Innovation strategy choices in the urban economy

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Abstract

This paper analyzes how the innovation strategies of individual firms reflect the density, diversity and international connectivity of their urban locations. It makes three contributions. Theoretically, it argues that observed strategies reflect a series of inter-related choices, and that each may be influenced differently by the knowledge dynamics of firms' locations. Empirically, it uses Norwegian Community Innovation Survey data to demonstrate how firms in the Capital are less inclined to engage in innovation activities, but also more likely to commit strongly once engaged, than are comparable firms located elsewhere. Methodologically, it illustrates how the results of sequential regressions on inter-related strategy choices differ from those obtained using a more conventional estimation strategy. Implications for innovation policy and research are drawn.

Keywords: Urbanization, innovation, collaboration, knowledge dynamics, Norway.

JEL: R11, O31, O33

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Introduction

A number of empirical contributions have investigated whether locations differentiate firms in terms of innovativeness in general (Doloreux and Shearmur, 2012; Shearmur, 2012; Lee and Rodríguez-Pose, 2013), and network linkages in particular (Solesvik and Gulbrandsen, 2014; Fitjar and Rodríguez-Pose, 2013; Teirlinck and Spithoven, 2008). Some of these studies have found positive associations between the density of related economic activity in an area, and patterns of collaboration (Bennett, Robson, & Bratton, 2001). Others claim that associations between locations and behavior or output are far from apparent (Doloreux et al., 2008; Doloreux and Shearmur, 2012; Shearmur, 2012). Some have even found that firms located outside high-density agglomerations are more committed to innovation, more network-oriented in their innovation processes (Fritsch, 2003; Tödtling and Trippl, 2005; Teirlinck and Spithoven, 2008; Suarez-Villa and Walrod, 1997), and better connected to non-local markets than are their urban counterparts (O'Farrell et al., 1996). From this ambiguity, it is evident that the context-dependency of innovation practices remains to be understood (Huizingh, 2011).

As growing proportions of societies' human resources are drawn towards large-city regions, it becomes more important for policy to account for the behavioral incentives and constraints that such locations represent. The following approaches this from the perspective of three conceptual and methodological issues that are critical to the question at hand. First, prior studies have largely ignored the layers of inter-related decisions that lies between influences from locations, and observable innovation output at the level of the firm: Prior to output lies a set of innovation strategy choices, including what networks to establish, and prior to networking choices lies the decision to engage or not in innovation (e.g. Herstad et al., 2014).

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Because these decisions may be influenced differently by the same external conditions, research attention specifically to strategy choices is warranted.

Second, the tendency of research to focus on the 'average' firm response is clearly at odds with the defining characteristics of urban locations; that is, local diversity of knowledge supply and market demand combined with intra-urban differentiation into business districts with their own micro-ecologies (e.g. Kloosterman and Lambregts, 2001). Thus, methodological approaches are needed that allow firms to respond differently to the same local resource conditions (Herstad and Ebersberger, 2014) , without assuming that all urban locations are the same (Lee and Rodríguez-Pose, 2013). Third, while some firms thrive on the vibrant labor markets and rich information 'buzz' of large cities (Storper and Venables, 2004), others may depend more on stable external environments to support cumulative organizational learning (Doloreux and Shearmur, 2012). As this causes an uneven regional distributions of firms in terms of sectors, age and size, the sensitivity of findings to what control variables that are implemented warrants attention.

Following prior research in focusing specifically on the geography of innovation collaboration (e.g. Fitjar and Rodríguez-Pose, 2013), this paper starts out by identifying the hierarchy of inter-related innovation strategy choices that leads to a certain network configuration being observed. The empirical analysis is based on Community Innovation Survey data from Norway. It uses probit regressions to analyse choices sequentially, and compares the results with those obtained using a conventional, non-sequential approach. The concluding discussion reflects on implications for future scholarly work, and for innovation policy.

Locations and innovation strategy choice

The labor markets, business networks and information ecologies of territorial economies provide firms with access to resources that reflect prevalent industrial and institutional

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conditions (e.g. Coenen et al., 2016). ‘Localisation economies’, a term drawn from the work of Alfred Marshall (Marshall, 1920), describe the benefits of locating in regions that are specialised in certain industries. These include privileged access to intra-industry information flows, common supplier infrastructures and pools of labour with competences and work practices adapted to the operational needs of the industry in question.

The contrasting concept of ‘urbanization economies’ reflect the work of Jane Jacobs (1969) on the benefits of diversity and density . Recently, it has been suggested that advantages such as better infrastructures and broader local markets should be distinguished from the ‘urban knowledge dynamics’ (Shearmur, 2012) that arises from cross-fertilization between firms that engage in different businesses but concentrate within a geographically confined area. Essential to these dynamics is high inter-firm mobility in local labour markets that also serve as points of gravitation in domestic and international mobility flows (Aslesen et al., 2008; Almeida and Kogut, 1999). Vibrant labour markets allow collocated firms to tap into each other’s knowledge bases and networks (Agrawal et al., 2006; Dokko and Rosenkopf, 2010; Dokko et al., 2009), and draw inspiration from different organizational practices and routines (Madsen et al., 2003).

On the one hand, this may strengthen the capacity of firms to successfully execute innovation projects. On the other, it may reduce their propensity to engage in such work. This is due to the real option of allowing ‘learning-by-hiring’ and other forms of imitation to substitute for own development efforts (Glaeser, 2000; Herstad and Ebersberger, 2014). In the literature on policy (e.g. Coenen et al., 2016), this is referred to as the problem of ‘market failures’ that arise because the common good characteristics of knowledge causes firms to under-invest in developing it. From the perspective of individuals, urban locations offer a wide range of employment opportunities. This may weaken the commitment to people to specific workplaces. As a result, firms may experience problems in retaining employees that further

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reduces their willingness to engage in innovation, because this is to a large extent an investment in human capital (Combes and Duranton, 2006; Arrow, 1962).

Firms outside large-city regions, by contrast, may experience that their development work is constrained by thinner local labour markets, and less diverse, if not also weaker, local markets and partner bases. However, they may also be more inclined to engage in such work at the outset because they need to 'internalize' the benefits that are external to firms in more dense and diverse regions (e.g. O'Farrell et al., 1996). This means that whether or not firms actively engage in innovation is a first and fundamental aspect of how they respond to the characteristics of their locations:

Decision #1: To engage in innovation activities, or stay passive.

Following the literature on innovation systems (e.g. Lundvall et al., 2002; Asheim and Isaksen, 2002), interactions between firms, sectors and institutions are important to the dynamics of territorial economies. The mirroring policy concern is that of 'system failures', which include 'network failures' stemming either from weak linkages between actors or from lock-in to established network configurations (e.g. Coenen et al., 2016). The firm-level parallel to this is the choice of whether to implement different open innovation practices (e.g. Ebersberger et al., 2012). Among these, collaborative ties are of particular interest because they reflect strategic choices made to 'open up' organizational knowledge bases to other firms and institutions. This exposes firms to partner opportunism and increases the risk of uncontrolled knowledge leakages (Ritala et al., 2015). Moreover, the benefits that accrue to each partner is contingent on their respective capacities to understand, assimilate and transform what is communicated. This need for 'absorptive capacity' (Cohen and Levinthal, 1990) translate into a risk of communication problems and asymmetric benefits that become apparent only as the work progresses (e.g. Lane and Lubatkin, 1998).

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Thus, collaboration for innovation is a selective activity in which firms can be expected to engage only when estimated costs and perceived uncertainties are outweighed by expected benefits, and alternatives for accessing external knowledge are not available. As illustrated by the notion of ‘fragmented urban regions’ (Tödtling and Trippl, 2005), firms may be particularly reluctant to engage if located in urban agglomerations where the risk of knowledge leakages is high and the option of ‘learning-by-recruiting’ is real (Herstad and Ebersberger, 2014). The second decision that must be considered is therefore:

Decision #2: To contain innovation activities within the boundaries of the firm, or involve external partners

The geography of network linkages *inherently* mirrors contextual influences, and determines the role of individual firms in the formation of innovation networks that operate at various spatial scales (e.g. Graf, 2010). Thus, geography warrants special attention. One the one hand, nearby partners are easier to identify, evaluate and monitor than those outside the local environment, and are often easier to trust (Laursen et al., 2012a). Proximity may also be associated with similarity of organizational structures and routines, which increases absorptive capacity (Lane and Lubatkin, 1998), and allow continuous experimentation, adaption and adjustments through frequent face-to-face contact. On the other, collaboration is increasingly viewed as an activity that allow firms to tap distant knowledge pools (Herstad et al., 2014). As relationships with foreign partners evolve and firms learn about their business contexts, trust and *familiarity* may compensate for the disadvantages of geographical distance (Boschma, 2005).

The potential for accessing valuable new insights and knowledge is higher the larger the number of different business contexts that firms’ networks cover (Meyer et al., 2011). However, adding partners in new business contexts exponentially increases network

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complexity (Owen-Smith and Powell, 2004). Consequently, firms face a choice of whether to establish geographically narrow collaboration networks, i.e. networks that either benefit from proximity (to local partners) or familiarity (with specific business context abroad), or broader networks that include partners in multiple business contexts and combine a higher potential for learning with higher uncertainty and demands on the organization:

Decision #3: To collaborate only in a limited number of (well-known) business contexts, or establish geographically dispersed collaboration network ties

On the one hand, the diversity of potential partner firms and institutions available around urban region firms translate into locational advantages, which should increase their propensity to collaborate locally and reduce the need to engage in collaboration abroad. If this the case, firms in urban regions should be more inclined to choose a geographically narrow collaboration strategy over engaging with partners in multiple business contexts. Conversely, in order to overcome disadvantages in terms of local resource endowments, firms in peripheral regions can be expected to establish network linkages that are broader in geographical terms.

However, it is increasingly acknowledged that success in establishing extra-regional ties reflect *local* resources and incentives in its support (Ebersberger et al., 2014), in particular during the initial stages when weak existing network linkages and lack of prior experiences form barriers to broader engagement (Johanson and Vahlne, 2009). Due to the position of urban regions as points of gravitation in international networks and mobility flows, they may, through spill-over effects, provide local firms with privileged access to information about opportunities abroad (Fernhaber et al., 2008; Herstad and Ebersberger, 2015). For instance, the labour markets of large-city regions may allow firms to recruit managers and employees with prior work-life experiences and interpersonal networks that serve in support of

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internationalisation (Deprey, 2011). These are locational advantages that accrue to urban firms, the absence of which in peripheral regions cannot be compensated by means of internalization or the implementation of more innovative strategies.

Thus, while influences on each decision may be strong, those exerted by urban economy knowledge dynamics on the decision to engage in innovation must be clearly distinguished from those exerted on the collaboration and network configuration choices of innovation-active firms. In the following, the Norwegian case is used to explore these issues.

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The Norwegian urban system

Norway is a small, open economy specialised in offshore oil & gas extraction, weapons & ammunition, fisheries and advanced maritime equipment. A classification of functional housing and labour market regions is available (Gundersen and Jukvam, 2013), which is based on commuting patterns. It can be used to delineate business locations that belong to the four large-city labour market regions from those that do not. Reflecting the 'polycentrism' (e.g. Kloosterman and Lambregts, 2001) of the Capital that stem from the distinctiveness of different business districts within it (Isaksen, 2004), a distinction is further made between the Central Capital City (CAPITAL C), the Western business district that extends into neighbouring counties (CAPITAL W) and the outer dwelling municipalities (CAPITAL O) that combined constitute the Capital labour market region.

The Capital dominates the landscape of research, higher education and employment (Onsager et al., 2010; Aslesen et al., 2008). In 2010, it accounted for 27.5 per cent of Norwegian employment; compared to only 8 per cent, 7 per cent and 5 per cent in the other major cities of Bergen, Stavanger and Trondheim (cf. Table 1). Moreover, it houses the largest and most diverse Norwegian university, in addition to university colleges, business schools and research institutes. It has been estimated to represent one third of all Norwegian R&D personnel and account for over 40 per cent of industry expenditures on research, development and innovation (Foyn et al., 2011).

The polycentric nature of the Capital is evident form the location quotients displayed in Table 1, which have been computed on the basis of official business register data for 2010. The Western business district is characterised by over-representation of employment in the offshore oil & gas sector, and in industries such as high-tech manufacturing, ICTs and scientific and technical services. In the inner City itself, offshore oil & gas employment and

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manufacturing employment is under-represented and the specialisation in ICTs, scientific and technical services is less strong. This underscores the unique position of the Western Capital business district in the Norwegian industrial and technological landscape (Isaksen and Onsager, 2010; Isaksen, 2004).

Table 1 approximately here

The second, third and fourth largest cities are different from the Capital in terms of share size, and in terms of industry composition. Generally, business services are less over-represented, and the role of Stavanger as operational stronghold for the Norwegian offshore oil and gas industry is evident from strong location quotient. Local over-representation of employment also in the medium high-tech and medium low-tech manufacturing and technical services industries must be understood against this background, as these sectors supply the oil & gas industry with equipment, technology and support services.

The smaller large-city labour market region of Trondheim exhibit particularly strong employment performance in high-tech manufacturing, scientific and technical services, and in public administration and teaching; reflecting that it hosts the dominant technical university and one of Europe's largest institutes of applied industrial research. These two institutions have evolved in dense interaction with incumbent industries, creating the main Norwegian stronghold for engineering education, and for R&D conducted by research institutions on behalf of industry (Strand and Leydesdorff, 2013). As a result, a substantial proportion of public R&D and innovation funding is allocated to this region (Wendt and Solberg, 2013).

Manufacturing employment is generally over-represented outside the large-city labour market regions. This is consistent with the notion that industrial activities characterized by a particularly strong dependence on complex and cumulative knowledge development thrive in

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locations wherein they are sheltered from the disturbances of vibrant labour markets and overall urban economy information ‘buzz’ (Suarez-Villa and Walrod, 1997; Shearmur, 2012), whereas firms that are more dependent on innovation by means of ‘trial and error’ based on external resources thrive in large-city regions (Shearmur, 2015; Duranton and Puga, 2001).

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Data, variables and methodological approach

Data

The empirical analysis is based on Norwegian micro-data from the Seventh Community Innovation Survey (CIS2010), collected by Statistics Norway in 2010 as an extended version of the harmonized European survey (Eurostat, 2010). The questionnaire is based on the definitions of innovation input, behaviour and output laid out in the third edition of OECDs Oslo Manual (OECD, 2005), and covers the three-year reference period 2008-2010. In contrast to many other European countries, participation in the CIS2010 was compulsory for sampled Norwegian firms. This resulted in a comparatively large dataset, which is not plagued by a non-response bias. Data were thoroughly reviewed and validated by Statistics Norway prior to release for research purposes. Previous national waves of the Community Innovation Survey have been used for analysis in economics (e.g. Cassiman and Veuglers, 2002; Czarnitzki et al., 2007), in management studies (e.g. Laursen and Salter, 2006; Sofka and Grimpe, 2010) and in economic geography (e.g. Laursen et al., 2011; Ebersberger and Herstad, 2012).

The CIS2010 data provided by Statistics Norway are supplied with identifiers that allow supplementary information on each sampled enterprise to be drawn from publicly maintained registers covering all business enterprises and individuals above the age of 16.

Locations

The CIS states the municipality in which the sampled enterprises are registered. Based on this, observations can be assigned to either one of the six large-city labour market regions presented in the descriptive section above, or to the reference group consisting of all other labour market regions. As all 161 labour market regions are ranked by degrees of centrality relative to the Capital (Centrality 5) and the three non-capital urban agglomerations

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(Centrality 4), the reference category consisting of labour market regions ranked at the three lowest levels is referred to as CENTRALITY 1-3 (cf. Gundersen and Jukvam, 2013).

CIS is sampled at the enterprise level, and enterprises can consist of several establishments. This means that they do not necessarily conduct their businesses in the regions where they are registered. Of particular concern herein is the risk that enterprises registered in urban regions conduct most of their activities elsewhere. Using information from the business register, enterprises have therefore been reassigned to the regions in which the largest proportions of their employment occurs. This procedure relocated approximately 8 per cent of the CIS2010 sample, predominantly by moving large enterprises officially registered in the Capital region into the CENTRALITY 1-3 reference group.

Dependent variables

The dependent variable ACTIVE takes on the value 1 if the firm was engaged innovation activities during the period 2008-2010; i.e. reported positive innovation expenditures (R&D or non-R&D), on-going or abandoned innovation projects, the successful launch of a new or significantly improved product (goods or services) onto the market, or the implementation of improved production processes or support functions (cf. Herstad and Ebersberger, 2015; Herstad et al., 2014).

The variable COLLAB assumes that ACTIVE = 1. It takes on the value 1 if the firm reported innovation collaboration as defined strictly in the CIS questionnaire to include only *"active participation with other enterprises or institutions on innovation activities"* (underscores added). Thus, business partnerships more generally are excluded, as is pure contractual sourcing of technology and R&D services. Last, the variable COLLAB_BROAD assumes that COLLAB =1, and thus ACTIVE = 1. It takes on the value 1 if the firm reported innovation collaboration in two or more of the world regions specified in the CIS questionnaire[i].

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Control variables

The size of the firm is known to positively influence the innovation activity decision (Herstad et al., 2015). Therefore, the log of firm size in 2010 is included (SIZE). Similarly, the age of the firm may negatively influence the initial innovation activity decision (ibid), yet also, due to network positioning effects associated with age, positively influence the collaborative ties of firms that are engaged. The log of firm age is therefore included (AGE). Moreover, when enterprises are controlled by larger enterprise groups through equity ownership, this may influence their innovation activities (Cantwell and Mudambi, 2005). The binary control variable GROUP is provided by Statistics Norway, and used to capture these effects.

Market presences determine potential market size, and the diversity of market information to which the firm is exposed. Therefore, it may influence innovation activities (e.g. Crepon et al., 1998). MARBREADTH captures the number of geographical levels specified in the CIS questionnaire on which the firm states it is present[ii].

Since different industrial sectors are characterized by different incentives to engage in innovation activities and collaborate at various spatial scales, controls for sector are included. The first (agriculture, fisheries and forestry) and three last (public administration, health, culture & sports) sectors given in Table 1 are not sampled by the CIS. Consequently, differences in innovation activity and collaboration propensities among the remaining 15 sectors that are covered by the survey are in the estimations captured by 14 sector dummies.

Employment registers contains information on the educational backgrounds of all individuals above age 16, summarized on a scale that span from 1 (compulsory schooling) to 8 (researcher education, e.g. PhD). Based on this, the average education level of firms' staff can be computed. The variable HR_ENDOW is used as a proxy for human resource endowments under the assumption that education reflect learning abilities and conditions

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career paths, and thus correlate with experience-based knowledge brought into the firm by employees from their prior places of employment (cf. Nelson and Phelps, 1966).

Estimation strategy

Probit regressions are used to analyze the inter-related decisions in three steps, based on which average marginal effects , i.e. percentage-point changes compared to the reference, are computed and reported instead of coefficient estimates (Hoetker, 2007). Reflecting the explorative objectives of the analysis, the collaboration variables are also estimated using a more conventional non-sequential approach and the results are then compared. Post-estimation Wald Chi2 tests are used to for two purposes: 1) to evaluate the significance of differences between the estimates for different urban locations; 2) to evaluate whether estimates for different locations are jointly significant from the reference.

In the first regression stage, ACTIVE = 1 is estimated for all firms. In the second stage, COLLAB = 1 is estimated only for the sub-sample of firms that have engaged in innovation activity, and then for all firms. In the third stage, COLLAB_BROAD is estimated only for the sub-sample of firms that have decided to engage in innovation collaboration (and therefore also in innovation activity), and again for all firms.

Control variables are added step-wise. Following journal standards, estimates are only reported as statistically significant at the 5 per cent level or stronger.

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Results

Model 1, reported in Table 2, estimates the probability of innovation activity. In the baseline Model 1A, no control variables are included, and a significantly positive marginal effect estimate is obtained for CAPITAL W. Supplementary Wald's tests reveal that the positive estimates for CAPITAL W and CAPITAL C are jointly significant (Chi2 = 8.99**) compared to the reference. This means that these two business districts consists of firms that are more inclined to engage in innovation, than are firms located in the reference category. The estimate for CAPITAL W is significantly different from those obtained for the other (non-capital) urban locations, except TRONDHEIM. Tested jointly, the positive estimates for TRONDHEIM and BERGEN are insignificant, meaning that the probabilities to engage are comparable to that of firms in the reference.

Table 2 approximately here

The signs of the marginal effect estimates changes as controls are entered, and a negative estimate is obtained in Model 1B for the offshore oil & gas stronghold of STAVANGER. During the period considered, growth impulses from high energy prices may have extended beyond the Oil & Gas sector as narrowly defined in the business register (cf. Table 1) and captured by the sector control, to include supplier industries and allow local firms more generally to relax their innovation efforts. When entered in Model 1C, a strong, positive estimate for HR_ENDOW is obtained, and the estimates for the three capital region locations become negative and jointly significant (Chi2 = 17.93***). Moreover, the estimates for CAPITAL C and CAPITAL W are both individually different from the estimate for TRONDHEIM (Chi2 = 8.29*** and Chi2 = 4.74**, respectively). Consequently, while human resources play an important role in triggering innovation activity, firms in the Capital

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exhibit a lower propensity to engage than would be expected from their endowments of such resources.

Table 3 approximately here

Model 2 (Table 3) estimates the probability that firms engage in innovation collaboration. Following the sequential decision structure, regressions are first estimated only for active firms (Models 2A – 2C) and the results compared to those obtained when all firms are included (Model 2D). Reflecting the position of this region as a point of convergence in industrial R&D networks, firms in TRONDHEIM exhibit a higher collaboration propensity than firms in the reference, and the estimate is significantly different also from the negative estimates obtained for the other urban agglomerations. When tested jointly, the latter are *insignificant* compared to the reference. Thus, active firms in urban regions are generally no more or less inclined to collaborate, than are active firms elsewhere; but firms in TRONDHEIM exhibit higher collaboration propensities than found in any other location considered.

In Model 2D, where COLLABORATION is estimated for all firms instead of just active firms, the negative estimates for urban locations are jointly *significant* (Chi2 = 13.63**). This is consistent with the notion of urban fragmentation (Tödtling and Trippl, 2005). However, the dependent variable in this estimation capture two fundamentally different choices: That to engage, which by Model 1C was found negatively influenced by location in the Capital, and the choice to collaborate, which according to Model 2C is not significantly influenced once the first decision has been made.

Model 3 (Table 4) estimates the propensity that firms maintain a broad network, i.e. have partners in at least two world regions. In all regressions that include only collaborating firms

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(Model 3A – 3C), a strong and highly significant estimate for CAPITAL W is obtained. Moreover, supplementary Wald's tests reveal that the estimate for this region in Model 3C is significantly different from the estimates for all other urban agglomerations. Thus, while firms in CAPITAL W initially are less inclined to engage in innovation activities, those that do engage uses local resources in support of establishing geographically broad network ties.

When COLLAB_BROAD = 1 is estimated for all firms (Model 3D), the dependent variable captures all three choices, instead of only the specific network configuration choice in question. Because the knowledge dynamics of urban locations influence these different choices in different ways, no estimates that are individually or jointly significant are obtained.

Table 4 approximately here

Sample selection issues

Models 2A-C and 3A-C were estimated only for firms that, through their foregoing strategy choices, had self-selected into the samples used. This translates into a risk that estimates are biased by *unobserved* firm characteristics that influences the sample selection decision, and correlate with the dependent variables in the outcome stages. Supplementary regressions which in the tradition of Heckman (1979) include Mills ratios as controls for such unobserved characteristics have therefore been estimated. In terms of regional influences, the results obtained are structurally consistent with those reported in Model 2C and 3C. However, in the absence of the instrumental variables this procedure requires[iii] (e.g. Herstad and Ebersberger, 2015), the inclusion of Mills ratios create severe multicollinearity problems. As then advised in the literature (e.g. Puhani, 2000), controls for sample selection are not included in the reported regressions.

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Conclusion

This paper investigated how the density, diversity and international connectivity of urban agglomerations influences the innovation strategy choices of individual firms. In descriptive terms, the Central and Western business districts of the Capital *consists* of firms that *are* more inclined to engage in innovation, than are firms located outside the large urban agglomerations. Yet, when the probability of innovation activity is estimated for firms that are comparable in terms of sector, size, age, and human resource endowments, the contrasting picture portrayed demonstrates that the characteristics of 'firms-in-regions' must be isolated from influences on individual firm behavior exerted by the knowledge dynamics of regions as such.

These influences, second, differ depending on what choices that are being made: Firms in the Western Capital are less inclined than comparable firms in other locations to engage in innovation, but no more or less inclined to collaborate once engaged. However, once involved in collaboration, they are more likely than similar firms elsewhere to have established the broad network ties that are particularly demanding to operate and signal a strong commitment to innovation. Unless strategy choices are analyzed sequentially, the two opposing responses to the same urban economy knowledge dynamics are effectively concealed.

Third, there are few clear-cut urban-rural dividing lines in terms of innovation strategy choices. Instead, there is inter- and intra-urban differentiation. The unique innovation strategy preferences of firms in the Western Capital reflect not only the position of the Capital in the urban hierarchy, but also the micro-ecologies that exists within it. Inter-urban differentiation is also evident from innovation activity propensities that are significantly higher in Trondheim than in the Central and Western Capital, and from collaboration propensities that are higher in Trondheim than in all other locations. Presumably, this reflects the position of the region as

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point of gravitation in industrial R&D networks and its role as stronghold for Norwegian technical research and education (Strand and Leydesdorff, 2013). Consequently, research on the link between location and innovation must account for the actual characteristics of different regions, and for the micro-ecologies that may exist within them.

From this, a first limitation to the analysis is evident, as the reference group used does not do justice to what is a differentiated landscape of industry and innovation also outside the large-city regions (Onsager et al., 2007). This landscape can be described in terms of place-specific social capital (Laursen et al., 2012b) or institutional and organizational 'thickness'(Tödtling et al., 2011); and in terms of related versus unrelated industrial variety (Aarstad et al., 2016). As these are factors that may exert their own independent influences on the innovation activity and collaboration choices of firms (e.g. Ebersberger et al., 2014), future research on the location-behavior link should consider a broader range of characteristics than urbanization per se.

For explorative purposes, a set of sequential regressions were estimated that allowed direct comparison of results with those obtained using a more conventional estimation strategy. This use of regressions retains the focus of prior research on mean, albeit conditional in the analysis herein, responses. A second limitation is therefore that the analysis sacrificed precision in capturing the actual differentiation of innovation strategies in Norwegian regions for the sake of empirical comparisons that allowed more fundamental analytical points to be made. Consequently, future research should use methods that are better suited for describing the diversity and interdependencies of innovation behavior in different types of regions. This extends into studying specifically whether certain firm clusters (comprised e.g. of firms that engage in internationally networked innovation), opens up, through localized spillovers, opportunities for other clusters to form that are characterized by very different strategy choices (e.g. to not engage in development work).

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For innovation policy, three closely related implications are evident. First, if observed at the outset, lower collaboration propensities should not automatically be taken as signs of ‘urban fragmentation’ (Tödtling and Trippl, 2005) or ‘network failure’(e.g. Coenen et al., 2016), as the root cause may be more fundamental incentives against investments in development work arising out of particularly *vibrant* urban knowledge dynamics (Suarez-Villa and Walrod, 1997). If this is the case, it approximates that of a market ‘failure’ reflecting the *effectiveness* rather than failure of the regional knowledge diffusion infrastructure. Related to this, second, is the danger that urban firms respond to the concentration of human resources in their locations by economizing on own development efforts. Unless counteracted by policy, this may keep the real innovation potential of the urban economy, and of thus of societies’ human resource bases, from being captured. Consequently, and third, it is evident that policies which seek to mobilize firms into engaging in development work should be viewed as complementary to initiatives seeking to stimulate knowledge diffusion between them (e.g. Herstad et al., 2010).

Inevitably, the data used in this study mirror the industrial composition, geography and business cycle of the Norwegian economy. It is therefore important that resulting limitations to the external validity of empirical results, in terms of what choices firms make, and where in the urban hierarchy they do so, do not deter researchers from moving this line of research forward along the lines suggested herein.

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Tables

Table 1: Location quotients and employment in the Norwegian urban system in 2010.

	Capital labour market region			**Other urban labour market regions**			**Non-urban labour market regions**	**Employment**
	Central	*Western*	*Outer*	*Bergen*	*Stavanger*	*Trondheim*		
Agriculture, forestry and fisheries	0,04	0,18	0,56	0,40	0,99	0,58	**1,57**	57 830
Offshore oil & gas, mining	0,06	**1,45**	0,05	**1,34**	**5,42**	0,54	0,82	55 163
High-tech manufacturing	0,85	**1,65**	0,27	0,78	0,64	**1,41**	**1,13**	11 855
Medium high-tech manufacturing	0,25	0,53	0,51	**1,11**	**1,03**	0,51	**1,37**	40 493
Medium low-tech manufacturing	0,24	0,71	0,58	**1,14**	**1,19**	0,58	**1,32**	99 293
Low-tech manufacturing	0,49	0,25	0,91	0,86	0,94	0,97	**1,27**	81 285
Infrastructure	0,80	0,36	0,68	1,05	0,61	0,85	**1,21**	28 023
Construction	0,74	0,77	0,96	0,99	0,94	0,99	**1,12**	199 500
Wholesale and retail trade	0,95	**1,18**	**1,56**	0,93	0,89	0,95	0,97	362 494
Transportation	**1,01**	0,63	**1,83**	**1,15**	0,91	0,86	0,93	146 769
Hotels & restaurants	**1,07**	0,79	1,00	1,00	**1,07**	**1,17**	0,96	81 848
Telecom, software and publishing	**2,36**	**3,17**	0,47	0,90	0,78	**1,01**	0,48	86 927
Financial & real estate services	**1,89**	**1,70**	0,47	**1,26**	0,75	**1,11**	0,69	72 740
Scientific and technical services	**1,50**	**2,41**	0,78	**1,08**	**1,19**	**1,51**	0,67	123 894
Business services, other	**1,42**	1,00	0,97	**1,08**	**1,15**	**1,11**	0,82	134 991
Public administration & teaching	**1,33**	0,59	0,90	0,92	0,74	**1,17**	0,96	345 531
Health services	0,72	0,88	**1,02**	**1,03**	0,82	0,99	**1,12**	499 430
Culture, sports & membership org.	**1,57**	0,78	0,85	**1,01**	0,87	0,98	0,86	87 924
Share of employment	17,9 %	3,7 %	5,9 %	8,1 %	6,8 %	5,3 %	52,3 %	2 515 990 (100 %)

Note: Computations based on business register data from 2010. Industry, employment and location is identified at the individual establishment level. Location quotients are computed as region share of Norwegian employment in sector over region share of all employment in Norway.

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Table 2: Innovation activity

	Model 1					
	ACTIVE = 1					
	Model 1A		Model 1B		Model 1C	
	ME	*SE*	*ME*	*SE*	*ME*	*SE*
CAPITAL C	0,006	0,015	-0,021	0,014	-0,053	0,015***
CAPITAL W	0,083	0,028***	-0,011	0,025	-0,053	0,026**
CAPITAL O	-0,110	0,028***	-0,053	0,024**	-0,035	0,024
BERGEN	0,004	0,023	0,006	0,020	0,009	0,020
STAVANGER	-0,034	0,022	-0,057	0,021***	-0,051	0,020**
TRONDHEIM	0,036	0,027	0,038	0,024	0,025	0,024
CENTR. 1-3	*Reference*		*Reference*		*Reference*	
GROUP			-0,011	0,013	-0,018	0,013
AGE			-0,021	0,008**	-0,014	0,008
SIZE			0,055	0,005***	0,053	0,005***
MARBREADTH			0,105	0,005***	0,094	0,005***
HR_ENDOW					0,087	0,007***
Sector controls			Included (14)***		Included (14)***	
Sample			All (N = 6079)			
LR Chi2 (df)	26.99(6)***		1439.65(24)***		1260.83(25)***	
Pseudo R2	0.0034		0.1819		0.1998	

Note: Marginal effects and robust standard errors from probit regressions. *** and ** indicate significance at the 1 per cent and 5 per cent levels respectively.

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Table 3: Innovation collaboration

	Model 2							
	COLLAB = 1 if ACTIVE = 1						COLLAB = 1	
	Model 2A		Model 2B		Model 2C		Model 2D	
	ME	SE	ME	SE	ME	SE	ME	SE
CAPITAL C	-0,034	0,026	0,010	0,027	-0,024	0,027	-0,032	0,011***
CAPITAL W	0,030	0,042	0,014	0,042	-0,048	0,041	-0,032	0,017
CAPITAL O	-0,094	0,052	-0,069	0,051	-0,048	0,048	-0,029	0,018
BERGEN	-0,028	0,038	-0,028	0,037	-0,025	0,036	-0,004	0,015
STAVANGER	0,002	0,038	-0,051	0,038	-0,040	0,038	-0,026	0,015
TRONDHEIM	0,121	0,042***	0,137	0,041***	0,098	0,042**	0,040	0,016***
CENTR. 1-3	*Reference*		*Reference*		*Reference*		*Reference*	
GROUP			0,014	0,024	0,020	0,024	0,000	0,009
AGE			-0,019	0,016	-0,005	0,016	-0,006	0,006
SIZE			0,042	0,008***	0,043	0,008***	0,031	0,003***
MARBREADTH			0,047	0,010***	0,035	0,009***	0,041	0,004***
HR_ENDOW					0,117	0,013***	0,066	0,005***
Sector controls			Included (14)***		Included (14)***		Included (14)***	
Sample			Active only (N = 2162)				All (N=6097)	
LR Chi2 (df)	14.22(6)**		170.04(24)***		223.52(25)***		722.04 (25)***	
Pseudo R2	0.0051		0.0608		0.0894		0.1968	

Note: Marginal effects and robust standard errors from probit regressions. *** and ** indicate significance at the 1 per cent and 5 per cent levels respectively.

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Table 4: Broad collaboration

	Model 3							
	COLLAB_BROAD = 1 if ACTIVE = 1 & COLLAB = 1						**COLLAB_BROAD = 1**	
	Model 3A		Model 3B		Model 3C		Model 3D	
	ME	*SE*	*ME*	*SE*	*ME*	*SE*	*ME*	*SE*
CAPITAL C	0,032	0,046	0,047	0,047	0,029	0,047	-0,012	0,009
CAPITAL W	0,291	0,081***	0,240	0,077***	0,208	0,078***	0,006	0,013
CAPITAL O	-0,015	0,100	-0,016	0,096	-0,016	0,093	-0,016	0,015
BERGEN	-0,022	0,068	-0,004	0,066	0,006	0,067	-0,001	0,012
STAVANGER	0,041	0,067	0,006	0,068	0,018	0,067	-0,017	0,012
TRONDHEIM	-0,016	0,066	0,001	0,063	-0,017	0,065	0,022	0,013
CENTR. 1-3	*Reference*		*Reference*		*Reference*		*Reference*	
GROUP			-0,057	0,042	-0,051	0,042	-0,009	0,008
AGE			-0,026	0,028	-0,017	0,028	-0,006	0,005
SIZE			0,068	0,013***	0,070	0,013***	0,028	0,003***
MARBREADTH			0,085	0,016***	0,079	0,016***	0,047	0,005***
HR_ENDOW					0,061	0,023***	0,033	0,003***
Sector controls			Included (13)***		Included (13)***		Included (13)***	
Sample	Collaborators only (N = 751)						All (N=6079)	
LR Chi2 (df)	14.72(6)**		107.73(23)***		100.30(24)***		532.11(24)***	
Pseudo R2	0.0144		0.1057		0.1133		0.2184	

Note: Marginal effects and robust standard errors from probit regressions. *** and ** indicate significance at the 1 per cent and 5 per cent levels respectively

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Table A1: Descriptive statistics and correlations, CIS2010 sample. N = 6079

		Mean	**SD**	**Min**	**Max**	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	ACTIVE	0,356	0,479	0	1	1													
2	COLLAB	0,124	0,329	0	1	0,506	1												
3	COLLAB_BROAD	0,072	0,259	0	1	0,376	0,742	1											
4	CAPITAL C	0,199	0,399	0	1	0,006	-0,013	-0,005	1										
5	CAPITAL W	0,051	0,220	0	1	0,033	0,026	0,054	-0,011	1									
6	CAPITAL O	0,059	0,235	0	1	-0,046	-0,038	-0,026	-0,024	0,123	1								
7	BERGEN	0,079	0,270	0	1	0,002	-0,006	-0,006	-0,060	0,087	0,073	1							
8	STAVANGER	0,084	0,278	0	1	-0,020	-0,008	0,000	-0,068	0,080	0,065	0,034	1						
9	TRONDHEIM	0,056	0,230	0	1	0,015	0,041	0,029	-0,019	0,126	0,110	0,077	0,070	1					
10	GROUP	0,701	0,458	0	1	0,050	0,050	0,042	0,019	0,031	0,004	-0,010	0,033	-0,023	1				
11	AGE (log)	2,705	0,671	1,099	4,718	-0,009	-0,007	-0,002	-0,017	-0,030	0,013	-0,016	-0,032	-0,029	0,043	1			
12	SIZE (log)	3,518	1,238	1,609	9,771	0,125	0,126	0,142	0,042	0,007	0,008	-0,005	0,039	-0,018	0,343	0,156	1		
13	MARBREADTH	2,025	1,056	0	4	0,347	0,245	0,237	0,012	0,059	-0,017	-0,002	0,032	-0,007	0,107	0,009	0,125	1	
14	HR_ENDOW	4,041	1,027	1	7,667	0,274	0,225	0,192	0,279	0,171	-0,077	-0,015	0,000	0,046	0,027	-0,102	-0,015	0,231	1

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Notes

[ii] Norway, other Nordic Countries, EU countries except the Nordic countries, North America, Asia and 'other' world regions.

[ii] Norway, other Nordic Countries, other European Countries, North America, Asia and 'other'

[iii] An instrumental variable is one that strongly determines selection, but can reasonably be excluded from subsequent outcome stages (or is insignificant when included). In the analysis herein, two such variables are required: One that strongly determines ACTIVE = 1 but can be excluded from both subsequent stages; and one that strongly determines COLLAB = 1 but can be excluded from the regression estimating COLLAB_BROAD = 1.

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