Global pipelines for innovation in Norway

Rune Dahl Fitjar, University of Stavanger, Norway - rune.d.fitjar@uis.no

Franz Huber, University of Southampton, United Kingdom – f.huber@soton.ac.uk

Abstract

Using data on 418 Norwegian firms, the results confirm the hypotheses that innovative/radically innovative firms tend to be more involved in international personal and formal networks than non-innovative/incrementally innovative ones. Whilst regional and national networks are much more widespread than international ones, they are not significantly positively associated with innovation. International personal networks and international links with suppliers and customers, as well as with universities and research institutions as well as global buzz with strangers, are positively related with innovation. This suggests that innovation management and policy, in particular in countries with a limited national innovation base, could benefit from facilitating certain international networks.

Key words: networks; global pipelines; international collaboration; innovation

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1. Introduction

It has been widely argued that networks external to the firm are critical for innovation (Pittaway et al., 2004). Yet, there is an unresolved debate on which type of external relationships are important. Whilst some contributions have stressed the importance of informal personal networks, others have emphasised formal network relationships of various types. Only rarely is the role of personal versus formal external networks for innovation compared and contrasted (Keupp et al., 2012; Trippl et al., 2009). Furthermore, it is an unresolved question which spatial scales of network partners are beneficial for innovation. Traditionally, the role of face-to-face contacts within regional environments has been addressed, but the literature increasingly highlights the significance of extra-regional networks. In particular, international networks as global pipelines are often regarded as vital for sourcing new knowledge for innovation (Bathelt et al., 2004). Until recently, the literature on global pipelines predominantly discussed formal firm networks, whilst personal networks have been more prominent in the literature on local buzz (e.g. Storper and Venables, 2004). Furthermore, whilst an agreement seems to be emerging on network relationships at multiple spatial scales being important for innovation, the nature and role of international networks are still unclear. Moreover, it remains an open question whether global buzz in the form of temporary proximity (e.g. in trade fairs) and virtual buzz affect innovation over and above formal and personal networks. Overall, there is a need for research that compares the importance of informal versus formal networks for innovation, and there is demand for examining the role of international networks and global as well as virtual buzz to substantiate the global pipelines metaphor.

This paper addresses these issues by examining the nature and the role of international personal and formal networks, as well as global buzz with strangers and virtual buzz,

for innovation in Norwegian urban firms. It addresses the following research questions: To what extent are non-innovative versus innovative versus radically innovative firms involved in international personal and formal networks? To what extent are international personal and different types of formal networks, as well as global buzz with strangers and virtual buzz, associated with product and process innovation?

The results confirm the hypothesis that innovative firms, in particular radically innovative firms, tend to be more involved in international personal and formal networks than non-innovative ones. Furthermore, international networks tend to be more closely associated to innovation than regional/national networks. Whilst regional and national networks are much more widespread than international ones, they do not have significant positive relationships with innovation. The results suggest that beneficial 'global pipelines' for innovation are based on a range of relational types rather than on a single type. Yet, there are important differences in how personal versus formal relationships matter for innovation. International personal networks exhibit a more robust positive relationship with innovation than international formal networks. Nonetheless, formal links with international suppliers and customers, as well as with scientific institutions abroad, are positively related to certain aspects of innovation. Chatting with strangers at trade fairs and conferences is also shown to have a positive effect on process innovation.

Overall, the results contribute to a more nuanced understanding of the role of international pipelines, which suggest that networking initiatives in firms and public policy would benefit from facilitating a range of international linkages, rather than focusing mainly on the regional and national level, in particular for countries with a limited national innovation base such as Norway. The remainder of this paper is

organized as follows. Section 2 reviews the literature and develops hypotheses. The data used are introduced in section 3. Section 4 presents descriptive and bivariate results on personal networks, global buzz with strangers, virtual buzz, and formal networks. In section 5 the question of which scale matters for innovation will be tackled, which is followed-up by a more detailed examination of the types of international networks that affect innovation in section 6. Section 7 concludes.

2. External networks, scale and innovation in firms

It is widely accepted that external networks are important for innovative firms. Given that the knowledge sourcing requirements for innovation have become ever more complex, sourcing external knowledge is critical (Chesbrough, 2003; Howells et al., 2003; Huggins, 2010; Maskell, forthcoming; Nooteboom, 2004). The literature on innovation systems and much of the recent literature on innovative firms have argued that inter-organizational interactive learning is an important phenomenon. Much of the literature on regional innovation has emphasised the beneficial role of local or regional networks. Territorial innovation models (Moulaert and Sekia, 2003) have tended to stress the decisiveness of inter-organizational networks for innovation and regional economic development (Boggs and Rantisi, 2003; Grabher, 2006; Huber, 2012a). Here, territorial social, institutional and cultural assets have been argued to facilitate knowledge linkages (e.g. Camagni, 1991; Cooke et al., 2005; Malmberg and Maskell, 2002; Storper, 1997).

Inter-organizational networks can be based on individual-level personal networks (related resources are often called social capital - Huber, 2009) or on firm-level formal strategic relationships (conceptualised as network capital by Huggins, 2010; 2012), both of which have been linked to innovation. On the one hand, the literature

has discussed *formal networks* such as alliances, cooperative arrangements, joint ventures, R&D collaboration, sub-contracting or licencing (e.g. Fitjar and Rodríguez-Pose, 2011; Segelod and Jordan, 2004; Trippl et al., 2009). On the other hand, informal *personal networks* have been highlighted in the form of personal ties, embedded relationships, in-groups, social networks and the like (e.g. Granovetter, 1973; Lechner and Dowling, 2003; Storper and Venables, 2004; Uzzi, 1996). To clarify the terminology in this article, *personal relationships* are delimited as any interactions between individuals which go beyond official collaborations and formal roles. They can be purely informal but might be embedded in co-existing formal relationships, and there can be intricate interrelationships between formal and personal networks (Grabher and Powell, 2005; Huber, 2012c). Yet the interactions in personal relationships go beyond formal arrangements and are driven by the inter-personal dimension. Personal networks are defined as a set of individuals and their personal relationships, and personal contacts are the people with whom individuals have personal relationships. For the purpose of this paper, the notion of personal networks covers all kinds of informal inter-organisational relationships.

Whilst the literature implicitly tends to argue that both formal and personal networks are useful for innovation, there is uncertainty about the relative significance of different types of networks. According to the extensive review by Keupp et al. (2012), the performance implications of inter-firm networks for innovation are still unclear. As Huber (2013) argued, rather than generally assuming that inter-organisational networks are important for innovation, more research on a contingency-theoretic perspective is needed to clarify which type of networks are important in which contexts. This paper aims to address this issue by comparing and contrasting the

effects of personal networks and various types of formal networks, as well as global buzz with strangers and virtual buzz, on innovation in Norway.

Furthermore, the literature has increasingly criticised the territorial focus, stressing instead *multi-scalar* network dimensions (e.g. Amin and Cohendet, 2004; Bunnell and Coe, 2001; Lorentzen, 2008; Yeung, 2005). It has been argued that in order to avoid the risk of lock-in, international networks beyond the region, and even the nation, are vital for being exposed to fresh knowledge (Bathelt et al., 2004; Boschma, 2005; Morrison, Rabellotti, et al., 2013). Embeddedness in global innovation networks affects competitiveness (Kafouros et al., 2012). For the individual firm, international networks potentially offer access to sources of knowledge and relational resources (Lechner and Dowling, 2003) which are rare or inimitable (Barney, 1991), rather than being accessible simply by "being there" (Gertler, 1995). Yet, absorptive capacity is necessary to benefit from international collaboration (De Jong and Freel, 2010). This literature originally focused on formal links in the form of global pipelines, or "strategic partnerships of interregional and international reach" (Bathelt et al., 2004). In keeping with this, global networks have been conceptualised mainly as formal types of relationships (Tödtling et al., 2012). However, the nature of such international networks can vary, and recent literature has gone beyond a simplistic reading of the buzz-and-pipelines metaphor to substantiate the mechanisms. This has included three advancements.

First, several studies have shown that global pipelines are constituted through *complex social processes*, often based on informal personal networks rather than only on formalised linkages. Lorenzen and Mudambi (2012) distinguished between organization-based and person-based global linkages. Moodysson (2008) clarified the mechanisms of knowledge interactions in Swedish life science by showing that

interactive knowledge flows occur in carefully chosen, globally configured professional interpersonal communities or interorganisational alliances. Trippl et al. (2009) elaborated on the diverse range of mechanisms through which knowledge linkages operate at different spatial scales, demonstrating that informal personal knowledge networks operate at all spatial scales, complemented by some formalised relationships. Overall, there has been an increasing awareness that informal knowledge networks are not a territorialised phenomenon, but can occur at multiple spatial scales. Importantly, this can occur in situations of temporary proximity (Torre, 2008) as part of *'global buzz'* in trade fairs or conferences (Bathelt and Schuldt, 2008; Maskell et al., 2006). These more unstructured international communication channels enable accessing gossip or rumours from 'strangers' in trade fairs or conferences. The concept of global buzz includes a range of mechanisms of interactive learning and observation as part of the information and communication ecology of events such as trade fairs (Bathelt and Schuldt, 2010), including the development of personal relationships of the type discussed above. In this paper we use the more specific term *global buzz with strangers* to refer to gaining knowledge from people one does not know personally in events such as trade fairs, conferences, seminars or workshops, which is a specific sub-type of global buzz. Since research on personal networks tends to be biased towards strong ties (Grabher, 2006), it is important to include the role of more unstructured and ephemeral interactions. Furthermore, an additional important mechanism of potentially global knowledge interaction can occur in purely internet-based online communities such as online discussion forums (Grabher and Ibert, forthcoming; Huber, 2013; Trippl et al., 2009). We use the term *virtual buzz* (Bathelt and Turi, 2011) to refer to mechanisms of knowledge interactions which take place purely online via discussion forums, email discussion lists or other information on the

Internet such as blogs. The literature on communities of practice and related conceptualisations of knowing have mentioned these virtual forms of interactions (Amin and Roberts, 2008). In contrast with personal knowledge networks, virtual buzz occurs purely online and does not need to involve personal acquaintance. Personal networks, as understood in this paper, tend to use a range of means of communication, including face-to-face or technology mediated interaction (Huber, 2012c; Rainie and Wellman, 2012).

Second, there is growing evidence that a *range of types* of international linkages facilitate innovation. On the basis of a small sample, Trippl et al. (2009) suggest that more radical innovation is associated with a higher number of different types of sources of knowledge. This argument was substantiated by Fitjar and Rodríguez-Pose (2011), whose analysis of innovation in Norwegian city-regions demonstrated that firms involved in a greater diversity of international partnerships tend to be more innovative. Yet, the following issues have not been addressed by this research: First, the paper only analyses formal partners and does not compare the effect of formal networks with personal networks, or with global and virtual buzz. Second, the study focused on the diversity of formal partners but did not examine which qualitative types of international partners matter for innovation. Fitjar and Rodríguez-Pose (2013) addressed the latter point by illustrating that non-regional (national or international) supply chain linkages as well as non-regional linkages with consultants, universities and research centres are conducive to innovation. Yet, the regional/non-regional dichotomy does not shed light specifically on the nature of international pipelines.

Third, the conceptual and empirical work on the role of *scale and proximity* for innovation has become more sophisticated. It has been widely argued that both local

networks and global pipelines are important for successful regions (Bathelt et al., 2004; Owen-Smith and Powell, 2004), as the complementary interplay between local and global knowledge networks provides benefits for innovation (Cooke et al., 2007; Gertler and Levitte, 2005; Malecki, 2010; Morrison, Rabelotti, et al., 2013; Patel et al., forthcoming). However, a simplistic local-global dichotomy of the early buzz-and-pipelines approach has been challenged by more nuanced differentiations of scales. In particular, the distinction between the national level and the international level is critical, since the national level still tends to provide a distinct—and often dominant—legal, institutional, social and cultural context (Isaksen, 2009; Lundvall, 1992; Trippl et al., 2009). Therefore, one can argue that international linkages are more likely to bridge different environments in various dimensions (cognitive, institutional etc.) than national ones. These differences might make the establishment of international networks more challenging (Leung, 2013). Yet, they might also provide innovation benefits from tapping into a new knowledge base. This issue links to the debate of which types of proximity—spatial, social, organizational, institutional or cognitive—matter for networks and innovativeness (Boschma, 2005; Gertler, 2004; Huber, 2012b), which, while beyond the focus of this paper, provides a useful framework for thinking about international networks.

Despite the recent contributions to the debate, there is still a need to unpack the global pipelines metaphor further. First, we still know little about which qualitative types of international networks matter for innovation. In particular, the question of the relative importance of formal versus personal networks deserves more attention. Second, the relative importance of different spatial scales is unclear. It remains an unresolved issue whether international networks are mainly a complement to regional and national (formal and personal) networks, or whether they can provide a perhaps

superior substitute to regional and national networks for innovation. Furthermore, it is unclear whether the spatiality is similar or different in formal versus personal networks. Third, whilst global buzz and virtual buzz have received conceptual and empirical attention, their effect on innovation in comparison to formal/personal networks remains to be examined.

This paper aims to address these issues by systematically comparing the role of different types of formal and personal networks, global buzz with strangers, and virtual buzz for innovation. It contrasts the relative importance of formal versus personal international networks for incremental and radical product and process innovation. Furthermore, the paper elaborates on which type of international networks are most closely related to innovation, controlling for different spatial scales. Finally, it compares the relative strength of the association of innovation with networks and with global buzz with strangers and virtual buzz. The paper aims to test several theoretical expectations:

First, we expect international personal and formal networks to be more relevant and vital for innovative firms than for non-innovative ones. Non-innovative firms have less need to source cutting-edge knowledge internationally. Furthermore, product innovation is positively associated with exporting (Roper and Love, 2002). Since non-innovative firms do not tend to introduce new products, services or processes in foreign countries, networks are less important for market entry.

H1: Innovative firms tend to be more involved in international personal and formal networks than non-innovative ones.

What is more, one can expect that international (personal and formal) networks are more important for radically innovative firms than for incrementally innovative firms. For radical innovation, external cooperation (Tether, 2002) and access to cutting-edge technological or market knowledge tends to be more essential. Moreover, radically innovative firms are more likely to enter international markets, which makes international networks more likely to be useful for accessing market knowledge (Huber, 2013) and serving international markets. To the best of our knowledge, these two hypotheses have not been systematically empirically tested before.

H2: Radically innovative firms tend to be more involved in international personal and formal networks than incrementally innovative ones.

Furthermore, as discussed above, there is still uncertainty about the role of different spatial scales of networks. On the one hand, much of the literature suggests that linkages at multiple scales are important for innovation because they complement each other (Cooke et al., 2007; Gertler and Levitte, 2005; Malecki, 2010; Patel et al., forthcoming). However, on the other hand, one could argue that for relatively small nations such as Norway, international linkages are most critical. Since smaller countries tend to have less innovation-related activity within the national boundaries, it seems more likely that the cutting-edge knowledge required for innovation needs to be sourced internationally (Morrison, Rabellotti, et al., 2013; Rodríguez-Pose and Fitjar, 2012). Tödtling et al.'s (2012) study on ICT companies in Austria found that knowledge sourcing at the national level was less frequent than expected and that "the small size of Austria certainly limits the potential for sourcing knowledge in specialized fields" (p. 342). Yet, even if many regional or national knowledge

networks exist, their effect on innovation might still be limited due to the potential lack of new knowledge and cognitive lock-in effects (Fitjar and Rodríguez-Pose, 2011). The same could be expected for larger countries with low levels of innovation activity. That is, the fundamental factor might not be the geographical size of a country but rather the extent of national innovation activity.

The causal relationship between international networks and innovation may operate in different ways. First, as indicated above, several theoretical and empirical contributions suggest that interaction with network partners and associated knowledge acquisition may make firms more innovative. Second, innovative firms may have a greater need to engage with external partners as a consequence of their innovation activities, for instance regarding securing equipment, consultancy advice, training, etc. That is, international relationships do not make the firms more innovative but innovative firms need them. Whilst it seems likely that both causal effects are at play, this paper will not be able to examine the exact mechanisms but will instead focus on the association between networks and innovation.

Overall, whilst there will always be variation according to individual firms' contexts, we can conclude that there are two competing hypotheses regarding overall tendencies.

H3a: Regional, national and international networks are complementary and therefore networks at all spatial scales are positively associated with innovation.

H3b: The clearest positive association of networks with innovation is at the international scale.

Finally, whilst personal and formal networks might be interrelated, the literature tends to stress the qualitative difference between person-centred versus organization-centred inter-organizational linkages (Huggins et al., 2012; Lorenzen and Mudambi, forthcoming; Trippl et al., 2009). In the light of this, we expect that personal networks and formal networks exhibit distinct associations with innovation. In other words, one type of network cannot be subsumed under another type of network. Therefore we test the following hypothesis.

H4: Personal and formal networks have positive associations with innovation that are independent from one another.

3. Data on innovation in Norwegian urban firms

These hypotheses are analyzed with data from a 2010 survey of firms located in the five largest urban regions of Norway: Oslo, Bergen, Stavanger, Trondheim and Kristiansand. The survey included firms with more than ten employees located in municipalities in which ten percent or more of the population commute into the above-mentioned cities. The firms were sampled from the compulsory Norwegian Register of Business Enterprises, and the top manager of each firm was contacted by telephone. The survey itself had two stages. In the first stage, interviewers from the professional market research firm Synovate conducted a telephone interview of each firm's manager. A total of 1600 interviews were completed from an initial random sample of 5887 firms, giving a response rate of 27.2 percent. Furthermore, all respondents were invited to fill in an online questionnaire containing further questions. Those who were willing to participate in the online survey were e-mailed a unique code for accessing the questionnaire, and their answers were subsequently matched to those from the telephone interview. In total, 418 managers completed both

the telephone interview and the web questionnaire. The indicators of innovation, formal firm networks, and manager norms and values, as well as the control variables, are all drawn from the telephone interviews. The data on personal networks and knowledge sources were collected in the web-based follow-up survey. This mixed method of data collection is an increasingly common approach in survey-based research. In business surveys in particular, the initial telephone interview is important to get past gatekeepers, while the follow-up web survey create opportunities for additional data collection that can be more easily worked into business managers' schedules. However, the mixed-mode approach also carries potential disadvantages in terms of the potential for measurement error (De Leeuw, 2005).

The study has been conducted in the context of Norway, which might matter for the results in several ways. First, Norway is a small country of 5 million inhabitants and consequently has a limited national innovation base. It has 8 universities and a comparatively low level of industrial R&D expenditure, in part due to its industrial composition, which is highly reliant on resource-based industries. Consequently, important knowledge resources may frequently be found outside the country. Second, it has an open economy, with exports in 2011 amounting to 41.9 percent of GDP (OECD, 2013), and a well-educated population with a high level of proficiency in foreign languages, in particular in English. These factors may make international collaboration more common and more successful. Finally, levels of trust are high and have created conditions for a collaborative innovation model, in which many firms conduct R&D as part of collaborative projects rather than in-house (Fagerberg et al., 2009). The high levels of domestic collaboration might spill over and create favourable conditions also for international collaboration. While all of these contextual conditions should be taken into account when interpreting the results, these

characteristics are not unique to Norway. Indeed, many of them are common across small developed countries.

Table 1 shows summary statistics of the sample, both for the telephone interviews and the web questionnaire.

[Insert Table 1 about here]

As a measure of the firm's innovation output, managers were asked four questions about different categories and levels of innovation: First, whether the firm had introduced any goods or services into the market during the preceding three years that were new to the company or significantly improved compared to their existing products (*product innovation*). Second, firms that gave a positive reply to the first question were asked whether any of these product innovations were new to the market, or only new to the company and very similar to a product that already existed in the market (*radical product innovation*). Third, all firms were asked whether the company had introduced any methods or processes for production or delivery of products during the preceding three years that were new to the company or significantly improved compared to their existing methods (*process innovation*). Once more, firms that gave a positive reply were asked whether any of these innovations of methods or processes were new to the industry (*radical process innovation*). Among firms that completed the web survey, 58.4 percent reported product innovation and 35.9 percent radical product innovation, while 46.9 percent reported product innovation and 18.4 percent radical process innovation.

4. Norwegian firms' use of knowledge linkages

4.1. Personal networks

In order to measure the geographical scope of managers' personal networks, managers were asked about the locations of the personal contacts that had been useful for them personally for collecting work-related knowledge during the preceding year. They were allowed to provide multiple responses from the following list of possible locations:

1) In the same city as me
2) In the same region as me
3) Elsewhere in Norway
4) Elsewhere in Scandinavia
5) Elsewhere in Europe
6) In the US or Canada
7) In the rest of the world

Figure 1 shows the distribution of responses to this question.

[Insert Figure 1 about here]

The analysis shows that the majority of managers collect work-related knowledge from personal contacts at the local, regional or national scale. It is much less common to source knowledge from personal contacts located abroad (22 percent in other Scandinavian countries, 29 percent elsewhere in Europe, 13 percent in the US or Canada, and 11 percent in other parts of the world).

However, there is a marked difference between innovative and non-innovative firms in the use of personal contacts abroad: Managers of firms that report product

innovation sourced knowledge from foreign personal contacts to a much higher extent than managers of non-innovative firms. While 16 percent of managers in non-innovative firms collected knowledge from personal contacts in Europe, 38 percent of managers of innovative firms did so – 42 percent of radical innovators and 31 percent of incremental innovators. The differences between each of the groups are statistically significant (incremental innovators vs. non-innovators: $z = 2.82$, $P = 0.005$, radical innovators vs. incremental innovators: $z = 1.75$, $P = 0.08$). The difference is even more remarkable for contacts beyond Europe: 5 percent of managers in non-innovative firms reported getting work-related knowledge from personal contacts in the US or Canada, compared to 18 percent of managers in innovative firms – 11 percent in incremental innovators and 23 percent in radically innovative firms. Each of these differences is also statistically significant (incremental innovators vs. non-innovators: $z = 1.89$, $P = 0.06$, radical innovators vs. incremental innovators: $z = 2.49$, $P = 0.01$). There are also significant differences between radically innovative firms and incrementally innovative firms when it comes to the number of partners within Scandinavia ($z = 1.80$, $P = 0.07$) and in the rest of the world ($z = 2.43$, $P = 0.02$), while the differences between incremental innovators and non-innovators are not statistically significant for these two types of contacts. However, the differences between non-innovators and all innovators are still statistically significant (Scandinavia: $z = 2.71$, $P = 0.007$, Rest of the world: $z = 3.01$, $P = 0.003$).

Figure 2 shows the distribution of responses by levels of process innovation, rather than product innovation.

[Insert Figure 2 about here]

In this case, the differences between innovative and non-innovative firms are smaller than for product innovation, but the pattern remains the same: There are very small differences between innovative and non-innovative firms when it comes to the use of personal contacts within Norway for work-related knowledge, while innovative firms—in particular radical innovators—tend to source knowledge from abroad more often, although the difference is only statistically significant for contacts in the US/Canada.

Overall, taking all results together, the results confirm H1 and H2. Innovative firms tend to be more involved in international personal networks than non-innovative ones, and radically innovative firms tend to be more involved than incrementally innovative ones. Whilst for process innovation this tendency is not always statistically significant, the trend is clear for product innovation.

4.2. Global buzz with strangers and virtual buzz

In order to examine the use of temporary proximity (Maskell et al., 2006; Torre, 2008) and online knowledge sourcing (Grabher and Ibert, forthcoming; Huber, 2013), we further asked the managers about different sources which they personally used for keeping informed about and assessing the importance of the latest technological developments. The managers were asked to rate the importance of each source on a four-point scale. Table 2 shows the distribution of responses for four of these sources: a) "personal contacts from other firms and institutions", i.e. the type of personal networks with which we have hitherto been concerned, b) "chatting with strangers (e.g. in trade fairs, seminars, conferences, workshops)", which is an important sub-dimension of temporary clusters, or what some have referred to as global buzz

(Bathelt and Schuldt, 2010), c) “online discussion forums or e-mail lists”, and d) “other information on the internet (e.g. blogs)”. The latter two sources constitute virtual buzz (Bathelt and Turi, 2011).

[Insert Table 2 about here]

The table shows that managers rate personal contacts as by far the most important external sources of knowledge. More than 90 percent of managers consider personal contacts in other firms as fairly or very important. A high share of managers also rely on chatting with strangers at trade fairs or conferences, with more than 70 percent rating this source as fairly or very important. The use of online sources is less widespread. Less than 25 percent of managers think online discussion forums are fairly or very important, which might be because online discussion forums are less relevant for senior managers than for people in purely technical roles as suggested by Huber (2013). Yet slightly more than half think other information on the internet is fairly or very important.

Overall, global buzz with strangers, as well as to some extent virtual buzz in the form of blogs or other webpages, are perceived to be important for keeping up-to-date with the latest technological developments. The relative effects of all these variables will be examined in sections 5 and 6.

4.3. Formal firm networks

Managers were also asked about formal partnerships in which their firm was involved. For this dimension, we asked whether the company had cooperated with any

of these types of partners during the preceding three years: Other companies in the same conglomerate, suppliers, customers, competitors, consultants, universities, and research institutes. For each type of partner, managers were also asked whether the firm had collaborated with a partner of this type located within the region, elsewhere in Norway, and/or abroad. On the basis of this question, we constructed an index of the number of different types of partners with whom the firm collaborated at each geographical scale. The mean scores for the index are shown separately for firms reporting different levels of product innovation in Figure 3.

[Insert Figure 3 about here]

Once more, collaboration within the region was most common. On average, firms collaborated with 2.3 different types of partners within the region, 1.4 types of partners based elsewhere in Norway, and 0.9 types of foreign partners. Comparing across levels of product innovation, innovative firms tend to collaborate with a more diverse set of partners than non-innovative firms at each geographical scale. Whilst the differences are fairly small at the regional scale, they are larger when moving beyond the region. When it comes to international collaboration, innovative firms collaborate with 1.2 partner types, which is twice as many partners as the 0.6 types consulted by non-innovative firms ($t = 10.27$, $P < 0.000$). The average radically innovative firm collaborates with 1.5 types of international partners, while incremental innovators on average collaborate with 0.9 types of partners ($t = 5.40$, $P < 0.000$). For process innovation, there are also significant differences between radically innovative, incrementally innovative, and non-innovative firms when it comes to collaboration with national and international partners, but not with regional partners. This confirms—for a larger and broader sample—the proposition by Trippl et al. (2009) that the more radical the innovation, the larger the number of different types of

knowledge networks. It also reinforces the results by Fitjar and Rodriguez-Pose (2011) and is in line with those of Ebersberger and Herstad (2011).

In order to assess the relationship between the geographical scale of formal firm partners and personal contacts, we transformed the seven variables for the latter dimension into the same three geographical scales used to assess formal firm partnerships. Personal contacts within the city or city region were coded as *regional personal contacts*, personal contacts located elsewhere in Norway as *national personal contacts*, and personal contacts in Scandinavia, Europe, US/Canada or the rest of the world as *foreign personal contacts*, producing three dummy variables measured at the same scale as formal firm partnerships. It is worth noting that personal contacts and firm partnerships are significantly correlated at the international scale (R=0.34) and at the national scale (R=0.19), but not at the regional scale (R=0.01).

Overall, the results confirm H1 and H2. Innovative firms tend to be more involved in international formal networks than non-innovative ones, and radically innovative firms tend to be more involved than incrementally innovative ones.

5. Multivariate analysis of the relationship between networks and innovation

Given that international personal and formal networks are correlated, it is necessary to conduct a multivariate analysis if we want to compare and contrast the partial association between innovation and each type of network at a specific scale and reduce the risk of detecting spurious associations. In this analysis, we also include indicators for global buzz with strangers and virtual buzz. Furthermore, the

multivariate analysis will allow us to control for other potentially confounding variables, such as size and sector. Thus, we now proceed to conduct a logit regression analysis that estimates the effects of these variables on the likelihood of four types of innovation, controlling for other relevant characteristics of the firms and their managers. The regression model takes on the following form:

$$\text{Logit}(\pi_i) = \alpha + \beta_1 \text{ Personal contacts}_i + \beta_2 \text{ Knowledge sources}_i + \beta_3 \text{ Firm partners}_i + \beta_4 \text{ Controls}_i + \varepsilon$$

In this equation, π_i refers to the probability π that firm *i* has introduced an innovation in the preceding three years. We fit four models, one for each of the four measures of innovation outlined above (*Product innovation*, *Radical product innovation*, *Process innovation*, *Radical process innovation*). *Personal contacts* is a vector of three dummy variables measuring whether or not the firm's manager has collected work-related knowledge from personal contacts located a) within the region, b) elsewhere in Norway, and c) abroad. *Firm partners* is a vector of three count variables measuring on a scale from 0 to 7 the number of different types of partners with whom the firm has collaborated a) within the region, b) elsewhere in Norway, and c) abroad. *Knowledge sources* is a vector of two variables referring to the perceived value of relationships that transcend traditional geographical scales, based on the question presented in Table 2 on the perceived importance of different knowledge sources. We include "chatting with strangers" as a measure of the use of temporary proximity based global buzz with strangers (Bathelt and Schuldt, 2010; Maskell et al., 2006). For "virtual buzz" (Bathelt and Turi, 2011), we create an additive index, combining the responses for "online discussion forums" and "other information on the internet". *Controls* refer to several control variables, further specified below. ε is the error term.

The analysis includes control variables related both to characteristics of the manager and to characteristics of the firm. For the manager, we include indicators of education level (number of years), age and log number of board positions in other firms. For the firm, we include indicators of size (log number of employees), foreign ownership (proportion of shares), industry (a set of dummy variables) and region (a set of dummy variables referring to the five city regions included in the analysis).

[Insert Table 3 about here]

The results (Table 3) show that personal contacts within the region actually tend to have a negative association with the likelihood of innovation. However, the effect is significant only for process innovation. National personal contacts are not significantly associated with innovation. Yet, foreign personal contacts are positively related to both product innovation and radical product innovation, an association that is significant at the 1 percent level in both cases. Controlling for all other factors—notably also for international formal networks—the odds of their firm being involved in product innovation are more than twice as high for those managers who collect work-related knowledge from personal contacts abroad compared to those who do not. The association is also positive, although not significant, for both forms of process innovation.

The trend is similar for formal firm partnerships. The use of a wide range of firm partners within the region or elsewhere in Norway is not significantly related to any type of innovation, although in this case all coefficients bar one are on the positive side. Foreign partners are significantly associated with radical product innovation,

where the firm's odds of introducing new-to-market products increase by 26 percent for each additional type of partner consulted. The effect is not statistically significant for any of the other innovation outputs, but is positive for all of them. The findings are compatible with earlier analyses, which showed a significant positive association between foreign firm partners and both product innovation and radical process innovation for a larger sample (Fitjar and Rodríguez-Pose 2011).

Underlining the importance of more subtle forms of interactions, the results also show a positive relationship of chatting with strangers at trade fairs or conferences. For Norwegian firms, such events will often take place abroad or involve foreign visitors[1]. The relationship is significant for both process innovation and radical process innovation. This finding suggests that inter-personal interactions that matter are not only constituted via personal contacts, but also via weaker, more ephemeral ties such as random connections with strangers resulting from temporary proximity (Maskell et al., 2006; Torre, 2008). Conversely, the analysis does not detect any significant innovation-related association with online communities or "virtual buzz" (Bathelt and Turi, 2011; Grabher and Ibert, forthcoming), which has been one of the more frequently discussed forms of non-territorialized knowledge sources. Face-to-face communication thus seems to matter even in these more ephemeral ties, while purely virtual interaction not only tends to be rated by managers as less important than random physical encounters, but is also more weakly (or not at all) associated with innovation.

1 In 2011, more than 40 percent of Norwegian business travel by air was international (Statistics Norway, 2012). The share is probably even higher in the private sector, as the public sector accounts for a fair share of domestic business travel. In 1998, courses, conferences and conventions accounted for around a third of Norwegian business travel (Lian and Denstadli, 2004). Furthermore, there were 1.1 million international business visits to Norway in 2011 (Farstad et al., 2011).

The control variables are not very closely associated with innovation. With the exception of a positive relationship between manager's age and radical process innovation and a significant region dummy for product innovation, the only control variables that seem to matter are the fixed effects for different industries.[2]

Overall, the results support H3b, in particular for product innovation, whereas they are not statistically significant for process innovation: networks at the international scale are most critical for innovation whereas regional/national networks are not significantly associated with innovation. H3a cannot be supported. This suggests that networks at different spatial scales should not necessarily be regarded as complementary but, in particular in countries with a limited national innovation base, the international scale seems most relevant for innovation. Furthermore, both personal and formal networks at the international scale are independently related to product innovation, with the former having the most robust relationship in terms of the significance level of the coefficients. For the international spatial scale, the results support H4, since the associations of personal and formal networks are independent from one another in the sense that each is associated with innovation when controlling for the other.

6. Which types of international linkages matter for innovation?

Whilst the above analyses showed that both formal and personal international networks have a positive association with product innovation, this section explores the different types of international formal firm networks in more detail. Although we do

2 Against other services as the baseline, the coefficients are negative and significant for construction (product and radical product innovation), wholesale and retail trade (process and radical process innovation) and transport, storage, information and communication (process innovation), and positive and significant only for manufacturing (radical product innovation).

not have data on different types of informal personal contacts, the data on formal firm partners allows us to distinguish between seven different types of international partners, as outlined in section 4.3 above.

Starting once more with a bivariate analysis of differences in proportions, Figure 4 shows the percent of firms using different types of foreign firm partners for firms with different levels of product innovation.

[Insert Figure 4 about here]

Suppliers are the most common type of international partners (30 percent). Furthermore, 19 percent are involved in international collaboration with customers and with other firms within a multinational enterprise. Foreign competitors and consultants are used as partners by 8 percent of firms, while only 5 percent collaborate with foreign universities and 4 percent with research institutes abroad.

Regardless of the type of formal partner, the share of firms collaborating with partners is highest among firms reporting radical product innovation. With the exception of collaboration with universities and research institutes, firms reporting incremental product innovation also tend to collaborate more frequently with international partners than firms reporting no product innovation.

In order to probe the relationship between different types of international partners and innovation more deeply, we have also run a multivariate regression analysis, applying the same model as above:

$$\text{Logit}(\pi_i) = \alpha + \beta_1 \text{ Personal contacts}_i + \beta_2 \text{ Knowledge sources}_i + \beta_3 \text{ Firm partners}_i + \beta_4 \text{ Controls}_i + \varepsilon$$

However, in this case, the vectors *personal contacts* and *firm partners* only include international networks. Instead, we add separate indicators for the different types of international firm partners.

Due to the low level of collaboration with international scientific partners, we have also combined the three different types of STI partners—universities, research institutes and consultancies (Fitjar and Rodríguez-Pose, 2013; Jensen et al., 2007)—into one single indicator for collaboration with foreign STI partners[3], which was used by 12.4 percent of firms. We keep the indicators for temporary clusters and virtual buzz, as we expect these knowledge sources—at least for Norwegian firms—to be predominantly international. The control variables are the same as in the previous analysis. Once more, the model is run four times, one for each of the four types of innovation examined (Table 4).

[Insert Table 4 about here]

Foreign personal contacts are still significantly positively associated with both product innovation and radical product innovation. Again, the association with personal networks remain when controlling for formal networks, which confirms H4. As for foreign firm partners, only some types of partners turn out to matter. Collaboration with other units within multinational enterprises is never significantly associated with innovation, which suggests that this often stressed type of global pipeline (Hervás-Oliver and Albors-Garrigós, 2008) should not be overrated regarding its role in innovation. Global supply-chain relations seem to play a more important

3 We also tried running the model with the three types of international STI partners as separate indicators. This produced estimates with much higher standard errors than in the analysis reported, and consequently, only the estimate for the effect of consultancies on product innovation was statistically significant.

role in innovation: collaboration with foreign suppliers has a significant positive relationship with product innovation, while collaboration with foreign customers is significantly positively associated with radical product innovation and with process innovation. Conversely, collaboration with foreign competitors tends to be negatively related to innovation, significantly so for radical product innovation. Collaboration with international scientific partners is also important. This is the only variable which is significantly positively associated with three types of innovation: product innovation, radical product innovation and radical process innovation. This is not altogether surprising, considering that these partners typically possess more codified and analytical knowledge that is more easily transferred across large distances (Asheim and Gertler, 2005; Moodysson et al., 2008). However, the benign association with collaboration with international scientific institutions does raise the question of why this type of collaboration is not used more frequently by firms (cf. Figure 4). While Laursen et al. (2011) find that UK "firms appear to give preference to the research quality of the university partner over geographical closeness", only a limited number of Norwegian firms seem to consider foreign universities as viable partners. Those who do use such partners tend to be more innovative.

7. Conclusions

This paper has sought to substantiate the global pipelines metaphor by examining the role of international personal and formal networks, as well as global buzz with strangers and virtual buzz, in innovation in Norway. The paper contributes to a contingency-theoretic perspective on inter-organizational relationships for innovation. There are three main contributions to the literature.

First, this paper provides novel evidence for an association between international networks and the level of innovativeness, which goes beyond Fitjar and Rodríguez-Pose (2011). Innovative firms tend to be more involved in international personal and formal networks than non-innovative ones. This is particularly so for radically innovative firms. Whilst one might debate the direction of causality and the underlying mechanisms, this suggests that the international dimension of networks as global pipelines represents an important feature for innovation.

A second novel contribution is to compare and contrast the role of personal networks with formal networks at various spatial scales, and to include the alternative mechanisms of global buzz with strangers and virtual buzz in the multivariate model. Importantly, whilst regional and national networks of both personal and formal types are much more widespread than international ones, only international networks are significantly associated with product innovation. Yet there are important differences in how different types of networks are related to innovation. Foreign personal networks have the most robust associations with product innovation, whilst the diversity of foreign firm partners is associated with radical product innovation only. For process innovation, there are no statistically significant associations with networks at any scale. However, the analysis suggests that global buzz with strangers, enabled through temporary clusters, may be positively related to process innovation. Overall, this suggests that firms benefit from developing a wide range of international relations, as each has an independent relationship with innovation. The results are consistent with the view that international global pipelines in the form of inter-organisational personal networks and a range of formal networks—as well as global buzz with strangers—are vital for sourcing fresh knowledge for innovation. The latter might not be available within national boundaries in increasingly complex and

specialised knowledge bases, particularly in relatively small countries such as Norway. International networks might not only be important for sourcing cutting-edge technological innovation, but they might also be critical for the development of market knowledge (Huber, 2013) necessary for serving international markets (Huggins et al., 2012). International linkages might make firms more innovative or innovative firms, by the nature of their activities, might require international linkages for their operations. All this suggests that not all spatial scales of networks are necessarily important for innovation. Yet, arguably, the role of spatial scales can vary according to the context of specific firms.

Third, the paper elaborates on the question of which specific types of international formal networks are associated with innovation, finding that international partnerships with scientific institutions are important for incremental and radical product innovation, as well as for radical process innovation. Furthermore, the results substantiate that international partnerships with customers are related with radical product innovation. These partnerships also tend to be positively associated with process innovation. Moreover, international suppliers are positively related to incremental product innovation but not radical innovation, possibly because of the path-dependent nature of supplier relationships.

Several issues could not be addressed by this study and require further research. First, whilst firm context may influence knowledge networks (Giuliani, 2007), the analysis did not systematically control for internal innovation-related resources such as R&D spending, internal communication or organisational routines. More research is needed on the role of firm context and the interaction with external networks (Ebersberger and Herstad, 2013). The low R^2 obtained in the analysis highlight the continued importance of contingency and individual firm context in determining innovation

outcomes. Second, the exact causal mechanisms underlying the associations need to be examined by future research. Third, global pipelines can also take place within transnational corporations (Faulconbridge, 2006), which was not the focus of this paper, even if collaboration with other firms within conglomerates was probed and was not significantly related to innovation. Fourth, knowledge sourcing might operate differently for other job positions such as purely technical ones (Huber, 2013). Fifth, it remains to be seen whether these patterns hold in other countries. We have argued that generalisation of the findings seem most relevant for countries with a limited national innovation base, either countries with a small population or larger countries with low levels of innovation. Moreover, the national industry composition (e.g. Norway's strong natural-resource based industries) might matter, which needs to be further explored. Finally, successful use of international networks might require a certain absorptive capacity in the form of general education and technical knowledge, as well as foreign language and intercultural communication skills, which might be easier to access in a highly developed country, such as Norway. Finally, the relatively low response rate and the relatively low R^2 unavoidably generate uncertainty.

Overall, the results suggest that the effectiveness of widespread regional or national networking initiatives for innovation might be limited, since international access to knowledge and markets seems critical for many firms. In particular in smaller countries, innovation policy and management might benefit more from (i) facilitating the establishment and maintenance of international personal networks and international partnerships with universities/research institutions, customers and suppliers, as well as (ii) facilitating participation in international professional events such as trade fairs or conferences. Yet, as highlighted by Ebersberger and Herstad (Ebersberger and Herstad, 2013), this might mainly concern firms with high

innovation performance, whereas low innovation performance SMEs might first benefit from strengthening internal resources before benefiting from international linkages.

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Table 1: Summary statistics

	Telephone survey		Web survey	
Company size				
Median	22		25	
Interquartile range	36		36	
Mean	70.5		66.4	
Standard deviation	220.1		227.8	
Foreign ownership share				
Mean	12.8		12.1	
Standard deviation	3.2		3.2	
Industry	*N*	*Percent*	*N*	*Percent*
Mining and quarrying	31	1.9	8	1.9
El., gas and water supply	296	18.5	83	19.9
Manufacturing	12	0.8	5	1.2
Construction	258	16.1	60	14.4
Trade	276	17.2	68	16.3
Hotels and restaurants	129	8.1	27	6.5
Transport and comm.	124	7.7	27	6.5
Financial services	45	2.8	11	2.6
Other services	432	27.0	128	30.7
Total	1603	100.0	417	100.0
Region	*N*	*Percent*	*N*	*Percent*
Oslo	403	25.1	91	21.8
Bergen	401	25.0	88	21.1
Stavanger	400	24.9	140	33.5
Trondheim	300	18.7	78	18.7
Kristiansand	100	6.2	21	5.0
Total	1604	100.0	418	100.0

Table 2: Self-assessed importance of external sources of knowledge

	Not at all important	Not very important	Fairly important	Very important	N
Personal contacts	6 1.5 %	32 7.8 %	211 51.1 %	164 39.7 %	413
Global buzz with strangers	11 2.7 %	109 26.6 %	223 54.4 %	67 16.3 %	410
Online discussion forums	111 26.9 %	209 50.6 %	87 21.1 %	6 1.5 %	413
Other information on the internet	38 9.2 %	139 33.5 %	181 43.6 %	57 13.7 %	415

Table 3: Logit regression analysis of four types of innovation

	Product innovation	Radical product innovation	Process innovation	Radical process innovation
Regional personal contact	-0.43 (0.33)	-0.08 (0.31)	-0.53* (0.30)	-0.35 (0.35)
National personal contact	0.03 (0.24)	0.22 (0.25)	-0.23 (0.23)	0.06 (0.30)
Foreign personal contact	0.71*** (0.26)	0.67*** (0.26)	0.12 (0.25)	0.11 (0.31)
Diversity of regional partners	0.05 (0.07)	0.10 (0.07)	0.03 (0.07)	0.01 (0.08)
Diversity of national partners	0.08 (0.09)	-0.05 (0.08)	0.11 (0.08)	0.09 (0.09)
Diversity of foreign partners	0.17 (0.11)	0.23** (0.10)	0.12 (0.10)	0.16 (0.11)
Global buzz with strangers	0.18 (0.17)	0.18 (0.17)	0.30* (0.16)	0.46** (0.21)
Virtual buzz	0.01 (0.09)	0.02 (0.09)	-0.02 (0.09)	-0.07 (0.11)
Manager's education level	-0.00 (0.05)	0.04 (0.05)	0.05 (0.05)	0.09 (0.07)
Manager's age	-0.01 (0.01)	0.00 (0.01)	0.00 (0.01)	0.03* (0.02)
Log no. of employees	0.04 (0.12)	-0.06 (0.12)	0.05 (0.12)	-0.04 (0.15)
Manager's log no. company dir.ships	0.22 (0.16)	0.03 (0.16)	-0.02 (0.15)	-0.29 (0.20)
Share held by foreign owners	0.48 (0.45)	0.23 (0.39)	0.01 (0.39)	-0.41 (0.48)
Industry	Controlled*	Controlled**	Controlled***	Controlled*
Region	Controlled*	Controlled	Controlled	Controlled
Constant	0.51 (1.18)	-2.52** (1.21)	-0.65 (1.11)	-3.91*** (1.45)
N	407	407	407	380[a]
Pseudo R^2	0.13	0.13	0.08	0.09

Note: * = P < 0.10 ** = P < 0.05 *** = P < 0.01

The top number in each cell denotes the coefficient, with the standard error listed below in parentheses.

[a] *Industry: Hotels and restaurants* predicts failure perfectly and had to be dropped from the analysis.

Table 4: Logit regression analysis, using type of foreign firm partner

	Product innovation	Radical product innovation	Process innovation	Radical process innovation
Foreign personal contact	0.68*** (0.26)	0.72*** (0.26)	0.15 (0.25)	0.14 (0.31)
Foreign parent, sister or subsidiary	-0.21 (0.39)	0.17 (0.37)	0.08 (0.35)	0.04 (0.42)
Foreign suppliers	0.61** (0.30)	0.04 (0.29)	-0.06 (0.28)	0.36 (0.35)
Foreign customers	0.05 (0.34)	0.81** (0.32)	0.53* (0.30)	-0.14 (0.38)
Foreign competitors	-0.33 (0.43)	-0.79* (0.43)	0.30 (0.39)	-0.25 (0.48)
Foreign STI partners	1.04** (0.46)	0.76** (0.38)	0.25 (0.37)	0.87** (0.41)
Global buzz with strangers	0.17 (0.17)	0.19 (0.18)	0.29* (0.16)	0.49** (0.22)
Virtual buzz	0.04 (0.09)	0.05 (0.09)	-0.02 (0.09)	-0.05 (0.11)
Manager's education level	-0.01 (0.05)	0.05 (0.06)	0.06 (0.05)	0.09 (0.07)
Manager's age	-0.01 (0.01)	-0.00 (0.01)	0.00 (0.01)	0.03* (0.02)
Log no. of employees	0.07 (0.12)	-0.05 (0.12)	0.06 (0.11)	0.01 (0.14)
Manager's log no. company dir.ships	0.24 (0.16)	-0.01 (0.16)	-0.01 (0.15)	-0.30 (0.20)
Share held by foreign owners	0.58 (0.51)	-0.04 (0.45)	-0.00 (0.44)	-0.48 (0.53)
Industry	Controlled**	Controlled*	Controlled**	Controlled*
Region	Controlled**	Controlled	Controlled	Controlled
Constant	0.30 (1.10)	-2.27** (1.13)	-1.27 (1.04)	-4.18*** (1.38)
N	407	407	407	380[a]
Pseudo R^2	0.13	0.14	0.08	0.09

Note: * = P < 0.10 ** = P < 0.05 *** = P < 0.01

The top number in each cell denotes the coefficient, with the standard error listed below in parentheses.

[a] *Industry: Hotels and restaurants* predicts failure perfectly and had to be dropped from the analysis.

Figure 1: Share of managers with personal contacts at various scales by level of product innovation

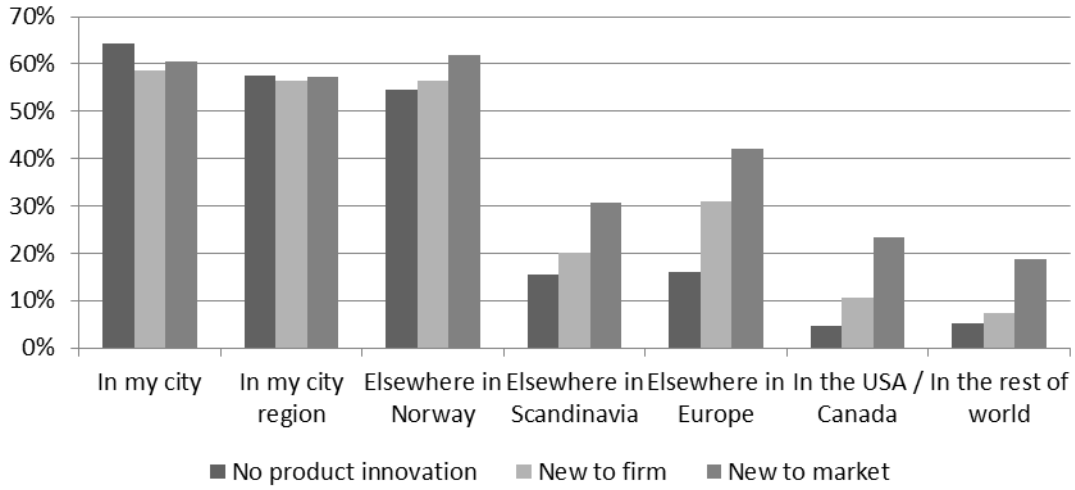

Figure 2: Share of managers with personal contacts at various scales by level of process innovation

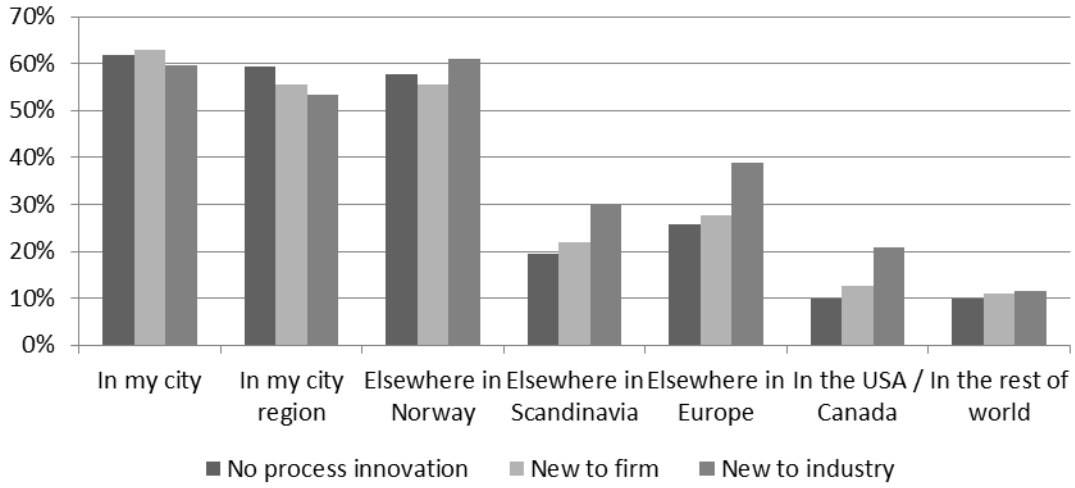

Figure 3: Number of firm partner types at different geographical scales by level of product innovation

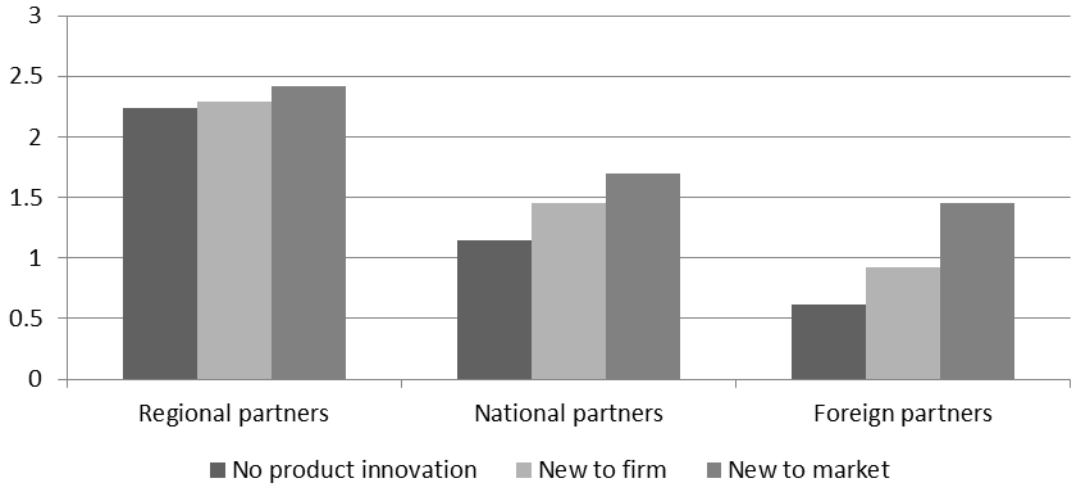

Figure 4: Percent using different types of foreign formal partners by level of product innovation