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Knowledge context, learning and innovation: an integrating framework

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ABSTRACT

In this conceptual paper, we develop a framework which identifies those elements of firms' knowledge context which are important for innovation, and the mechanisms through which that knowledge impacts on firms' innovation performance. We make four main contributions to the existing literature. First, our characterisation of knowledge context provides the basis for a more specific identification of which elements of firms' knowledge environment are important for innovation, discriminating between spatial, sectoral and network influences. Second, we reflect the role of innovation ambition in shaping firms' knowledge search strategies. Third, we differentiate between firms' interactive and non-interactive knowledge search activities and recognise that these may be complemented by unanticipated and serendipitous knowledge spillovers. Finally, we employ the notion of encoding capacity to reflect firms' internal ability to assimilate and apply external knowledge, and clarify its distinctiveness from the more general concept of absorptive capacity. Our framework provides an integrating mechanism for existing empirical studies, and suggests a number of new research directions related to the determinants of innovation performance and the heterogeneity of innovation outcomes.

KEYWORDS

Knowledge; innovation; ambition; sector; learning

JEL CLASSIFICATION

O31; O32; O44

1. Introduction

Contextual influences on innovation have attracted significant recent attention (Carney et al. 2011), with strategic implications as firms seek to establish coherence between their organisational strategies and their context, and so maximise the value of their organisational assets and capabilities (Akgun, Keskin, and Byrne 2012; Vaccaro et al. 2012). Discussion of governments' ability to create advantage by shaping the framework conditions within which firms operate also focuses attention on the contextual influences on innovation (Asheim et al. 2007; Todtling, Asheim, and Boschma 2013), and the interplay between these contextual influences and firms' own internal competencies (Cassiman and Veugelers 2002a; Cassiman and Veugelers 2006).

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In this conceptual paper, we develop a framework within which it is possible to identify those elements of firms' knowledge context which are important for innovation, and the mechanisms through which that knowledge impacts on firms' innovation performance.¹ The argument proceeds in three stages. In Section 2, we focus on the relationship between knowledge and innovation identifying some of the specificities of locational, sectoral and network elements of the knowledge context for innovation. Knowledge linked to specific locations, sectors and networks have different characteristics but a consistent theme is that the impact of context on innovation depends on firms' willingness or ability to take advantage of external knowledge (Wolfe 2009). In Section 3, we then discuss the role of agency and ambition in determining 'why' firms seek to access external knowledge and their willingness to invest in external relationships and knowledge search. Individual firms may not only react very differently in terms of their strategic responses to a given knowledge context (Arvanitis et al. 2015), but may also vary in their capacity to take advantage of the external knowledge that is available (Cohen and Levinthal 1990).

Section 4 focusses on 'how' firms can benefit from external knowledge for innovation – through interactive relationships, non-interactive search, spillovers and through investments in capacity building (Glückler 2013). Here, we also consider how firms' internal capabilities may moderate the relationship between external knowledge and its effect on innovation performance. These capabilities – which we call encoding capacity – vary markedly between firms, forming part of what economists describe as 'unobserved heterogeneity'. Section 5 integrates the contextual and firm-level elements of the framework, and the final section and outlines the research questions this suggests.

Our contribution is explicitly conceptual, and we draw on a range of empirical studies which are illustrative of the key arguments. In doing so we directly contribute to the objectives of this special issue, by developing conceptual models which add to our understanding of 'how learning and innovation take place across geographical and organizational boundaries', and helping to show 'how different kinds of knowledge and knowing combine in innovation processes in private firms and public organizations.'² Our characterisation of knowledge context provides the basis for a more specific identification of which elements of firms' knowledge environment are important for innovation, discriminating between spatial, sectoral and network influences. Further, we argue that the vagueness of the absorptive capacity concept has been a barrier rather than an enabler of understanding, and suggest a focus on a conceptualisation built around more readily measurable constructs, including encoding capacity. Our framework therefore provides an integrating mechanism for empirical studies,³ and suggests a number of new research directions related to the determinants of innovation performance and the heterogeneity of innovation outcomes.

2. Knowledge and innovation

Definitions of innovation vary, but generally stress the commercialisation of new knowledge or technology to generate increased sales or business value. The U.S. Advisory Committee

¹Love and Roper (2015) in their review of the firm-level evidence on the key 'external enablers' of (SME) innovation and exporting also note the potential importance of external resource enhancing or augmenting factors which may help firms to overcome internal resource constraints.

²Taken from the call for a special issue on 'Knowledge Dynamics, Innovation and Learning'.

³See Roper, Love, and Bonner (2017) for an example of the use of this integrating framework.

on Measuring Innovation, for example, defines innovation as: ‘The design, invention, development and/or implementation of new or altered products, services, processes, systems, organisational structures or business models for the purpose of creating new value for customers and financial returns for the firm’ (Advisory Committee on Measuring Innovation in the 21st Century Economy 2008, i). The link between innovation and knowledge is more explicit in the following definition of innovation developed by the UK House of Lords Select Committee on Science and Technology in 1991: innovation is the ‘commercial application of knowledge or techniques in new ways or for new ends. It may involve radical innovation or incremental innovation. In each case the innovator achieves a competitive advantage, at least until another company catches up or goes one better.’ Hansen and Birkinshaw (2007) suggest that the innovation process can be represented as an innovation value chain (IVC) comprising three stages. The first of these includes firms’ efforts to source the bundle of different types of knowledge necessary for innovation (Hansen and Birkinshaw 2007; Roper, Du, and Love 2008). This may involve firms undertaking in-house knowledge creation – through either design or R&D activities – alongside, and either complementing or substituting for, external knowledge sourcing (Pittaway et al. 2004).⁴ The next stage in the IVC is the process of transforming this knowledge into new services or business processes. This ‘encoding’ activity may again involve a combination of firms’ internal and external resources (Love, Roper, and Bryson 2011). The final stage in the IVC relates to the exploitation of firms’ innovations through product creation and the generation of added value through commercialisation. Each stage of the IVC is likely to require different types of knowledge, and different types of partners (Rosenkopf and Nerkar 2001; Rothaermel and Deeds 2004).

Implicit in the open innovation variants of the IVC (Love, Roper, and Bryson 2011) is the idea of contingency, i.e. that appropriate strategy decisions and outcomes depend on the market environment in which a firm operates.⁵ In studies of business failure, for example, contingency models focus on the effect of the market environment on the implications of strategic decisions such as the relative timing of technological developments, and the technological complexity of new product offerings (Bayus and Agarwal 2007; Christensen, Suarez, and Utterback 1998; Colombo and Delmastro 2001). In terms of innovation, Mueller, Rosenbusch, and Bausch (2013) highlight a number of studies which have related innovation success to industry level factors such as R&D intensity, market dynamism and concentration.⁶

A key element of all contingency models is a clear view of the context within which a firm is operating, and on which contingencies will be based. Our focus here is on the knowledge context for innovation. We begin in this section by profiling the spatial, network and sectoral elements of knowledge context.

⁴Cassiman and Veugelers (2002b), for example, find evidence of a complementary relationship between firms’ internal R&D and firms’ ability to benefit from external knowledge sources. Other studies, however, have identified a substitute relationship between internal knowledge investments and external knowledge sourcing. Schmidt (2010, 14), for example, notes that for Germany ‘firms with higher R&D intensities have a lower demand for external knowledge than firms with lower R&D intensities. The more R&D is done in-house the more knowledge is generated internally, and the less external knowledge is required’.

⁵Christensen, Suarez, and Utterback (1998) describe this as an ‘integrative perspective’.

⁶Mueller, Rosenbusch, and Bausch (2013) also note the potential moderating effect of firms’ internal resources – absorptive capacity – in moderating the effects on innovation of such industry level factors, a theme we return to in later sections.

2.1. Locational knowledge specificities

Despite – and in some instances because of – increases in global connectivity, knowledge and information continue to have a specific physical geography. Some nations, regions and local areas remain more ‘knowledge rich’ than others with potentially important consequences for firms’ location decisions (Lorentzen 2007) and the ability of firms in any specific location to develop innovations (van Beers and van der Panne 2011).⁷ In some senses therefore, knowledge is by definition ‘local’, i.e. it has some dimension of spatial specificity which in any location makes it different to the pool of knowledge available or accessible in other localities.⁸ In this sense, local knowledge may have the character of a semi-public – or even public good – with local properties of non-rivalry. As He and Wong (2012) suggest:

local knowledge is thus conceptualised as a semi-public good that is spatially bounded, and access to which requires nothing more than cluster membership. Next, local knowledge exchange is prompt or spontaneous because local firms are assumed to be more willing to share knowledge and exchange ideas with other local actors as a result of shared norms, values, and other formal and informal institutions that hold down misunderstanding and opportunism. (He and Wong 2012, 542)

Localised knowledge may also have other spatially distinct characteristics, reflecting the presence of specific institutions (typically universities, research labs), clusters of industrial activity, and/or concentrations of specific types of human capital. The character of these institutions may lead to very different subject or quality profiles of local knowledge. Universities with particular areas of research strength may intensify local knowledge in particular disciplines or technologies promoting cluster development and sustainability (Calzonetti, Miller, and Reid 2012). Alternatively, the presence of large-scale scientific research facilities – such as those linked to nuclear activity, biotechnology or particle acceleration – may create very specific local knowledge conditions and stimulate cluster formation.

Localised knowledge may also be linked to traditional knowledge, however, related to local environmental or agricultural conditions. Cannarella and Piccioni (2011) argue that such traditional knowledge may also be important in stimulating local innovation – traditio-vations – particularly where it is combined with inflows of non-local or distant knowledge. The potential for local knowledge to drive or contribute to global innovation is also implicit in the ‘learn local, act global’ business strategies of companies such as Toyota (Ichijo and Kohlbacher 2008).

To the extent that local knowledge influences innovation performance, variations in the specific characteristics of local knowledge (both in terms of content and richness) have the potential to shape matching variations in innovation success (Toedting, Lengauer, and Hoeglinger 2011; Jensen and Tragardh 2004). This also suggests the potential for local, regional or urban strategies to influence the characteristics of local knowledge as a means of driving competitiveness (Asheim et al. 2007; Hewitt-Dundas and Roper 2011).

⁷Discussion of the ‘digital divide’ and ‘digital exclusion’ emphasise the spatial and social elements of the same phenomena (Horriagan 2011).

⁸Typically, the spatial specificity of knowledge is linked to its tacit component ‘rooted in practice and technical. It is more related to know-how (procedural knowledge as opposite to declarative knowledge, or know-what/why knowledge). Often, the degree of codification in firms is very low, and the experience of more skilled workers is passed on to the newer generations through the word-of-mouth mechanism or face-to-face contacts’ (Belussi and Sedita 2012, 167).

2.2. Networks

In any specific location, the availability of knowledge and information is therefore likely to have some specific characteristics – whether knowledge is tacit, institutionally or sectorally embedded or traditional. The accessibility or availability of knowledge, however, is also likely to depend on the density of connections in the area in which a firm is operating and which might facilitate knowledge sharing and diffusion. Wolfe (2009) comments on Canada that:

The mere presence, or absence, of key institutional elements of the local or regional innovation system also affects their innovative capacity and their potential to serve as nodes for cluster development. Many clusters enjoy the knowledge assets and research infrastructure that are necessary for the development of an innovation-based development strategy, but they differ dramatically in their capacity to mobilize these assets in the pursuit of such a strategy. (Wolfe 2009, 186)

This is not to suggest – for the moment – that the extent or density of firms' own networks matter for innovation – this is discussed below – but rather that the extent of networking activity in the area in which a firm is located may be influential (Belussi et al. 2011; Spencer 2003). On the basis of an examination of technology diffusion in the flat-screen television sector, for example, Spencer (2003) suggests that⁹:

- High levels of network density are likely to be associated with higher levels of innovative activity and competitiveness and
- Dense or strongly centralised networks are more likely to facilitate convergence on a dominant design than less dense networks.

The suggestion is that network structure as well as the density of connections itself is important in shaping knowledge diffusion and, hence, innovation. In particular, Kesidou and Snijders (2012) find that gatekeeper firms, with strong external connections and extensive networks of linkages within the cluster play a particularly important role. Feldman (2003), Agrawal and Cockburn (2002) call similar firms 'anchor' companies, while Lorenzoni, Russo, and Ferriani (2010) also highlight the 'anchoring' role of multinational firms and universities.

To the extent that networks facilitate knowledge diffusion, they may either strengthen or offset the performance effects of variations in local knowledge. Intra-regional networks may, for example, have positive developmental effects by strengthening local knowledge diffusion, effects epitomised in the literatures on regional and local innovation systems (Shefer and Frenkel 1998; Toedtling, Lengauer, and Hoeglenger 2011). Strong intra-regional networks, particularly where these substitute for more geographically dispersed networks, may also have more negative effects through regional 'lock-in' (Dolfsma and Leydesdorff 2009; Sydow, Lerch, and Staber 2010). Spatially dispersed networks on the other hand may generate inter-regional knowledge flows weakening any locally specific effects either positive or negative. The extent of any such networks are likely to be strongly linked to ownership structures as in multi-national companies, supply chains or collaborative development projects (Breschi and Malerba 2011).

⁹Comparing the diverse experience of US and Japanese networks Spencer (2003) also suggests that cultural factors may also shape network structure: Corporatist countries are more likely to have greater network density than pluralist countries.

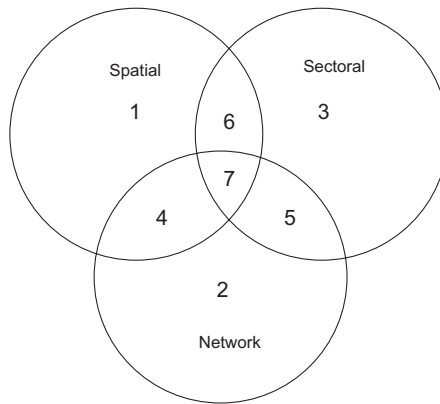


Figure 1. Elements of knowledge context.

2.3. Sectoral influences

The characteristics of the sector may also be important in shaping the knowledge context within which a firm is operating. It has long been observed, for example, that technological opportunity and intensity – measured for example by R&D spending and the average propensity to innovate (both product and process) – varies substantially across industries, but relatively little within industries through time (Levin, Cohen, and Mowery 1985). This has led to the contention that there are some, technology-based sectors in which the opportunities for innovation are intrinsically greater than that in other sectors. The nature of these technological opportunities, however, is often hard to define. Jaffe defines the term as ‘exogenous, technologically determined variations in the productivity of R&D’ (Jaffe 1986), while Klevorick et al. (1995, 188) prefer ‘the set of possibilities for technological advance’.¹⁰ Defined in either way, the possibility is clear: the nature of technological opportunities in a particular sector may also shape or limit the type of innovation which is undertaken. The technological opportunities in a sector may also influence the types of innovation opportunities available to firms. For instance, survival and prosperity in low value added industries are often based on high sales volumes, which means firms in these industries might place more emphasis on process rather than product innovation. On the other hand, firms in high value added industries might have more incentive to create distinguishable/unique products. Two other sectoral characteristics also have potentially important, and interacting, implications for innovation: competition (Aghion et al. (2005) and appropriability (Leiponen and Byma 2009).

Profiles of sectoral knowledge will therefore depend strongly on the maturity of the sector, the extent of competition and/or the potential for controlling appropriation either through legal or strategic mechanisms. Each has potential implications for firms’ innovation and export behaviour. The interaction of contextual influence of spatial and sectoral factors has been described in the literatures on industrial districts (Belussi and Sedita 2012; Parrilli 2004) and clustering (Beamish, Craig, and McLellan 1993). Sectoral networks, trade

¹⁰Finding suitable proxies to measure technological opportunities also proves difficult: Jaffe uses relatively simple ‘technological cluster’ dummies, based around high- and low-tech sectors, a fairly typical approach in the literature. Roper, Vahter, and Love (2013) use sectoral R&D intensity partially as a proxy for underlying technological opportunity.

associations or partnerships initiatives such as standards bodies may reinforce these linkages and enhance the competitive advantage of insiders (Bessant et al. 2012; Carayannis and Campbell 2009).

2.4. Knowledge context – towards an integrated view

The spatial, network and sectoral aspects of firms' knowledge context outlined earlier are clearly differentiable (Figure 1). Spatial influences (Area 1 in Figure 1), with specifically locational influences on innovation, have been considered in the literatures on geographical proximity and knowledge transfer (Parjanen, Melkas, and Uotila 2011), regional innovation systems (Braczyk, Cooke, and Heidenreich 1998; Buesa et al. 2006), structures and policy, with a particular focus on the impact of regional inequalities. Local contributors to innovation have also been considered (Shum and Watanabe 2008), along with the innovation effects of firms' location in metropolitan environments (Shefer and Frenkel 1998; Shefer, Frenkel, and Roper 2003).

Pure network effects (Area 2 in Figure 1) are reflected most clearly in studies of business groups and affiliations (Carney et al. 2011; Chang, Chung, and Mahmood 2006), business networks and associations (Balla 2001; Newell and Swan 1995). Such studies are more common in entrepreneurship research rather than innovation studies, however, where the effects of network membership on business growth and ambition have been extensively researched (Watson 2012). Pure sectoral effects on innovation (Area 3 in Figure 1) reflect more traditional Schumpeterian approaches in industrial economics with a focus on sectoral structure and concentration and their impact on technological development (Harris and Trainor 1995; Levin and Reiss 1984). Such studies have tended also to focus on more traditional drivers of innovation at firm level, however, such as R&D, ignoring the insights of studies of open innovation (Laursen and Salter 2006). More recent studies have however looked beyond industrial structure itself to also include related scientific or educational institutions along with science parks or enterprise zones (Yang and Huang 2005). This broader perspective is most evident in the literature on sectoral innovation systems which integrates Schumpeterian perspectives on firm size with more institutional and historical perspectives on institutional development and inter-relationships (Daim 2005; Malerba 2004).

Situations where pure spatial, network or sectoral effects dominate are, however, relatively unusual in the empirical literature and the majority of studies reflect the interaction or intersection of these effects creating more complex configurations (Figure 1). More specifically:

- Spatial and network elements of knowledge context (Area 4 in Figure 1) interact in the literatures on local, regional or community networks and local linkages whether through alliances, partnerships or along the supply chain (Bae and Koo 2009; Brown and Duguid 2002; Massard 2011).
- Network and sectoral elements of knowledge context (Area 5 in Figure 1) come together in literatures on trade associations or sectoral networks, sectoral technology development networks such as competence centres (Comacchio, Bonesso, and Pizzi 2012; Vinnova 2004) as well as international supply chain linkages (Ernst and Kim 2002).
- The conjunction of location and sectoral influences (Area 6 in Figure 1) is considered in a number of research studies related to industrial districts and the advantages of industrial co-location, including co-location of firms in the same sector within a given

geographic area (Marshallian agglomeration), or co-location of firms in different sectors within a given geographic area (Jacobian agglomeration) (Belussi and Sedita 2012; D'Angelo et al. 2013; Munari, Sobrero, and Malipiero 2012).

Finally, the conjunction of all three elements of knowledge context (Area 7 in Figure 1) – spatial, sectoral and network – is reflected most clearly in discussion of local or regional sectoral clusters, networks or partnerships. Clustering may, for example, generate agglomeration economies either related to regional specialisation or differentiation (Audretsch 1998; Chai and Huang 2007). Clustering may also have a more organisational origin reflecting initiatives such as science parks or special economic zones (Hu 2011).

3. From knowledge to innovation – agency and ambition

Within a given operating context the opportunities for knowledge acquisition for each firm are very similar. In a situation where firms also have similar internal knowledge resources we might expect this to lead to consistent forms of engagement with external organisations and to common profiles of innovation output. This is not what we observe, however, with levels of innovative activity varying widely within any given sector for example (Roper et al. 2009), as well as a variety of different strategies for engaging with the external knowledge context (Arvanitis et al. 2015). What creates this difference in firms' ability – or willingness – to generate innovation in any given context? Here, we consider issues of agency and ambition, which can influence the effect of any given knowledge context on firms' innovation activity, and which help create a diversity of innovation outcomes (Cohen and Levinthal 1989).

Ambitious entrepreneurs, who actively seek growth and engage in expansion opportunities for their businesses, adopt significantly different strategies to those content with less rapid growth. Gundry and Welsch (2001) for example, identify ambitious entrepreneurs as those who have, among other characteristics, strategic intentions that emphasise market growth and innovation and adopt a wider range of financing sources for the business. More broadly, in the innovation literature a distinction has been made between more ambitious innovation-based and imitation-based strategies:

Innovation orientation refers to a firm that has a strategy of developing and introducing innovative new products and services into the market before their competitors ... companies with an imitation orientation, try to avoid the exorbitant costs associated with basic scientific investigation and the development of novel technologies and adopt competitor's ideas and technology. (Naranjo-Valencia, Jimenez-Jimenez, and Sanz-Valle 2011, 56)

Innovation-based strategies focus on either disruptive or radical innovation which is either new to the world or at least new to the market. This type of strategy is likely to involve proactive, interactive and exploratory knowledge search strategies with partner choice depending on the type of innovation objective (i.e. product, process, service). Imitation-based strategies on the other hand focus on new-to-the-firm innovations and may rely purely on non-interactive approaches to knowledge acquisition or knowledge spillovers (Ulhoi 2012).

The innovation decisions that individual firms make in response to a given context will depend on their ambition and the perceived risks and rewards of different types of innovative activity. More ambitious firms may adopt innovation-based strategies involving new-to-the-market innovations, while imitations are new products or services, which are

new-to-the-firm but now new-to-the-market (Bolton 1993; Schnaars 1994; Shenkar 2010).¹¹ Innovation-based and imitation-based strategies have very different risks and rewards. Innovation may create first-mover advantages for the innovating firm. These may lead to higher returns from a desirable and unique product or service but may also have other advantages in terms of helping the first mover to learn rapidly about the markets and build brand loyalty among customers (Kopel and Löffler 2008).¹² For imitators on the other hand the potential for ‘second mover advantages’ are also evident. Perhaps the key advantage for imitators is that the market leader has already taken much of the uncertainty out of the initial product or service introduction.¹³ On the production side this may mean that the imitator can copy, emulate or reverse engineer the product design or service delivery of an innovator. On the demand side, the imitator can learn from the innovator about consumers’ appetite for a particular product or service and what consumers are prepared to pay. The imitator’s problem however is not always simple as they try to establish a position in a market share in which there is already at least one established player (Ulhoi 2012). Second mover advantages can certainly occur at a firm level and there is some evidence – particularly in less dynamic markets – that imitation may be a more profitable strategy than innovation (Lieberman and Asaba 2006).¹⁴

Innovation strategy may also involve process innovations which yield significant performance gains to the innovating firm (Rasiah, Gopal, and Sanjivee 2013). Strategies involving the adoption of advanced management techniques (AMTs), for example, may enable firms to develop more flexible and adaptive production systems allowing smaller batch sizes and enabling firms to cope better with perceived environmental uncertainty (Hofmann and Orr 2005; Zammuto and Oconnor 1992), changes to regulation etc. More flexible production systems may also allow firms to adopt more complex innovation strategies with potentially higher returns (Hewitt-Dundas 2004). Process innovation may also facilitate more radical innovation strategies as firms seek to create market turbulence by engaging in disruptive innovation in order to establish a position of market or technological leadership (Anthony et al. 2008; Hang, Chen, and Subramian 2010).

Firms’ innovation ambition may also shape the type of search partners with which they engage as different partners provide very different types of knowledge (Schmidt 2010). One recent study of Finnish firms, for example, relates the search behaviour of different types to firms’ strategic orientation, or in other words suggests that strategic orientation may moderate the nature of firms’ search behaviour (Ritala et al. 2013). Unsurprisingly perhaps firms with a ‘customer relations orientation’ emphasise knowledge search relationships with

¹¹Imitation may, of course, be of very different types ranging from licensed or unlicensed (counterfeit) copying of a product or service, through mimic products which copy some or all of the features of an innovative product or service, to products which emulate an existing product but may actually be better than the established market leader (Ulhoi 2012).

¹²A key issue for innovators in any market place, however, is their ability to sustain their position of market leadership. In some sectors – biotechnology or engineering – this may involve formal strategies such as patenting to protect intellectual property; in other sectors more strategic approaches may be adopted such as frequent changes or upgrades to product or service design. Aggressive pricing also provides a way in which market leaders may protect any first mover advantages (Ulhoi 2012).

¹³Imitation may also be a stepping stone towards innovation as firms build innovative capabilities. This process is perhaps clearest in developing economies where firms have steadily developed their R&D and creative competencies. On Korea see (Kim 1997), on Taiwan (Hobday 1995), on China (Lim and Kocaoglu 2011) and on Brazil, (Dorion, Pavoni, and Chalela 2008).

¹⁴Imitation – second-mover – strategies may provide individual firms with a less risky option than innovation. At an industry and social level, however, imitation can have either positive or negative effects. On the positive side imitation may help to maximise the social and consumer benefits of the original innovation by making products or services available to more consumers. Imitation may also have negative effects, however, by reducing the variety of products or services within a market and increasing the collective vulnerability to external competition (Lieberman and Asaba 2006).

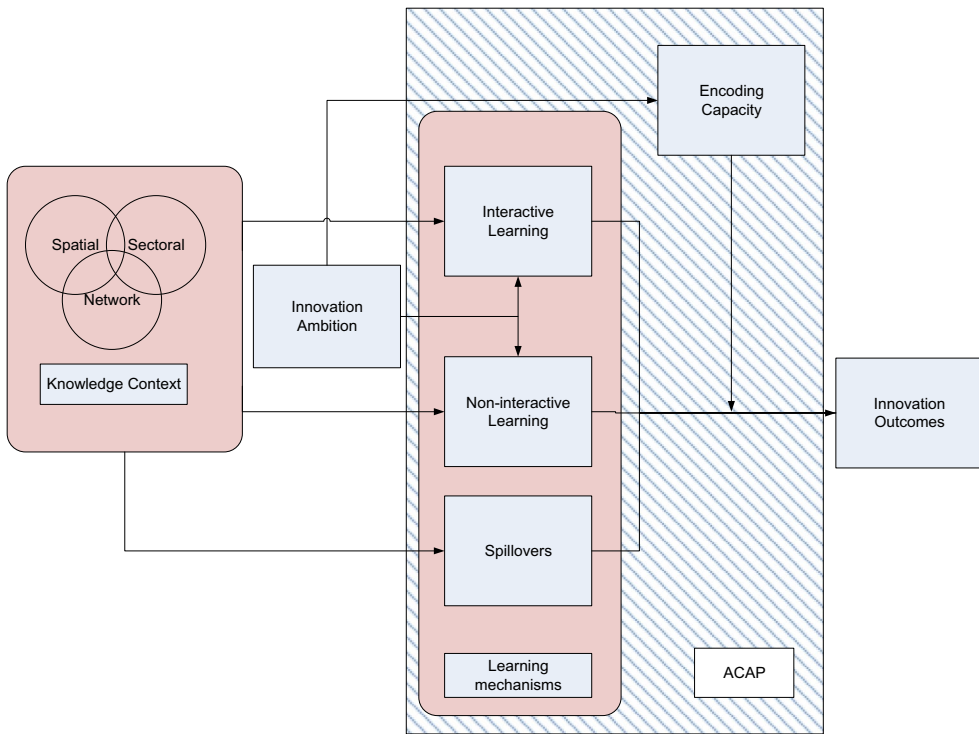


Figure 2. Knowledge context, learning and innovation.

customers while firms with a more technological orientation emphasise links to universities and other technology providers. Firms with more ambitious entrepreneurial orientation – and by implication an innovation-based strategy – tend to emphasise a broader range of search partners. This leads to the next area of interest: how firms access external knowledge for innovation.

4. Accessing external knowledge

Even with a suitable level of ambition, merely being present within a given knowledge environment does not guarantee that a firm will be able to absorb and use knowledge from the environment: some process of learning must occur, either deliberate or unintended. Learning can be considered as a ‘reflexive, interactive and continuous process of recombining information and existing knowledge with new insights’ (Glückler 2013, 881). More specifically, organizational learning involves being able to access both internal and external knowledge and build appropriate competences and routines to make use of this knowledge (Powell, Koput, and Smith-Doerr 1996).

Following Cohen and Levinthal (1990) this process is typically reflected in discussions of the broad notion of absorptive capacity which reflects both the multiple channels through which firms can search for and acquire knowledge and the capability to utilise the knowledge acquired. More specifically, we can identify three main types of mechanism through which firms may access, absorb and use external knowledge which may influence their innovation activity (Figure 2). First, firms may form deliberate, purposive relationships with other

firms or organisations as a means of acquiring or accessing new knowledge. These might be partnerships, network linkages or contractually based agreements entered into on either a formal or informal basis. This type of relationship is characterised by strategic intent and mutual engagement of both parties, and may be characterised as a form of interactive learning (Glückler 2013). Second, firms might acquire knowledge deliberately but without the direct engagement of another party. Examples of this type of mechanism include imitation, reverse engineering or participation in network or knowledge dissemination events. Here, there is a clear strategic intent on the part of the focal firm but no mutuality in the process, and may be characterised as non-interactive learning. For example, in their analysis of university–business relationships (Hewitt-Dundas and Roper 2011) distinguish between knowledge partnerships ‘characterised by a two-way flow of knowledge, e.g. through formal or informal joint ventures or collaborative R&D projects’ and knowledge suppliers ‘characterised by a more uni-directional transfer of knowledge’. Both interactive and non-interactive knowledge search – although perhaps more the latter – can be considered forms of in-bound open innovation (Parida, Westerberg, and Frishammar 2012; Spithoven, Clarysse, and Knockaert 2011) Third, firms may acquire knowledge vicariously and unintentionally through informal spillover mechanisms such as social contacts between employees and those in other firms, media publicity or demonstration effects, or through the mobility of labour between enterprises.¹⁵ These pure knowledge spillovers represent un-priced gains to the firm, effectively increasing the social returns to knowledge.¹⁶

We discuss each mechanism in turn and also consider, as the other element of absorptive capacity, ‘encoding capacity’, the ability of a firm to take advantage of external knowledge in its innovation activity (Figure 2).

4.1. Interactive learning

Interactive learning is characterised by firms strategically building links and relationships with other firms and economic actors (e.g. research institutes, universities and government departments) to capitalise on the knowledge of the linked parties or to cooperate with the linked parties and explore and/or exploit the knowledge together (Borgatti and Halgin 2011). Three characteristics seem important in interactive learning: the number of interactions or relationships the firm has; the mode of interaction adopted; and the nature of the embeddedness of the networks in which firms are involved (Borgatti and Halgin 2011; Glückler 2013). Firms’ internal capabilities may also need to be matched to the type of external knowledge the firm is seeking (Spithoven, Clarysse, and Knockaert 2011). Vega-Jurado, Gutierrez-Gracia, and Fernandez-de-Lucio (2009), for example, draw a distinction between scientific and sectoral absorptive capacity while Laviolette, Redien-Collot, and Teglborg (2016) highlight the role of employees other than R&D and technological staff in capturing ‘user knowledge’.

At its simplest, interactive learning and knowledge acquisition can be positively affected merely by the firms’ number of relationships. This is most clearly shown by the analysis of the ‘breadth’ of external linkages on innovation performance. In purely statistical terms,

¹⁵Recruitment may also be a strategic knowledge acquisition strategy with positive implications for firms’ innovation outputs (Al-Laham, Tzabbar, and Amburgey 2011; Diaz-Diaz and De Saa-Perez 2012).

¹⁶This type of spillover effect has received relatively little attention in the innovation literature but has been widely researched in the literature on FDI and inward investment (Crespo, Fontoura, and Proenca 2009; Jordaan 2008).

since the payoff from any given innovation linkage is unknown in advance, the chances of obtaining benefit from any linkage in a given distribution of payoffs increases as the number of linkages increases (Love, Roper, and Vahter 2014). Having more linkages increases the probability of obtaining useful external knowledge that can be combined with the firm's internal knowledge to produce innovation (Leiponen and Helfat 2010). The extent or breadth of a firm's innovation linkages may also have significant network benefits, reducing the risk of 'lock-in' where firms are either less open to knowledge from outside its own region (Boschma 2005) or where firms in a region are highly specialised in certain industries, which lowers their ability to keep up with new technology and market development (Camagni 1991). However, the capacity of management to pay attention to and cognitively process many sources of information is not infinite, since the span of attention of any individual is limited (Simon 1947). This attention issue means that while the returns to additional linkages may at first be positive, eventually the firm will reach a point at which an additional linkage actually serves to diminish the innovation returns to external networking. Vahter, Love, and Roper (2014), for example, find that for small firms (with less than 50 employees) this point is reached when firms have four to five types of external linkage while for larger firms the turning point is not reached until at least 8-9 linkage types.

Numerous empirical studies find support for the implied inverted U-shaped relationship between the number of external knowledge linkages (i.e. breadth) and firm-level innovation (Garriga, von Krogh, and Spaeth 2013; Grimpe and Sofka 2009; Laursen and Salter 2006; Leiponen and Helfat 2010). Love, Roper, and Vahter (2014) find this effect extends through time: having numerous linkages in previous time periods has a positive effect on the relationship between current linkage 'breadth' and innovation, suggesting that there are learning effects present in terms of innovation linkages. In addition to the number of relationships, the empirical evidence suggests the importance of two other factors in shaping the innovation benefits of firms' interactive learning; the mode of interaction and the nature of network embeddedness. For instance, a recent empirical study on five UK manufacturing industries reveals vertical co-operative ties with buyers and suppliers has a significantly larger impact on firm-level innovation than horizontal ties with competitors. Furthermore, the positive impact of supply-chain linkages is greater for stronger dyadic relations (Tomlinson 2010). Similar results on the strength of supply-side linkages are found for Irish manufacturing firms by Roper, Du, and Love (2008). By contrast, there is evidence from both the U.K. and Norway that linkages with competitors can have a substantially negative effect on innovation (Tomlinson and Jackson 2013), with the Norwegian case finding that association with competitors could reduce radical product innovation by as much as 75% (Fitjar and Rodriguez-Pose 2013).

The effectiveness of different modes of interaction can also differ significantly depending on sector and innovation characteristics, a distinction blurred by the generality of the absorptive capacity construct. In a study of Austrian firms, the adoption of different types of interactive learning mechanism differs noticeably among firms in medium-tech, high-tech and knowledge and innovation-based services. While medium-tech and knowledge and innovation-based services firms engage more in market-based linkages (i.e. with suppliers and clients) and informal linkages at regional level, high-tech firms engage more in formal linkages such as R&D cooperation and joint use of R&D facilities (Todtling, Lehner, and Trippel 2006). The value of supply-chain relationships also depends on the complexity of activities: firms may form linkages with their suppliers and buyers only

if the innovation task is complex and cannot be accomplished internally (Oerlemans, Meeus, and Boekema 2001).

Network embeddedness can also be a moderator or facilitator of interactive knowledge and learning. Gilsing et al. (2008) show that the impact of networks differs significantly depending on the combined effects of firms' technology proximity, location in the network and network density. For instance, either being highly central or highly peripheral could be the optimal choice of network position for a firm to maximise its returns to innovation depending on the structure of the network. When technology gaps among firms in the network are small (large), centrality (peripheral position) is more efficient in generating innovation success (Gilsing et al. 2008).

The relationship between technology heterogeneity and the impact of networks on innovation is not only restricted to central or peripheral firms in a network, but may affect the innovation performance of all firms in the network, regardless of their position. For example, one longitudinal study of global telecommunications equipment firms suggests that technological diversity enhances the positive effect of networks on innovation for all firms in the network. Networks also have a stronger positive effect on innovation success when firms in the network are more technological diverse; diversity which creates more opportunities for learning (Jacobian externalities). The effects of technological diversity are also stronger in more dense networks (Phelps 2010).

4.2. Non-interactive learning

Non-interactive learning is characterised by the absence of reciprocal knowledge and/or resource transfers between actors. The most frequently discussed non-interactive modes of learning are: imitation, where a firm absorbs the knowledge of other actors through observation of the actions/behaviour of the source actor; reverse engineering, where a firm derives knowledge from the final product of another firm, obtained from the market or through supply chain interaction; and codification of knowledge, where a firm obtains knowledge through knowledge which is a public good such as news, patents and regulations etc. (Glückler 2013). Imitation, for example, may inform second mover or fast-follower type innovation strategies and may suggest alternative market entry modes (Ulhoi 2012) and may generate more significant growth impacts than innovation (Shenkar 2010).

It has been argued that non-interactive learning can intensify the impact of geographical proximity on innovation by allowing firms to more closely monitor their neighbouring firms, especially in the same sector, and to absorb the necessarily knowledge for innovation (Malmberg and Maskell 2002). Moreover, geographical proximity allows firms to share similar cultural, linguistic, education and institution frameworks, which allow them to understand, interpret, absorb and utilise public codified knowledge and information (Bathelt and Glückler 2005). Furthermore, non-interactive learning can promote information and knowledge transfer without the presence of networks among firms and sometimes can replace the role of network in promoting firm-level innovation activity. In other words, the presence of non-interactive learning could weaken the relationship between network connectivity and knowledge production (Glückler 2013).

Non-interactive learning in the form of attendance at fairs, seminars, congresses and workshops, reading of literature and patents, observation of other firms and the recruitment of skilled workers can complement the impact of networks and formal linkages on a firm's

innovation activities. In a study of the Austrian automotive sector, Grillitsch and Trippel (2013) find that more than 75% of firms combine informal interactive and non-interactive learning with market linkages to improve their innovation activities (Grillitsch and Trippel 2013). Non-interactive learning can also weaken the importance of proximity on firm level innovation. For instance, accessing relevant literature and patents allows knowledge transfer at extra-regional levels, and in many case from 'global pipelines', which makes firms less dependent on local knowledge base, at the same time reduces the possibility of regional 'lock-in'. However, this does not mean spatial proximity becomes irrelevant with the presence of non-interactive learning, but rather depends on the different modes employed: for example, non-interactive learning through hiring of skilled workers can still be very much a local phenomenon (Grillitsch and Trippel 2013).

4.3. Knowledge spillovers – 'being there'

The richness of local knowledge, and the nature of local knowledge networks and connectivity, will shape the potential for firms to benefit from spillovers. Although the term 'spillovers' has been variously used in recent studies we use the term here to mean un-priced, and unintentional, knowledge externalities which result from the characteristics of knowledge as a semi-public or public good. In this sense it is the simple presence of a firm within a location, sector or network – being there – which creates the potential for spillovers (He and Wong 2012).¹⁷

The potential for spillovers depends not only on firms' technological activity but may also be linked to other aspects of local knowledge. For example, a number of studies have examined spillovers from university research on innovation in both the U.S. (Acs, Audretsch, and Feldman 1992, 1994; Adams 1993, 1990; Jaffe 1989; Mansfield 1995) and Europe (e.g. Arundel and Geuna 2004; Fischer and Varga 2003) generally suggesting a positive linkage between university R&D and innovation levels in different industries. Tassev (2005), for example, argues that knowledge created by firms' research labs, government labs and universities may have some of the attributes of a quasi-public good, and play a significant role in enabling the development of proprietary technologies. Diffusion of such knowledge may be mediated through mechanisms such as social interaction or inter-personal networks, trade publications, professional associations etc. or through firms' direct links with knowledge brokers such as consultants or intermediary institutions. A related literature suggests that there is a strong geographical dimension to this spillover effect, with the impact of university R&D being confined largely to the region in which the research takes place, (Anselin, Varga, and Acs 2000, 1997; Audretsch and Feldman 1996). Potential spillover effects may also be sector specific (Jaffe 1989).

The potential for spillovers may also be greater where spatially bounded or concentrated networks facilitate 'buzz', or intensive face-to-face interaction between network members (Breschi and Lissoni 2009; Ibrahim, Fallah, and Reilly 2009; Storper and Venables 2004). In particular, in knowledge intensive industries, the importance of buzz and face-to-face interaction have been emphasised to the diffusion of tacit knowledge or emerging knowledge which has yet to be codified (Asheim, Coenen, and Vang 2007). Combinations of buzz and the availability of knowledge which has quasi-public characteristics – due perhaps to the

¹⁷Knowledge spillovers may also play a role in stimulating innovative entrepreneurial activity (Audretsch 2005).

presence of universities – may be particularly powerful in generating positive spillovers raising firms' innovation productivity above that suggested by their private investments in knowledge creation and external search.

Positive and localised externalities may also occur as a direct consequence of openness in the innovation process (Roper, Vahter, and Love 2013). For example, externalities of openness may arise from extensive knowledge diffusion in sectors in which technology has some of the characteristics of a public good, and/or sectors which are more densely networked (Kovacs et al. 2006). Knowledge diffusion may also be greater where spatially bounded or concentrated networks facilitate 'buzz', or intensive face-to-face interaction between network members (Storper and Venables 2004). In particular, in knowledge intensive industries, the importance of buzz and face-to-face interaction have been emphasised to the diffusion of tacit knowledge or emerging knowledge which has yet to be codified (Asheim, Coenen, and Vang 2007). Externalities of openness might occur relate to imitation and demonstration effects similar to those suggested in the technology adoption literature (Rao and Kishore 2010). Here, externalities of openness may arise as firms respond to openness in a sector by becoming more open themselves.

Knowledge spillovers can also be affected by labour mobility, and this too has a spatial dimension. Inter-regional mobility of highly skilled labour has been shown to significantly increase knowledge spillovers among firms in clusters and in the same region, which in turn significantly improves innovation success as measured by patent application (Almeida and Kogut 1999; Breschi and Lissoni 2009). Furthermore, a study of U.S. semiconductor industry patent citations shows that long distance mobility of key inventors and alliances between firms can significantly reduce the effect of long distance on knowledge transfer (Breschi and Lenzi 2010). The mobility of labour can not only bridge gaps between geographic spaces, but can intensify the impact of regional and sectoral clustering on firm-level innovation.¹⁸

4.4. Encoding capacity

In the innovation literature discussion around firms' ability to take advantage of external knowledge has focussed on the notion of absorptive capacity (ACAP). Originating with Cohen and Levinthal (1990), absorptive capacity is typically seen as a firm's ability to identify, evaluate, assimilate and apply external knowledge. Thus ACAP includes firms' ability both to search for and then assimilate and use external knowledge – in other words it encapsulates all the elements of the cross-hatched area in Figure 2. Here, we are interested in identifying separately the different 'search' mechanisms and 'assimilation' elements of ACAP both to clarify the concept conceptually and to allow more systematic empirical analysis. Previous sections have identified the three mechanisms through which external knowledge may become available to an enterprise – interactive and non-interactive learning and spillovers. Once acquired, the innovation effect of external knowledge will depend on firms' ability to encode that knowledge into their innovation outputs – or what we might call encoding capacity. The key idea here is that encoding capacity reflects firms' ability to make effective use of incoming knowledge for innovation, and that encoding capacity will therefore play

¹⁸A study of IT cluster in Cambridge UK reveals that one key advantage for firms to locate in Cambridge is the potential for the R&D workers to find alternative jobs in the industry without moving house. This helps to keep local talent and encourages the inflow of global talent into the region, which in turn enriches human capital at the firm level and enhances innovation ability (Huber 2012).

a moderating role in the relationship between any given level of external knowledge and marketable innovation. Different types of internal capacities may also be necessary if firms are to effectively make use of different types of external knowledge (Laviolette, Redien-Collot, and Teglborg 2016; Vega-Jurado, Gutierrez-Gracia, and Fernandez-de-Lucio 2009).

The notion of 'encoding' has been discussed elsewhere as the link between an external knowledge search process and the commercialisation of firms' innovation outputs (Love, Roper, and Bryson 2011). Encoding capacity itself is likely to be determined by a range of factors related to organisational culture, structure and resources. More open organisational cultures which facilitate internal knowledge sharing and creativity may facilitate the encoding of external knowledge, whereas more closed or rigid cultures may make this more difficult (Lucas and Goh 2009). Attitudinal differences, reflecting a not-invented-here syndrome, may also create barriers to encoding potentially useful external knowledge (Agrawal, Cockburn, and Rosell 2010). Structural factors may also be important in shaping encoding capacity. The number of individuals with boundary-spanning roles, for example, may shape firms' ability to share knowledge effectively within the firm and their encoding capacity (Johri and Ieee 2008). Similarly, the use of cross-functional development teams may help to distribute and apply knowledge effectively within a firm maximising encoding capabilities (Atuahene-Gima and Evangelista 2000; Ernst, Hoyer, and Rubsamen 2010; Love and Roper 2009). Resource availability may also be important in shaping encoding capacity, with investment in IT systems, for example, supporting knowledge diffusion within the firm.¹⁹

This range of influences mean that encoding capacity will differ markedly between firms (even within a given sector or region) and that any given firms' ability to encode different types of incoming knowledge may also vary significantly (Schmidt 2010). For example, as both boundary spanning and knowledge diffusion capacities are likely to be greater in larger firms, this may mean that larger firms have greater encoding capacity.

Levels of encoding capacity may also have implications beyond the firm itself as firms – and other organisations – with effective boundary-spanning capabilities can also absorb knowledge then act as a gateway to that knowledge for other networked or linked firms. For example, in the Chilean Colchagua Valley wine cluster, those firms with a higher number of technical qualified personnel, a more experienced professional staff, and a higher intensity of experimentation have wider linkages with organisations both outside and inside the cluster (Giuliani and Bell 2005).²⁰ Universities can also play a similar gateway role. For example, one study of German regional innovation networks emphasised the central position of local universities and the linking role of each university between local and international networks (Kauffeld-Monz and Fritsch 2013).

¹⁹The effects of IT investment on innovation are not always straightforward, however. In their study of Canadian manufacturing SMEs, for example, Raymond, Bergeron, and Croteau (2013) find positive effects from IT investment on growth-driving innovations but negative effects on productivity.

²⁰Similarly, a study of firms in Italian furniture districts reveals that the leading firms absorb external knowledge then spread it to their clients and suppliers in their own network (Morrison 2008).

5. Integrating framework

Arising from the analysis above, Figure 2 presents the integrating framework linking knowledge context, learning and innovation. Knowledge – of markets, new technology and opportunities – is a key input to innovation. New knowledge may arise from inside the firm, through discovery or invention, but in most cases is likely to originate outside the enterprise. The potential for such external knowledge to drive innovation arises from the properties of some forms of knowledge – as a public good and being non-rival – which create the potential for knowledge diffusion between firms and other organisations. The characteristics and richness of the knowledge context within which a firm operates will, however, depend significantly on its spatial, network and sectoral position. Specific locations may, for example, be knowledge rich depending on the presence of universities or other development organisations. This may positively influence local innovation (Lorenzoni, Russo, and Ferriani 2010). Industries differ too both in their technological and innovation intensity and the extent of knowledge diffusion (Raider 1998). Finally, network characteristics, and firms' individual position within any given network, will also contribute to shaping innovation potential (Grabher 2001; Massard 2011; Oerlemans, Meeus, and Boekema 1998).

The ability of a given firm to access, absorb and implement the external knowledge available to it depends both on its ambition, the mechanisms by which it accesses external knowledge, and by the links between them. Here, we suggest that the general notion of absorptive capacity can usefully be divided into four more readily measurable components (Figure 2). There are three very different mechanisms through which external knowledge may influence firms' innovation: interactive learning, non-interactive learning and spillovers. Interactive learning – the formation of contractual or informal partnerships with an element of mutual benefit – is a strategic activity and will be influenced by the nature of firms' innovation ambition. The extent of such relationships will significantly influence firms' ability to benefit from ambient knowledge. The extent of non-interactive learning (e.g. imitation, reverse engineering) will also be influenced by firms' innovation ambition and again will influence firms' ability to benefit from ambient knowledge. Spillovers also provide a mechanism by which firms may benefit from ambient knowledge (Figure 2). This mechanism is serendipitous, however, rather than strategic, with learning resulting primarily from social interaction. (Of course, valuable interactions are more likely in some locations, industries and networks than others and a firm's choice of 'location' in each dimension may therefore have implications for the extent of knowledge spillovers).

The non-strategic nature of potential spillovers suggests that these cannot be influenced by firms' innovation ambition. The effect of spillovers on innovation outputs will, like the innovation returns to both interactive and non-interactive however, be moderated by firms' encoding capacity, i.e. their ability to absorb and utilise external knowledge. This moderating effect may either be positive or negative. Positive moderating effects may occur where internal knowledge and capabilities are complementary to externally sourced knowledge leading to higher levels of innovative activity. There is for example, substantial evidence of the complementary roles of external knowledge and internal R&D (Cassiman and Veugelers 2006; Lichtenthaler and Lichtenthaler 2009; Miravete and Permiás 2004). Negative moderating effects may also be possible, however, where internal knowledge sharing is ineffective or cultural barriers such as the Not-Invented-Here syndrome exist to the adoption of external knowledge (Agrawal, Cockburn, and Rosell 2010). Finally, encoding capacity itself will

also be shaped by firms' innovation ambition. Firms adopting play-to-win strategies based on radical and open innovation will need to build greater encoding capacity than firms adopting imitation strategies (Davila, Epstein, and Shelton 2006).

6. Discussion and conclusions

In this paper, building on the existing literature on external knowledge effects on innovation, we outline a framework relating firms' knowledge context, their innovation ambition, search behaviours and internal encoding capacity. We make four main contributions to the existing literature. First, our characterisation of the knowledge context provides the basis for a more specific identification of which elements of firms' knowledge environment are important for innovation. Are beneficial spillovers, for example, linked more closely to sectoral, spatial or network inter-relations? Or, to a combination of these factors? It may also be important to distinguish how each aspect of knowledge context contributes to the extent of interactive and non-interactive learning. Spatial proximity, for example, may facilitate both types of learning as may network centrality or density although developments in ICT may weaken these effects (Lengyel and Jakobi 2016).

Second, we reflect the role of innovation ambition and strategy in shaping firms' knowledge search strategies. More ambitious firms – those pursuing radical innovation rather than imitation strategies – seem likely to have more active search strategies, although previous studies have shown search strategies may also differ in terms of the type of search partner they involve (Ritala et al. 2013). Search strategies may also reflect more complex innovation objectives involving different types of innovation (technological, business model etc.) with implications for the configuration of firms' internal resources (Vega-Jurado, Gutierrez-Gracia, and Fernandez-de-Lucio 2009). Third, building on the arguments outlined in Glückler (2013) we differentiate between firms' interactive and non-interactive knowledge search activities and recognise that these may be complemented by unanticipated and serendipitous knowledge spillovers. Together these three mechanisms provide a comprehensive framework within which the extent and determinants of knowledge flows across firm boundaries can be considered. Finally, we introduce the notion of encoding capacity to reflect firms' internal ability to assimilate and apply external knowledge, recognising that innovation ambition may also influence firms' willingness to invest in creating encoding capacity. Together with the three mechanisms through which firms may acquire knowledge, the notion of encoding capacity provides a more readily measurable alternative to broader notions of absorptive capacity.

An initial attempt at employing this framework empirically is contained in Roper, Love, and Bonner (2017). However, our framework suggests a number of potential areas for future investigation. First, in terms of the antecedents of knowledge search activity, the framework highlights the potential importance of different aspects of knowledge context and firms' innovation ambition in shaping the strategic choices between interactive and non-interactive knowledge search methods. The role of innovation ambition in particular has to date received little attention in most innovation studies. Second, a series of interesting questions relate to the innovation effects of external knowledge as mediated through interactive learning, non-interactive learning and spillovers. For example, are some types of knowledge better accessed through interactive rather than non-interactive search methods? Similarly, what types of knowledge are most often associated with spillovers? Finally, it will be interesting

to explore the moderating role of firms' encoding capacity on the innovation effects of external knowledge. Further analysis might also consider what shapes encoding capacity. The integrative framework suggested by Vega-Jurado, Gutierrez-Gracia, and Fernandez-De-Lucio (2008) provides some potentially interesting hypotheses reflecting the degree of formalisation in the business, the extent of social integration or open communication, and the existing depth of knowledge within the organisation.

One further implication follows from our framework relating to the significant role of innovation ambition and encoding capacity – both firm-specific characteristics – in shaping the benefits which any firm will derive from its knowledge context. As innovation ambition, strategy and encoding capacity are likely to vary markedly within any specific knowledge context so will firms' ability and/or desire to use external knowledge to benefit their innovation. This will contribute to heterogeneity in innovation outcomes within any given knowledge context. Marked variations may also exist between groups of firms differentiated by size, ownership or age perhaps. Each may shape firms' ambition and the internal resources they have accumulated suggesting the potential value of a differentiated approach to modelling the relationships between knowledge context and innovation outcomes.

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References

- Acs, Z., D. B. Audretsch, and M. P. Feldman. 1992. "Real Effects of Academic Research." *American Economic Journal* 82: 363–367.
- Acs, Z. J., D. B. Audretsch, and M. P. Feldman. 1994. "R & D Spillovers and Recipient Firm Size." *Review of Economics and Statistics* 76: 336–340.
- Adams, J. D. 1990. "Fundamental Stocks of Knowledge and Productivity Growth." *Journal of Political Economy* 98: 673–702.
- Adams, J. D. 1993. "Science, R&D and Invention Potential Recharge: US Evidence." *American Economic Journal* 83: 458–462.
- Advisory Committee on Measuring Innovation in the 21st Century Economy. 2008. *Innovation Measurement – Tracking the State of Innovation in the US Economy*. A report to the Secretary of Commerce. Washington, DC: National Bureau for Economic Research.

- Aghion, P. B. N., R. Blundell, R. Griffith, and P. Howitt. 2005. "Competition and Innovation: An Inverted-U Relationship." *Quarterly Journal of Economics* 120: 701–728.
- Agrawal, A., and I. M. Cockburn. 2002. *University Research, Industrial R&D and the Anchor Tenant Hypothesis*. Cambridge, MA: National Bureau for Economic Research.
- Agrawal, A., I. Cockburn, and C. Rosell. 2010. "Not Invented Here? Innovation in Company Towns." *Journal of Urban Economics* 67: 78–89.
- Akgun, A. E., H. Keskin, and J. Byrne. 2012. "Antecedents and Contingent Effects of Organizational Adaptive Capability on Firm Product Innovativeness." *Journal of Product Innovation Management* 29: 171–189.
- Al-Laham, A., D. Tzabbar, and T. L. Amburgey. 2011. "The Dynamics of Knowledge Stocks and Knowledge Flows: Innovation Consequences of Recruitment and Collaboration in Biotech." *Industrial and Corporate Change* 20: 555–583.
- Almeida, P., and B. Kogut. 1999. "Localization of Knowledge and the Mobility of Engineers in Regional Networks." *Management Science* 45: 905–917.
- Anselin, L., A. Varga, and Z. Acs. 1997. "Local Geographic Spillovers between University Research and High Technology Innovations." *Journal of Urban Economics* 42: 422–448.
- Anselin, L., A. Varga, and Z. Acs. 2000. "Geographic and Sectoral Characteristics of Academic Knowledge Externalities." *Papers in Regional Science* 79: 435–443.
- Anthony, S. D., M. W. Johnson, J. V. Sinfield, and E. J. Altman. 2008. *The Innovators Guide to Growth – Putting Disruptive Innovation to Work*. Boston, MA: Harvard Business Press.
- Arundel, A. M., and A. Geuna. 2004. "Proximity and the Use of Public Science by Innovative European Firms." *Economics of Innovation and New Technology* 13: 559–580.
- Arvanitis, S., B. Lokshin, P. Mohnen, and M. Woerter. 2015. "Impact of External Knowledge Acquisition Strategies on Innovation: A Comparative Study Based on Dutch and Swiss Panel Data." *Review of Industrial Organization* 46: 359–382.
- Asheim, B., L. Coenen, J. Moodysson, and J. Vang. 2007. "Constructing Knowledge-based Regional Advantage: Implications for Regional Innovation Policy." *International Journal of Entrepreneurship and Innovation Management* 7: 140–155.
- Asheim, B., L. Coenen, and J. Vang. 2007. "Face-to-Face, Buzz, and Knowledge Bases: Sociospatial Implications for Learning, Innovation, and Innovation Policy." *Environment and Planning C: Government and Policy* 25: 655–670.
- Atuahene-Gima, K., and F. Evangelista. 2000. "Cross-functional Influence in New Product Development: An Exploratory Study of Marketing and R...D Perspectives." *Management Science* 46: 1269–1284.
- Audretsch, D. B. 1998. "Agglomeration and the Location of Innovative Activity." *Oxford Review of Economic Policy* 14: 18–29.
- Audretsch, D. B. 2005. "The Knowledge Spillover Theory of Entrepreneurship and Economic Growth." In *The Emergence of Entrepreneurial Economics*, edited by G. T. Vinig and R. C. Voort, 37–54. Bingley: Elsevier.
- Audretsch, D. B., and M. Feldman. 1996. "R&D Spillovers and the Geography of Innovation and Production." *American Economic Journal* 86: 630–640.
- Bae, J., and J. Koo. 2009. "The Nature of Local Knowledge and New Firm Formation." *Industrial and Corporate Change* 18: 473–496.
- Balla, S. J. 2001. "Interstate Professional Associations and the Diffusion of Policy Innovations." *American Politics Research* 29: 221–245.
- Bathelt, H., and J. Glückler. 2005. "Resources in Economic Geography: From Substantive Concepts towards a Relational Perspective." *Environment and Planning A* 37: 1545–1563.
- Bayus, B. L., and R. Agarwal. 2007. "The Role of Pre-entry Experience, Entry Timing, and Product Technology Strategies in Explaining Firm Survival." *Management Science* 53: 1887–1902.
- Beamish, P. W., R. Craig, and K. McLellan. 1993. "The Performance Characteristics of Canadian versus U.K. Exporters in Small and Medium Sized Firms." *Management International Review* 33: 121–137.
- van Beers, C., and G. van der Panne. 2011. "Geography, Knowledge Spillovers and Small Firms' Exports: An Empirical Examination for the Netherlands." *Small Business Economics* 37: 325–339.

- Belussi, F., and S. R. Sedita. 2012. "Industrial Districts as Open Learning Systems: Combining Emergent and Deliberate Knowledge Structures." *Regional Studies* 46: 165–184.
- Belussi, F., S. R. Sedita, T. Aage, and D. Porcellato. 2011. Inward Flows of Information and Knowledge in Low-Tech Industrial Districts: Contrasting the 'Few Firms Gatekeeper' and 'Direct Peer' Models. In *Knowledge Transfer and Technology Diffusion*, edited by P. L. Robertson and D. Jacobson, 64–90. Cheltenham: Edward Elgar.
- Bessant, J., A. Alexander, G. Tsekouras, H. Rush, and R. Lamming. 2012. "Developing Innovation Capability through Learning Networks." *Journal of Economic Geography* 12: 1087–1112.
- Bolton, M. K. 1993. "Imitation versus Innovation: Lessons to Be Learned from the Japanese." *Organizational Dynamics* 21: 30–45.
- Borgatti, S. P., and D. S. Halgin. 2011. "On Network Theory." *Organization Science* 22: 1168–1181.
- Boschma, R. A. 2005. "Proximity and Innovation: A Critical Assessment." *Regional Studies* 39: 61–74.
- Braczyk, H. J., P. Cooke, and M. Heidenreich. 1998. *Regional Innovation Systems: The Role of Governance in a Globalised World*. London: UCL Press.
- Breschi, S., and C. Lenzi. 2010. "Spatial Patterns of Inventors' Mobility: Evidence on US Urban Areas." *Papers in Regional Science* 89: 235–250.
- Breschi, S., and F. Lissoni. 2009. "Mobility of Skilled Workers and Co-invention Networks: An Anatomy of Localized Knowledge Flows." *Journal of Economic Geography* 9: 439–468.
- Breschi, S., and F. Malerba. 2011. "Assessing the Scientific and Technological Output of EU Framework Programmes: Evidence from the FP6 Projects in the ICT Field." *Scientometrics* 88: 239–257.
- Brown, J. S., and P. Duguid. 2002. "Local Knowledge – Innovation in the Networked Age." *Management Learning* 33: 427–437.
- Buesa, M., J. Heijns, M. M. Pellitero, and T. Baumert. 2006. "Regional Systems of Innovation and the Knowledge Production Function: The Spanish Case." *Technovation* 26: 463–472.
- Calzonetti, F. J., D. M. Miller, and N. Reid. 2012. "Building Both Technology-intensive and Technology-limited Clusters by Emerging Research Universities: The Toledo Example." *Applied Geography* 34: 265–273.
- Camagni, R. 1991. "Local Milieu, Uncertainty and Innovation Networks: Towards a New Dynamic Theory of Economic Space." In *Innovation Networks, Spatial Perspectives*, edited by R. Camagni. 121–144. London: New York Belhaven Press.
- Cannarella, C., and V. Piccioni. 2011. "Traditioventions: Creating Innovation from the Past and Antique Techniques for Rural Areas." *Technovation* 31: 689–699.
- Carayannis, E. G., and D. F. J. Campbell. 2009. "'Mode 3' and 'Quadruple Helix': Toward a 21st Century Fractal Innovation Ecosystem." *International Journal of Technology Management* 46: 201–234.
- Carney, M., E. R. Gedajlovic, P. Heugens, M. Van Essen, and J. Van Oosterhout. 2011. "Business Group Affiliation, Performance, Context, and Strategy: A Meta-analysis." *Academy of Management Journal* 54: 437–460.
- Cassiman, B., and R. Veugelers. 2002a. "Complementarity in the Innovation Strategy: Internal R&D, External Technology Acquisition and Co-Operation in R&D." EARIE Annual Conference, Madrid.
- Cassiman, B., and R. Veugelers. 2002b. "R&D Cooperation and Spillovers: Some Empirical Evidence from Belgium." *The American Economic Review* 92: 1169–1184.
- Cassiman, B., and R. Veugelers. 2006. "In Search of Complementarity in Innovation Strategy: Internal R&D and External Knowledge Acquisition." *Management Science* 52: 68–82.
- Chai, Z. X., and Z. H. Huang. 2007. "Agglomeration, Knowledge Spillover and Provincial Innovation – Evidences from Mainland China." *Proceeding of China Private Economy Innovation International Forum*, 1: 119–128.
- Chang, S.-J., C.-N. Chung, and I. P. Mahmood. 2006. "When and How Does Business Group Affiliation Promote Firm Innovation? A Tale of Two Emerging Economies." *Organization Science* 17: 637–656.
- Christensen, C. M., F. F. Suarez, and J. M. Utterback. 1998. "Strategies for Survival in Fast-changing Industries." *Management Science* 44: S207–S220.
- Cohen, W. M., and D. A. Levinthal. 1989. "Innovation and Learning: The Two Faces of R & D." *The Economic Journal* 99: 569–596.
- Cohen, W. M., and D. A. Levinthal. 1990. "Absorptive Capacity: A New Perspective on Learning and Innovation." *Administrative Science Quarterly* 35: 128–152.

- Colombo, M. G., and M. Delmastro. 2001. "Technology Use and Plant Closure." *Research Policy* 30: 21–34.
- Comacchio, A., S. Bonesso, and C. Pizzi. 2012. "Boundary Spanning between Industry and University: The Role of Technology Transfer Centres." *Journal of Technology Transfer* 37: 943–966.
- Crespo, N., M. P. Fontoura, and I. Proenca. 2009. "FDI Spillovers at Regional Level: Evidence from Portugal." *Papers in Regional Science* 88: 591–607.
- D'Angelo, A., A. Majocchi, A. Zucchella, and T. Buck. 2013. "Geographical Pathways for SME Internationalization: Insights from an Italian Sample." *International Marketing Review* 30: 80–105.
- Daim, T. U. 2005. "Sectoral Systems of Innovation: Concepts, Issues and Analyses of Six Major Sectors in Europe." *Technological Forecasting and Social Change* 72: 1153–1154.
- Davila, T., M. J. Epstein, and R. Shelton. 2006. *Making Innovation Work*. Upper Saddle River, NJ: Wharton School Publishing.
- Diaz-Diaz, N. L., and P. De Saa-Perez. 2012. "Novelty of Innovation and the Effect of Existing and Recently Hired R&D Human Resources." *Innovation-Management Policy & Practice* 14: 74–89.
- Dolfsma, W., and L. Leydesdorff. 2009. "Lock-in and Break-out from Technological Trajectories: Modeling and Policy Implications." *Technological Forecasting and Social Change* 76: 932–941.
- Dorion, E., E. T. Pavoni, and L. R. Chalela. 2008. *Innovation or Imitation: A Comparative Study on Common Behavior of Brazilian Entrepreneurs*. Haidian District: Intellectual Property Publishing House.
- Ernst, D., and L. Kim. 2002. "Global Production Networks, Knowledge Diffusion and Local Capability Formation." *Research Policy* 31: 1417–1429.
- Ernst, H., W. D. Hoyer, and C. Rubsamen. 2010. "Sales, Marketing, and Research-and-Development Cooperation across New Product Development Stages: Implications for Success." *Journal of Marketing* 74: 80–92.
- Feldman, M. P. 2003. "The Locational Dynamics of the US Biotech Industry: Knowledge Externalities and the Anchor Hypothesis." *Industry and Innovation* 10: 311–329.
- Fischer and Varga. 2003. "Spatial Knowledge Spillovers and University Research: Evidence from Austria." *The Annals of Regional Science* 37: 303–322.
- Fitjar, R. D., and A. Rodriguez-Pose. 2013. "Firm Collaboration and Modes of Innovation in Norway." *Research Policy* 42: 128–138.
- Garriga, H., G. von Krogh, and S. Spaeth. 2013. "How Constraints and Knowledge Impact Open Innovation." *Strategic Management Journal* 34: 1134–1144.
- Gilsing, V., B. Nooteboom, W. Vanhaverbeke, G. Duysters, and A. van den Oord. 2008. "Network Embeddedness and the Exploration of Novel Technologies: Technological Distance, Betweenness Centrality and Density." *Research Policy* 37: 1717–1731.
- Giuliani, E., and M. Bell. 2005. "The Micro-Determinants of Meso-level Learning and Innovation: Evidence from a Chilean Wine Cluster." *Research Policy* 34: 47–68.
- Glückler, J. 2013. "Knowledge, Networks and Space: Connectivity and the Problem of Non-interactive Learning." *Regional Studies* 47: 880–894.
- Grabher, G. 2001. "Locating Economic Action: Projects, Networks, Localities, Institutions, Introductory Notes for the Workshop, in beyond the Firm?" *Beyond the Firm? Spatial and Social Dynamics of Project-Organization*, Bonn.
- Grillitsch, M., and M. Tripl. 2013. Combining knowledge from different sources, channels and geographical scales Working Paper 2013/23, Lund University.
- Grimpe, C., and W. Sofka. 2009. "Search Patterns and Absorptive Capacity: Low- and High-Technology Sectors in European Countries." *Research Policy* 38: 495–506.
- Gundry, L. K., and H. P. Welsch. 2001. "The Ambitious Entrepreneur: High Growth Strategies of Women-Owned Enterprises." *Journal of Business Venturing* 16: 453–470.
- Hang, C. C., J. Chen, and A. M. Subramian. 2010. "Developing Disruptive Products for Emerging Economies: Lessons from Asian Cases." *Research-Technology Management* 53: 21–26.
- Hansen, M. T., and J. Birkinshaw. 2007. "The Innovation Value Chain." *Harvard Business Review* (June) 85: 121–130.
- Harris, R. I. D., and M. Trainor. 1995. "Innovation and R&D in Northern Ireland Manufacturing: A Schumpeterian Approach." *Regional Studies* 29: 593–604.

- He, Z. L., and P. K. Wong. 2012. "Reaching out and Reaching Within: A Study of the Relationship between Innovation Collaboration and Innovation Performance." *Industry and Innovation* 19: 539–561.
- Hewitt-Dundas, N. 2004. "The Adoption of AMT and Innovation Strategy in Small Firms." *International Journal of Innovation and Technology Management* 1: 17–36.
- Hewitt-Dundas, N., and S. Roper. 2011. "Creating Advantage in Peripheral Regions: The Role of Publicly Funded R&D Centres." *Research Policy* 40: 832–841.
- Hobday, M. 1995. *Innovation in East Asia: The Challenge to Japan*. Aldershot: Edward Elgar.
- Hofmann, C., and S. Orr. 2005. "Advanced Manufacturing Technology Adoption – the German Experience." *Technovation* 25: 711–724.
- Horrigan, J. B. 2011. "What are the Consequences of Being Disconnected in a Broadband-Connected World?" *Daedalus* 140: 17–31.
- Hu, M.-C. 2011. "Evolution of Knowledge Creation and Diffusion: The Revisit of Taiwan's Hsinchu Science Park." *Scientometrics* 88: 949–977.
- Huber, F. 2012. "Do Clusters Really Matter for Innovation Practices in Information Technology? Questioning the Significance of Technological Knowledge Spillovers." *Journal of Economic Geography* 12: 107–126.
- Ibrahim, S. E., M. H. Fallah, and R. R. Reilly. 2009. "Localized Sources of Knowledge and the Effect of Knowledge Spillovers: An Empirical Study of Inventors in the Telecommunications Industry." *Journal of Economic Geography* 9: 405–431.
- Ichijo, K., and F. Kohlbacher. 2008. "Tapping Tacit Local Knowledge in Emerging Markets – The Toyota Way." *Knowledge Management Research & Practice* 6: 173–186.
- Jaffe, A. B. 1986. "Technological Opportunity and Spillovers of R&D." *American Economic Review* 76: 984–1001.
- Jaffe, A. 1989. "Real Effects of Academic Research." *American Economic Journal* 79: 957–970.
- Jensen, C., and B. Tragardh. 2004. "Narrating the Triple Helix Concept in Weak Regions: Lessons from Sweden." *International Journal of Technology Management* 27: 515–528.
- Johri, A., and Ieee. 2008. "Boundary Spanning Knowledge Broker: An Emerging Role in Global Engineering Firms." *Fie: 2008 Ieee Frontiers in Education Conference, Vols 1–3*, 1333–1338. New York: Ieee.
- Jordaan, J. A. 2008. "Regional Foreign Participation and Externalities: New Empirical Evidence from Mexican Regions." *Environment and Planning A* 40: 2948–2969.
- Kauffeld-Monz, M., and M. Fritsch. 2013. "Who Are the Knowledge Brokers in Regional Systems of Innovation? A Multi-actor Network Analysis." *Regional Studies* 47: 669–685.
- Kesidou, E., and C. Snijders. 2012. "External Knowledge and Innovation Performance in Clusters: Empirical Evidence from the Uruguay Software Cluster." *Industry and Innovation* 19: 437–457.
- Kim, L. 1997. *From Imitation to Innovation: The Dynamics of Korea's Technological Learning*. Boston, MA: Harvard Business Press.
- Klevorick, A. K., R. C. Levin, R. R. Nelson, and S. G. Winter. 1995. "On the Sources and Significance of Inter-industry Differences in Technological Opportunities." *Research Policy* 24: 185–205.
- Kopel, M., and C. Löffler. 2008. "Commitment, First-Mover-, and Second-Mover Advantage." *Journal of Economics* 94: 143–166.
- Kovacs, G., S. Kopacs, G. Haidegger, and R. Michelini. 2006. "Ambient Intelligence in Product Life-cycle Management." *Engineering Applications of Artificial Intelligence* 19: 953–965.
- Laursen, K., and A. Salter. 2006. "Open for Innovation: The Role of Openness in Explaining Innovation Performance among UK Manufacturing Firms." *Strategic Management Journal* 27: 131–150.
- Lavolette, E. M., R. Redien-Collot, and A.-C. Teglberg. 2016. "Open Innovation from the inside: Employee-driven Innovation in Support of Absorptive Capacity for Inbound Open Innovation." *International Journal of Entrepreneurship and Innovation*. 17 (4): 228–239.
- Leiponen, A., and J. Byma. 2009. "If You Cannot Block, You Better Run: Small Firms, Cooperative Innovation, and Appropriation Strategies." *Research Policy* 38: 1478–1488.
- Leiponen, A., and C. E. Helfat. 2010. "Innovation Objectives, Knowledge Sources, and the Benefits of Breadth." *Strategic Management Journal* 31: 224–236.

- Lengyel, B., and A. Jakobi. 2016. "Online Social Networks, Location, and the Dual Effect of Distance from the Centre." *Tijdschrift Voor Economische En Sociale Geografie* 107: 298–315.
- Levin, R., and P. Reiss. 1984. *Tests of a Schumpeterian Model of R&D and Market Structure*. Chicago, IL: University of Chicago Press.
- Levin, R. C., W. M. Cohen, and D. C. Mowery. 1985. "R&D Appropriability, Opportunity and Market Structure: New Evidence on Some Schumpeterian Hypotheses." *American Economic Review* 75: 20–24.
- Lichtenthaler, U., and E. Lichtenthaler. 2009. "A Capability-based Framework for Open Innovation: Complementing Absorptive Capacity." *Journal of Management Studies* 46: 1315–1338.
- Lieberman, M. B., and S. Asaba. 2006. "Why do Firms Imitate Each Other?" *Academy of Management Review* 31: 366–385.
- Lim, D. J., and D. F. Kocaoglu. 2011. *China – Can It Move from Imitation to Innovation?* New York: Ieee.
- Lorentzen, A. 2007. "The Geography of Knowledge Sourcing – A Case Study of Polish Manufacturing Enterprises." *European Planning Studies* 15: 467–486.
- Lorenzoni, G., D. Russo, and S. Ferriani. 2010. *Unfolding Local Knowledge and Field Emergence: The Rise of Bologna Nanotech*. Working Paper, Department of Management. University of Bologna.
- Love, J. H., and S. Roper. 2009. "Organizing Innovation: Complementarities between Cross-Functional Teams." *Technovation* 29: 192–203.
- Love, J. H., and S. Roper. 2015. "SME Innovation, Exporting and Growth: A Review of Existing Evidence." *International Small Business Journal* 33: 28–48.
- Love, J. H., S. Roper, and J. Bryson. 2011. "Knowledge, Openness, Innovation and Growth in UK Business Services." *Research Policy* 40: 1438–1452.
- Love, J. H., S. Roper, and P. Vahter. 2014. "Learning from Openness: The Dynamics of Breadth in External Innovation Linkages." *Strategic Management Journal* 35: 1703–1716.
- Lucas, H. C., and J. M. Goh. 2009. "Disruptive Technology: How Kodak Missed the Digital Photography Revolution." *Journal of Strategic Information Systems* 18: 46–55.
- Malerba, F. 2004. *Sectoral Systems of Innovation*. Cambridge: Cambridge University Press.
- Malmberg, A., and P. Maskell. 2002. "The Elusive Concept of Localization Economies: Towards a Knowledge-based Theory of Spatial Clustering." *Environment and Planning A* 34: 429–449.
- Mansfield, E. 1995. "Academic Research Underlying Industrial Innovation: Sources, Characteristics and Financing." *Review of Economics and Statistics* 77: 55–65.
- Massard, N. 2011. "Networks and Geography in the Economics of Knowledge Flows. A Comment." *Quality & Quantity* 45: 1053–1057.
- Miravete, E., and J. C. Permas. 2004. *Innovation Complementarity and the Scale of Production*. CEPR Discussion Paper 2004/07. London: Centre for Economics and Policy Research.
- Morrison, A. 2008. "Gatekeepers of Knowledge within Industrial Districts: Who They Are, How They Interact." *Regional Studies* 42: 817–835.
- Mueller, V., N. Rosenbusch, and A. Bausch. 2013. "Success Patterns of Exploratory and Exploitative Innovation: A Meta-Analysis of the Influence of Institutional Factors." *Journal of Management* 39: 1606–1636.
- Munari, F., M. Sobrero, and A. Malipiero. 2012. "Absorptive Capacity and Localized Spillovers: Focal Firms as Technological Gatekeepers in Industrial Districts." *Industrial and Corporate Change* 21: 429–462.
- Naranjo-Valencia, J. C., D. Jimenez-Jimenez, and R. Sanz-Valle. 2011. "Innovation or Imitation? The Role of Organizational Culture." *Management Decision* 49: 55–72.
- Newell, S., and J. Swan. 1995. "Professional Associations as Important Mediators of the Innovation Process." *Science Communication* 16: 371–387.
- Oerlemans, L., M. Meeus, and F. Boekema. 1998. "Do Networks Matter for Innovation? The Usefulness of the Economic Network Approach in Analysing Innovation." *Tijdschrift Voor Economische En Sociale Geografie* 89: 298–309.
- Oerlemans, L. A. G., M. T. H. Meeus, and F. W. M. Boekema. 2001. "Firm Clustering and Innovation: Determinants and Effects." *Papers in Regional Science* 80: 337–356.

- Parida, V., M. Westerberg, and J. Frishammar. 2012. "Inbound Open Innovation Activities in High-Tech SMEs: The Impact on Innovation Performance." *Journal of Small Business Management* 50: 283–309.
- Parjanen, S., H. Melkas, and T. Uotila. 2011. "Distances, Knowledge Brokerage and Absorptive Capacity in Enhancing Regional Innovativeness: A Qualitative Case Study of Lahti Region, Finland." *European Planning Studies* 19: 921–948.
- Parrilli, M. D. 2004. "A Stage and Eclectic Approach to Industrial District Development: Two Policy Keys for 'Survival' Clusters in Developing Countries." *European Planning Studies* 12: 1115–1131.
- Phelps, C. C. 2010. "A Longitudinal Study of the Influence of Alliance Network Structure and Composition on Firm Exploratory Innovation." *Academy of Management Journal* 53: 890–913.
- Pittaway, L., M. Robertson, K. Munir, D. Denyer, and A. Neely. 2004. "Networking and Innovation: A Systematic Review of the Evidence." *International Journal of Management Reviews* 5 (6): 137–168.
- Powell, W. W., K. W. Koput, and L. Smith-Doerr. 1996. "Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology." *Administrative Science Quarterly* 41: 116–145.
- Raider, H. J. 1998. "Market Structure and Innovation." *Social Science Research* 27: 1–21.
- Rao, K. U., and V. V. N. Kishore. 2010. "A Review of Technology Diffusion Models with Special Reference to Renewable Energy Technologies." *Renewable & Sustainable Energy Reviews* 14: 1070–1078.
- Rasiah, R., V. Gopal, and P. Sanjeev. 2013. "Export and Innovation in Cambodian Clothing Manufacturing Firms." *Asian Journal of Technology Innovation* 21: 305–316.
- Raymond, L., F. Bergeron, and A. M. Croteau. 2013. "Innovation Capability and Performance of Manufacturing SMEs: The Paradoxical Effect of IT Integration." *Journal of Organizational Computing and Electronic Commerce* 23: 249–272.
- Ritala, P., K. Henttonen, H. Salojarvi, L. M. Sainio, and S. Saarenketo. 2013. "Gone Fishing for Knowledge? The Effect of Strategic Orientations on the Scope of Open Knowledge Search." *Baltic Journal of Management* 8: 328–348.
- Roper, S., J. Du, and J. H. Love. 2008. "Modelling the Innovation Value Chain." *Research Policy* 37: 961–977.
- Roper, S., J. H. Love, J. Bryson, and C. Hales. 2009. *Measuring Sectoral Innovation Capability in Nine Areas of the UK Economy*. London: Report for the NESTA Innovation Index project.
- Roper, S., P. Vahter, and J. H. Love. 2013. "Externalities of Openness in Innovation." *Research Policy* 42: 1544–1554.
- Roper, S., J. H. Love, and K. Bonner. 2017. "Firms' Knowledge Search and Local Knowledge Externalities in Innovation Performance." *Research Policy* 46: 43–56.
- Rosenkopf, L., and A. Nerkar. 2001. "Beyond Local Search: Boundary Spanning, Exploration, and Impact in the Optical Disk Industry." *Strategic Management Journal* 22: 287–306.
- Rothaermel, F., and D. Deeds. 2004. "Exploration and Exploitation Alliances in Biotechnology: A System of New Product Development." *Strategic Management Journal* 25: 201–221.
- Schmidt, T. 2010. "Absorptive Capacity – One Size Fits All? A Firm-level Analysis of Absorptive Capacity for Different Kinds of Knowledge." *Managerial and Decision Economics* 31: 1–18.
- Schnaars, S. P. 1994. *Managing Imitation Strategies*. New York: Free Press.
- Shefer, D., and A. Frenkel. 1998. "Local Milieu and Innovations: Some Empirical Results." *Annals of Regional Science* 32: 185–200.
- Shefer, D., A. Frenkel, and S. Roper. 2003. "Public Policy, Locational Choice and the Innovation Capability of High Tech Firms: A Comparison between Israel and Ireland." *Papers in Regional Science* 82: 203–221.
- Shenkar, O. 2010. "Imitation is More Valuable than Innovation." *Harvard Business Review* 88: 28–29.
- Shum, K. L., and C. Watanabe. 2008. "Towards a Local Learning (Innovation) Model of Solar Photovoltaic Deployment." *Energy Policy* 36: 508–521.
- Simon, H. A. 1947. *Administrative Behavior: A Study of Decision-Making Process in Administrative Organization*. Chicago, IL: Macmillan.

- Spencer, J. W. 2003. "Global Gatekeeping, Representation, and Network Structure: A Longitudinal Analysis of Regional and Global Knowledge-Diffusion Networks." *Journal of International Business Studies* 34: 428–442.
- Spithoven, A., B. Clarysse, and M. Knockaert. 2011. "Building Absorptive Capacity to Organize Inbound Open Innovation in Traditional Industries." *Technovation* 31: 10–21.
- Storper, M., and A. J. Venables. 2004. "Buzz: The Economic Force of the City." *Journal of Economic Geography* 4: 351–370.
- Sydow, J., F. Lerch, and U. Staber. 2010. "Planning for Path Dependence? The Case of a Network in the Berlin-Brandenburg Optics Cluster." *Economic Geography* 86: 173–195.
- Tassey, G. 2005. "The Disaggregated Technology Production Function: A New Model of University and Corporate Research." *Research Policy* 34: 287–303.
- Todtling, F., P. Lehner, and M. Trippl. 2006. "Innovation in Knowledge Intensive Industries: The Nature and Geography of Knowledge Links." *European Planning Studies* 14: 1035–1058.
- Todtling, F., B. Asheim, and R. Boschma. 2013. "Knowledge Sourcing, Innovation and Constructing Advantage in Regions of Europe." *European Urban and Regional Studies* 20: 161–169.
- Toedtling, F., L. Lengauer, and C. Hoeglinger. 2011. "Knowledge Sourcing and Innovation in "Thick" and "Thin" Regional Innovation Systems-Comparing ICT Firms in Two Austrian Regions." *European Planning Studies* 19: 1245–1276.
- Tomlinson, P. R. 2010. "Co-operative Ties and Innovation: Some New Evidence for UK Manufacturing." *Research Policy* 39: 762–775.
- Tomlinson, P. R., and I. Jackson. 2013. "Cooperative Ties and the Impact of External Factors upon Innovation in an Industrial District: Some Insights from the North Staffordshire Table and Giftware Sector." *Regional Studies* 47: 580–596.
- Ulhoi, J. P. 2012. "Modes and Orders of Market Entry: Revisiting Innovation and Imitation Strategies." *Technology Analysis & Strategic Management* 24: 37–50.
- Vaccaro, I. G., J. J. P. Jansen, F. A. J. Van Den Bosch, and H.W. Volberda. 2012. "Management Innovation and Leadership: The Moderating Role of Organizational Size." *Journal of Management Studies* 49: 28–51.
- Vahter, P., J. H. Love, and S. Roper. 2014. "Openness and Innovation Performance: Are Small Firms Different?" *Industry and Innovation* 21: 553–573.
- Vega-Jurado, J., A. Gutierrez-Gracia, and I. Fernandez-De-Lucio. 2008. "Analyzing the Determinants of Firm's Absorptive Capacity: Beyond R&D." *R & D Management* 38: 392–405.
- Vega-Jurado, J., A. Gutierrez-Gracia, and I. Fernandez-de-Lucio. 2009. "Does External Knowledge Sourcing Matter for Innovation? Evidence from the Spanish Manufacturing Industry." *Industrial and Corporate Change* 18: 637–670.
- Vinnova. 2004. "Impacts of the Swedish Competence Centres Programme 1995–2003." Verket för Innovationssystem: 3. Stockholm: Vinnova.
- Watson, J. 2012. "Networking: Gender Differences and the Association with Firm Performance." *International Small Business Journal* 30: 536–558.
- Wolfe, D. A. 2009. "Embedded Clusters in the Global Economy." *European Planning Studies* 17: 179–187.
- Yang, C. H., and C. H. Huang. 2005. "R&D, Size and Firm Growth in Taiwan's Electronics Industry." *Small Business Economics* 25: 477–487.
- Zammuto, R. F., and E. J. Oconnor. 1992. "Gaining Advanced Manufacturing Technologies Benefits – The Roles Of Organization Design and Culture." *Academy of Management Review* 17: 701–728.