR_{i0}										0.538*	-0.103	0.089
										(0.324)	(0.192)	(0.192)
$SIZE_{it-1}$	-0.071	0.126	0.265**	0.211	-0.035	0.031	0.162	0.224*	0.070	0.129	-0.112	0.096
	(0.145)	(0.151)	(0.108)	(0.142)	(0.103)	(0.081)	(0.148)	(0.132)	(0.091)	(0.150)	(0.106)	(0.081)
$INN.INP_{it-1}$	0.042*	0.012	0.044**	0.023	0.065***	0.055***	0.022	0.054**	0.032*	0.041*	0.036*	0.031*
	(0.022)	(0.023)	(0.021)	(0.021)	(0.020)	(0.016)	(0.022)	(0.025)	(0.018)	(0.022)	(0.020)	(0.017)
$IMPORT_{it-1}$	-0.354	-0.430	-0.513	-0.186	-1.419*	-0.417	-0.956	-0.274	0.018	0.001	0.018	-0.098
	(0.892)	(0.982)	(0.846)	(0.944)	(0.764)	(0.702)	(0.933)	(0.899)	(0.599)	(0.803)	(0.750)	(0.592)
$EXPORT_{it-1}$	0.260	1.334**	1.612***	-0.030	0.071	0.071	-0.261	0.238	0.213	0.441	-0.025	0.727*
	(0.443)	(0.571)	(0.550)	(0.440)	(0.403)	(0.379)	(0.441)	(0.524)	(0.387)	(0.430)	(0.410)	(0.394)
$PH.CAP_{it-1}$	0.044	0.061	-0.026	0.060	0.094***	0.042	0.024	0.007	0.053	0.010	0.074*	0.015
	(0.055)	(0.051)	(0.037)	(0.061)	(0.035)	(0.028)	(0.061)	(0.048)	(0.033)	(0.063)	(0.045)	(0.025)
$HUM.CAP_{it-1}$	0.205	1.858**	1.771***	0.198	0.745	0.320	2.616**	0.233	0.186	-0.384	0.767	-0.485
	(0.971)	(0.745)	(0.538)	(0.919)	(0.462)	(0.365)	(1.018)	(0.765)	(0.482)	(1.026)	(0.580)	(0.464)
UNIN	-0.188	-0.399	-0.237	-0.297	0.053	-0.172	-0.001	0.367	-0.182	0.108	0.197	-0.034
	(0.219)	(0.285)	(0.275)	(0.217)	(0.185)	(0.224)	(0.270)	(0.338)	(0.293)	(0.289)	(0.251)	(0.285)
D.MNE	-0.082	-0.308	-0.463	-0.313	-0.038	-0.207	0.206	-0.096	-0.350	-0.250	-0.061	-0.182
	(0.240)	(0.309)	(0.295)	(0.246)	(0.207)	(0.235)	(0.301)	(0.370)	(0.318)	(0.315)	(0.276)	(0.305)
F.MNE	-0.014	-0.497	-0.444	-0.423	-0.277	-0.265	-0.242	-0.370	-0.465	-0.197	-0.337	-0.452

	(0.256)	(0.330)	(0.306)	(0.264)	(0.218)	(0.240)	(0.325)	(0.408)	(0.318)	(0.339)	(0.294)	(0.306)
Nr. of firms	200	244	211	211	255	211	208	214	201	210	218	201
Observation	717	718	768	752	753	768	400	367	356	404	374	357

Notes: The table reports the estimated parameters with standard errors in the parentheses. ***,** and * indicate significance on a 1%, 5% and 10% level. For each innovation type, the total sample is broken down into firms located in low, medium, and high labour market thickness. These three categories are obtained by means of three equal percentiles value of total regional employment in all regions as follows. Low: if total regional employment<2097, Medium: if total regional employment>=2097 & total regional employment<=36403, High: if total regional employment>36403. The estimation approach follows Wooldridge (2005). All models include sets of sector and time dummies as well as $\boldsymbol{x}_i$, which correspond to each of the explanatory variables in each period from t=2006 to t=2012. They are not shown in the table for the sake of brevity. Estimations are based on Gauss–Hermite quadrature approximations using twelve quadrature points. The accuracy of the results has been checked by applying eight, fourteen and sixteen quadrature points.

Table 4- The effect of Low, Medium, and High regional service provider thickness on persistency of various types of innovation

	$PROD_{it}$			$PROC_{it}$			ORG_{it}			MAR_{it}		
Variables	(1') Low	(2') Medium	(3') High	(4') Low	(5') Medium	(6') High	(7') Low	(8') Medium	(9') High	(10') Low	(11') Medium	(12') High
$PROD_{it-1}$	0.781***	0.098*	0.750***									
	(0.218)	(0.234)	(0.229)									
$PROD_{i0}$	0.283	1.282***	0.630***									
	(0.208)	(0.302)	(0.217)									
$PROC_{it-1}$				0.007	0.316*	0.182						
				(0.199)	(0.183)	(0.165)						
$PROC_{i0}$				0.618***	0.294*	0.113						
				(0.183)	(0.152)	(0.135)						
ORG_{it-1}							0.609*	0.008	0.388**			
							(0.333)	(0.385)	(0.168)			
ORG_{i0}							-0.275	0.184	-0.053			
							(0.291)	(0.306)	(0.174)			
MAR_{it-1}										0.392*	0.267	0.203
										(0.198)	(0.195)	(0.175)
MAR_{i0}										0.111	-0.106	0.298*
										(0.208)	(0.196)	(0.180)
$SIZE_{it-1}$	-0.016	0.074	0.370***	0.139	0.107	-0.016	0.299	0.194	0.042	0.143	-0.195*	0.108
	(0.145)	(0.128)	(0.127)	(0.136)	(0.084)	(0.104)	(0.186)	(0.127)	(0.086)	(0.139)	(0.116)	(0.077)
$INN.INP_{it-1}$	0.038*	0.010	0.085***	0.040**	0.031*	0.089***	-0.005	0.052**	0.050***	0.049**	0.016	0.037**
	(0.021)	(0.021)	(0.028)	(0.020)	(0.017)	(0.022)	(0.025)	(0.025)	(0.017)	(0.021)	(0.021)	(0.016)
$IMPORT_{it-1}$	-0.119	-0.658	0.998	0.711	-1.468**	0.357	-0.079	-1.125	0.124	-0.270	-0.110	0.069
	(0.959)	(0.797)	(1.204)	(0.932)	(0.637)	(1.011)	(1.123)	(0.951)	(0.527)	(0.864)	(0.767)	(0.529)
$EXPORT_{it-1}$	0.373	1.457***	1.598**	-0.204	0.375	-0.536	-0.616	0.422	0.023	0.213	0.422	0.482
	(0.450)	(0.505)	(0.719)	(0.422)	(0.346)	(0.506)	(0.557)	(0.480)	(0.344)	(0.429)	(0.416)	(0.346)
$PH.CAP_{it-1}$	0.037	0.049	-0.080*	0.069	0.054*	0.051	0.061	-0.015	0.062*	-0.031	0.111**	0.017
	(0.063)	(0.044)	(0.045)	(0.059)	(0.029)	(0.037)	(0.082)	(0.043)	(0.033)	(0.066)	(0.048)	(0.025)
$HUM.CAP_{it-1}$	-0.447	2.277***	1.689***	0.328	0.621	0.348	0.625	-0.031	0.192	-1.176	0.640	-0.399
	(0.878)	(0.779)	(0.511)	(0.791)	(0.454)	(0.398)	(1.091)	(0.741)	(0.456)	(0.924)	(0.628)	(0.448)
UNIN	-0.577***	-0.017	-0.097	-0.357*	0.189	-0.264	-0.147	0.364	-0.229	-0.142	0.349	0.090
	(0.214)	(0.287)	(0.292)	(0.193)	(0.178)	(0.251)	(0.315)	(0.295)	(0.299)	(0.238)	(0.252)	(0.292)
D.MNE	-0.272	-0.204	-0.194	-0.405*	-0.109	-0.254	0.369	-0.331	-0.490	-0.272	0.045	-0.125
	(0.235)	(0.305)	(0.302)	(0.235)	(0.195)	(0.262)	(0.381)	(0.317)	(0.315)	(0.293)	(0.271)	(0.306)
F.MNE	-0.440*	0.123	-0.367	-0.482*	-0.322	-0.335	-0.318	-0.505	-0.495	-0.485	0.046	-0.466

	(0.260)	(0.318)	(0.318)	(0.252)	(0.210)	(0.265)	(0.406)	(0.353)	(0.313)	(0.321)	(0.289)	(0.306)
Nr. of firms	202	269	244	214	275	247	175	198	240	181	198	240
Observation	687	771	752	735	793	760	349	347	431	361	347	432

Notes: The table reports the estimated parameters with standard errors in the parentheses. ***,** and * indicate significance on a 1%, 5% and 10% level. For each innovation type, the total sample is broken down into firms located in low, medium, and high employment in Knowledge Intensive Services (KIS) sectors as a proxy for regional service suppliers. These three categories are obtained by means of three equal percentiles value of KIS employment in all regions as follows. Low: if KIS regional employment<23, Medium: if KIS regional employment>=23 & KIS regional employment<=4106, High: if KIS regional employment>4106. The estimation approach follows Wooldridge (2005). All models include sets of sector and time dummies as well as $\boldsymbol{x}_i$, which correspond to each of the explanatory variables in each period from t=2006 to t=2012. They are not shown in the table for the sake of brevity. Estimations are based on Gauss–Hermite quadrature approximations using twelve quadrature points. The accuracy of the results has been checked by applying eight, fourteen and sixteen quadrature points.

Table 5- The effect of Low, Medium, and High regional knowledge spillover on persistency of various types of innovation

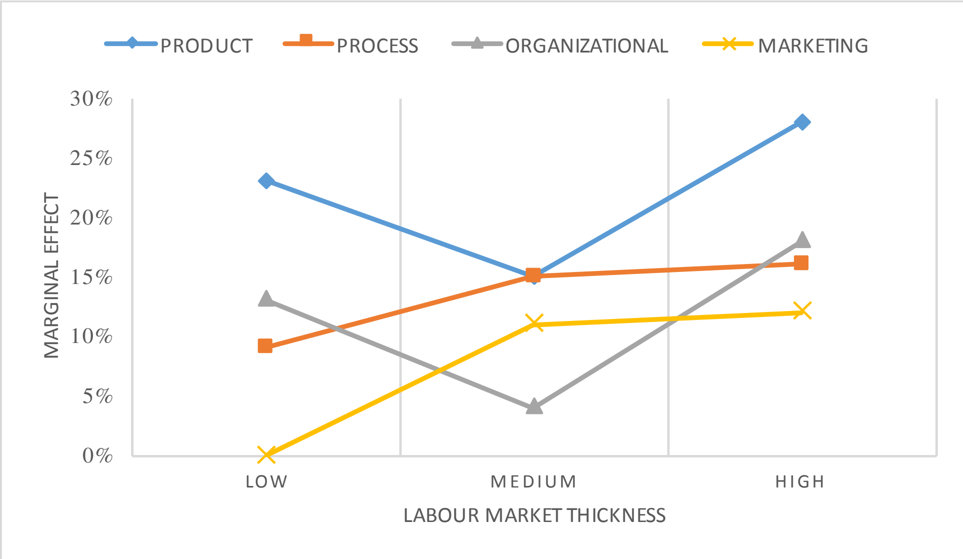
Variables	$PROD_{it}$			$PROC_{it}$			ORG_{it}			MAR_{it}		
	(1'') Low	(2'') Medium	(3'') High	(4'') Low	(5'') Medium	(6'') High	(7'') Low	(8'') Medium	(9'') High	(10'') Low	(11'') Medium	(12'') High
$PROD_{it-1}$	0.441**	0.671***	0.882***									
	(0.203)	(0.197)	(0.251)									
$PROD_{i0}$	0.538***	0.637***	0.568**									
	(0.184)	(0.202)	(0.236)									
$PROC_{it-1}$				0.066	0.394**	0.391**						
				(0.185)	(0.159)	(0.171)						
$PROC_{i0}$				0.574***	0.161	0.162						
				(0.165)	(0.128)	(0.135)						
ORG_{it-1}							0.553*	0.249	0.339*			
							(0.235)	(0.342)	(0.175)			
ORG_{i0}							-0.122	0.063	-0.082			
							(0.210)	(0.308)	(0.181)			
MAR_{it-1}										0.285*	0.315	0.247
										(0.172)	(0.206)	(0.188)
MAR_{i0}										0.111	0.005	0.204
										(0.177)	(0.212)	(0.190)
$SIZE_{it-1}$	-0.144	0.148	0.373***	0.187	0.077	-0.030	0.032	0.314**	0.058	0.018	-0.110	0.094
	(0.132)	(0.108)	(0.126)	(0.128)	(0.081)	(0.099)	(0.136)	(0.137)	(0.087)	(0.117)	(0.121)	(0.079)
$INN.INP_{it-1}$	0.025	0.016	0.082***	0.041**	0.032**	0.076***	0.018	0.038	0.038**	0.046**	0.033	0.023
	(0.020)	(0.018)	(0.028)	(0.019)	(0.015)	(0.022)	(0.020)	(0.023)	(0.018)	(0.019)	(0.021)	(0.017)
$IMPORT_{it-1}$	-0.464	-0.545	1.038	-0.488	-1.026*	0.217	-0.369	-0.689	0.027	0.249	-0.543	0.057
	(0.861)	(0.695)	(1.224)	(0.899)	(0.597)	(0.973)	(0.873)	(0.797)	(0.595)	(0.748)	(0.725)	(0.594)
$EXPORT_{it-1}$	0.679	0.824*	1.658**	-0.091	0.396	-0.415	-0.108	0.011	0.241	0.249	-0.149	0.918**
	(0.419)	(0.422)	(0.713)	(0.392)	(0.341)	(0.481)	(0.418)	(0.472)	(0.389)	(0.370)	(0.422)	(0.404)
$PH.CAP_{it-1}$	0.046	0.032	-0.076*	0.063	0.054**	0.051	0.098	-0.017	0.051	0.033	0.096**	0.017
	(0.052)	(0.035)	(0.046)	(0.057)	(0.027)	(0.035)	(0.069)	(0.044)	(0.033)	(0.055)	(0.049)	(0.025)
$HUM.CAP_{it-1}$	0.846	1.644***	1.481***	0.390	0.634*	0.147	2.223**	0.130	0.259	-0.615	0.778	-0.425
	(0.906)	(0.529)	(0.495)	(0.803)	(0.381)	(0.379)	(0.947)	(0.673)	(0.460)	(0.862)	(0.602)	(0.452)
UNIN	-0.063	-0.430**	0.109	-0.147	-0.057	-0.199	0.269	-0.046	-0.193	-0.016	0.104	0.218
	(0.209)	(0.203)	(0.298)	(0.193)	(0.154)	(0.251)	(0.278)	(0.274)	(0.312)	(0.231)	(0.238)	(0.305)
D.MNE	0.242	-0.536**	-0.149	-0.223	-0.271	-0.098	0.259	-0.483	-0.375	-0.112	-0.162	-0.017
	(0.230)	(0.227)	(0.306)	(0.221)	(0.176)	(0.257)	(0.299)	(0.322)	(0.329)	(0.267)	(0.269)	(0.320)
F.MNE	0.165	-0.382	-0.301	-0.443*	-0.398**	-0.207	-0.276	-0.507	-0.465	-0.404	-0.055	-0.328

	(0.248)	(0.236)	(0.318)	(0.241)	(0.189)	(0.258)	(0.334)	(0.351)	(0.329)	(0.293)	(0.286)	(0.321)
Nr. of firms	220	324	203	234	336	205	220	214	197	227	214	198
Observation	665	895	651	703	932	657	373	358	393	385	358	395

Notes: The table reports the estimated parameters with standard errors in the parentheses. ***,** and * indicate significance on a 1%, 5% and 10% level. For each innovation type, the total sample is broken down to firms located in low, medium, and high number of innovative firms in the region (*NR INNOVATIVE*) as a proxy for knowledge spillover. These three categories are obtained by means of three equal percentile values of *NR INNOVATIVE* in all regions as follows. Low: if *NR INNOVATIVE* <7, Medium: if *NR INNOVATIVE* >=7& *NR INNOVATIVE* <= 45, High: if *NR INNOVATIVE* > 45. The estimation approach follows Wooldridge (2005). All models include sets of sector and time dummies as well as $\boldsymbol{x}_i$, which correspond to each of the explanatory variables in each period from t=2006 to t=2012. They are not shown in the table for the sake of brevity. Estimations are based on Gauss–Hermite quadrature approximations using twelve quadrature points. The accuracy of the results has been checked by applying eight, fourteen and sixteen quadrature points.

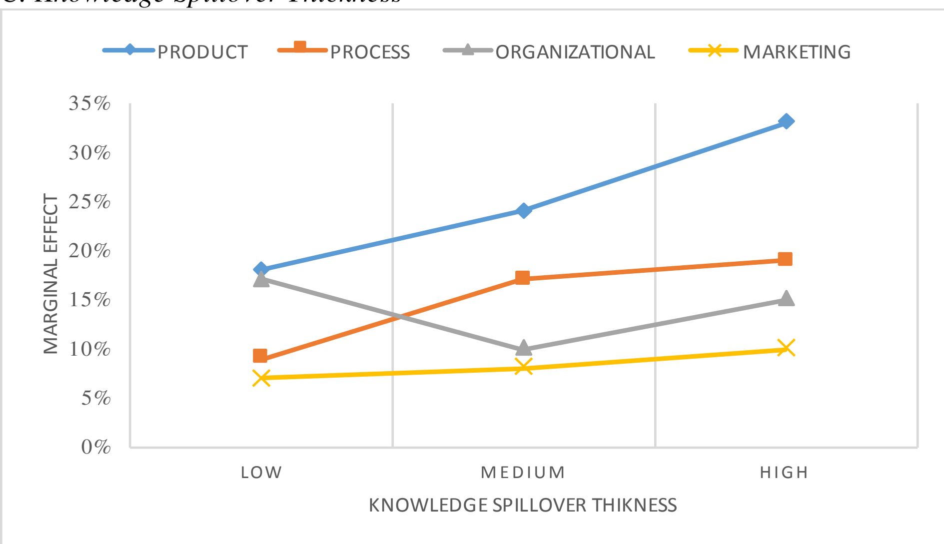
Figure 1-Marginal effect of innovation persistency across various regional context

A. Labour Market Thickness



B. Specialized Supplier Thickness

C. Knowledge Spillover Thickness



Appendix 1-Variable definitions

Variables	**Type**	**Definitions**
$PROD_{it}$	0/1	1 if firm *i* introduces a product innovation into the market in year *t,* 0 otherwise. A product innovation is the market introduction of a new or significantly improved good or service with respect to its capabilities, user friendliness, components or sub-systems. Product innovations (new or improved) must be new to the enterprise, but they do not need to be new to the market.
$PROC_{it}$	0/1	1 if firm *i* introduces a process innovation in year *t,* 0 otherwise. A process innovation is the implementation of a new or significantly improved production process, distribution method, or support activity for goods or services, such as maintenance systems or operations for purchasing, accounting, or computing (exclude purely organizational innovation). Process innovations must be new to the enterprise, but they do not need to be new to your market.
ORG_{it}	0/1	1 if firm *i* introduces an organizational innovation in year *t,* 0 otherwise. An organizational innovation is a new organizational method in the enterprise's business practices (including knowledge management), workplace organization and decision making, or external relations that has not been previously used by the enterprise. It must be the result of strategic decisions taken by management. It exclude mergers or acquisitions, even if for the first time.
MAR_{it}	0/1	1 if firm *i* introduces a marketing innovation in year *t,* 0 otherwise. A marketing innovation is the implementation of a new marketing concept or strategy that differs significantly from the enterprise's existing marketing methods and which has not been used before. It requires significant changes in product design or packaging, product placement, product promotion or pricing. It exclude seasonal, regular and other routine changes in marketing methods.
$INN.INP_{it}$	C*	Innovation inputs is the sum of following six expenditures in firm *i* year *t* (log): engagement in intramural R&D, engagement in extramural R&D, engagement in acquisition of machinery, engagement in other external knowledge, engagement in training of employees, and engagement in market introduction of innovation
$SIZE_{it}$	C	Number of employees in firm *i* year *t* (log)
$IMPORT_{it}$	C	The share of import per total sales for firm *i* in year *t* (value in SEK) (log)
$EXPORT_{it}$	C	The share of export per total sales for firm *i* in year *t* (value in SEK) (log)
$UNIN_{i}$	0/1	1 if firm *i* belongs to a group and is uninational, 0 otherwise (Non-affiliated as based)
$D.MNE_{i}$	0/1	1 if firm *i* belongs to group and is a domestic multinational enterprise, 0 otherwise
$F.MNE_{i}$	0/1	1 if firm belongs to group and is a foreign multinational enterprise, 0 otherwise
$PH.CAP_{it}$	C	Sum of investments in Buildings and Machines at year's end for firm *i* in year *t* (log)
$HUM.CAP_{it}$	C	Share of employees with 3 or more years of university educations in firm *i* in year *t*
$LABPORMAR_{ir}$	C	The total number of employees in functional region r in year t minus firm i's employment (log)
$SUPPLIER_{ir}$	C	The number of employees in KIS** sector in functional region r in year t minus firm i's employment, if firm I is in KIS sector itself (log)
$NR\ INNOVATIVE_{ir}$	C	The number of innovative firms in functional region r in year t minus firm i, if firm i is innovative itself (log). An innovative firm is identified if it introduces any of the four Schumpeterian innovation outputs (product, process, organizational, and marketing innovation) in year t.
Time Dummies	0/1	Time-specific component captured by five time dummies
Sector Dummies	0/1	Sector-specific component captured by forty two sector dummies

*C corresponds to continuous variables, **KIS: Knowledge Intensive Services, which corresponds to following NACE codes: 61-62 (Water transport; air transport), 64 (Post and telecommunication), 65-67 (Financial intermediation), 70 (Real estate activities), 71 (Renting of machinery and equipment), 72 (Computer and related activities), 73 (Research and development), 74 (Other business activities), 80 (Education), 85 (Health and social work), 92 (Recreational, cultural and sporting activities).

Appendix 2-Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) PROD	1												
(2) PROC	0.365	1											
(3) ORG	0.276	0.365	1										
(4) MAR	0.298	0.307	0.317	1									
(5) SIZE	0.337	0.330	0.299	0.211	1								
(6) INN.INP	0.558	0.502	0.308	0.279	0.305	1							
(7) IMPORT	0.233	0.037	0.051	-0.013	0.167	0.227	1						
(8) EXPORT	0.352	0.106	0.104	0.049	0.257	0.399	0.479	1					
(9) HUM.CAP	0.091	0.027	0.101	0.022	0.003	0.221	0.014	0.078	1				
(10) PHY.CAP	0.103	0.040	0.057	-0.010	0.094	0.368	0.255	0.373	0.088	1			
(11) UNI.N	-0.220	-0.091	-0.090	-0.033	-0.376	-0.135	-0.268	-0.333	-0.002	0.047	1		
(12) D.MNE	0.135	0.107	0.160	0.091	0.199	0.148	0.139	0.194	0.060	0.014	-0.408	1	
(13) F.MNE	0.189	0.074	0.047	0.019	0.382	0.092	0.203	0.254	-0.006	-0.066	-0.446	-0.383	1