Trust building in science-based SMEs in North East England: an ecosystem perspective

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Abstract

Purpose: This paper five identifies exigent factors that enable and constrain trust building in a science-based innovation ecosystem.

Design/methodology/approach: Set in Northeast England, this study adopts a processual sensemaking approach to thematically analyse interviews with a diverse range of participants in six science-based SMEs.

Findings: The findings provide a unique exposition of trust building in an innovation ecosystem across geographic and platform relationships. In doing so, the findings highlight factors outside of contractual agreements that enable or constrain trust building in an innovation ecosystem.

Research limitations/implications: Limitations centred on subjectivity in the use of thematic analysis, sample bias and size. Sampling limitations were mitigated through the research design and analysis.

Practical implications: The findings provide unique insights into understanding the exigent factors that enable or constrain trust building in a science-based innovation ecosystem.

Originality/value: The study identifies five exigent factors that constrain or enable trust building in science-based SMEs' innovation ecosystem at a micro-level – *Building network relationships, degree of novelty, protection of innovations, propensity for adding value, propensity for risk.*

Key words: trust building; innovation; SMEs, sensemaking; innovation ecosystem

Paper type: Research paper

Introduction

Trust building is a key enabler of ecosystem functionality between interconnected organizations (Autio and Thomas, 2014). Moreover, the innovation ecosystem concept applies to platforms (Adner, 2017) where the lack geographic closeness allows for the de-emphasis of face-to-face trust building (Tseng and Johnsen, 2011). The platform literature recognizes the importance of trust building amongst innovation ecosystem participants (Cusumano et al; 2020). Platform leaders must convince ecosystem participants to sacrifice short-term interests for the common good, which requires the initiation of trust building within the ecosystem (Gawer and Cusumano, 2014). For science-based SMEs, innovation ecosystems provide opportunities to collaborate with diverse actors, firms, civic/government and educational, to create and capture value, grow and survive (Pattinson and Preece, 2014). Science-based SMEs can utilize innovation ecosystems to support R&D efforts, as they comprise of a diverse range of competences, capabilities and expertise across an array of actors (Estrin, 2009). One of the weaknesses and challenges of innovation ecosystems is building trust and interconnectedness between different ecosystem actors (Reynolds and Uygun, 2018). Set in North East England the purpose of this paper is, therefore, to examine trust building in science based SMEs.

Given the nature of science-based innovation, the ecosystem perspective reflects the contextual realities of science based SMEs as they attempt to overcome trust related challenges related to commercialisation of innovation. Within an ecosystem, the focus is on forming relationships with actors, and the network is a by-product of these activities. The innovation ecosystem is therefore an intrinsic part of how science-based SMEs build trust in order to survive and complete with other science-based firms. This research explores a number of gaps in the innovation ecosystem literature. First, research that explores trust building in science-based ecosystems has been subject to limited empirical research (Sharif et al., 2005). This research provides a unique exposition of trust building in an innovation ecosystem across geographic and platform relationships. Second, the context of many investigations studying interconnectedness has been restricted to that of the network, but this research addresses the more helpful context of the innovation ecosystem (Adner, 2017). Third, innovation ecosystems are not defined solely by contractual relationships (Jacobides et al., 2018). A crucial missing element in innovation ecosystem research is identifying factors outside of contractual arrangements that enable or constrain trust building. In responding to this gap, the authors identify five exigent factors that enable or constrain trust building in a

science-based innovation ecosystem at the micro-level. Given the importance of trust building in supporting relationships within the innovation ecosystem, especially in a science-based context, this paper seeks to address the following research questions:

1. *How do science-based SMEs use geographic and platform relationships to build trust?*
2. *What factors enable or constrain trust building in a science-based innovation ecosystem?*

Using case studies of science-based SMEs in North East England the research develops an empirical account of how these SMEs engage in trust building within an innovation ecosystem through geographic and platform (non-geographic) relationships. Here, a distinction is made between geographic relationship, focused on connections between individual actors, and platform relationship, in which firms' innovations provide a platform for other firms to develop complementary new products and processes (Zeng *et al.*, 2010).

The rest of the paper is structured as follows. The conceptual background provides an overview of innovation ecosystems, trust and trust building. Next, the methodology is outlined, followed by the findings and discussion then the conclusion.

Conceptual background

Innovation ecosystems

Innovation ecosystems model the interconnectedness of complex relationships formed between actors whose purpose is to enable technological advancement and innovation (Jackson, 2011). Actors represent a mixture of physical resources (for example, finance, equipment, research facilities) and human capital (for example, employees, industry and academic researchers, industry representatives). Together, these actors constitute institutional entities that participate in the ecosystem, including universities, businesses (including SMEs), venture capital firms, governments and other policy makers.

The innovation ecosystem concept is contested with conflicting interpretations (Autio and Thomas, 2014). Criticisms centre on costs and benefits attribution (Stangler and Bell-Materson, 2015), cause and effect (Alvedalen and Boschma, 2017), and contributory factor attributions (Stam and Spigel, 2016) such as interconnectedness. Nevertheless, innovation ecosystems stress the importance of pluralism between a broad range of agents including universities, SMEs and large corporations (Carayannis and Campbell, 2009, p. 19). Jackson (2011) makes a distinction between two largely separate economies that comprise an

innovation ecosystem; the research economy driven by the desire to conduct basic research and development (R&D) and the commercial economy driven by marketplace and shareholder value. This creates a paradox between the two economies because investment in the research economy must be derived from the commercial activities. It is within these two largely separate economies that science-based SMEs operate (Pisano, 2006). They are reliant on the sharing of scientific expertise and engaging in mutually beneficial innovation activities in order to create value (Pattinson and Preece, 2014).

Interestingly there is a growing body of evidence to suggest that networking capability is crucial to the success of innovation ecosystems (Pierrakis and Saridakis, 2019). Networking capability is "the ability of a firm to exploit its existing interfirm relationships and explore new relationships with external entities" (Mu *et al.,* 2017, p. 187). Networks are "a firm's set of relationships with other organizations" (Pérez and Sanchez, 2002, p. 261). Networks are critical for promoting innovation activities through recurring social interactions (Ardichvili *et al.,* 2003). An innovation ecosystem emphasizes the importance of a broad range of loosely connected innovation networks and knowledge clusters (Carayannis & Campbell, 2009). Consequently, the value of diverse, trusted ecosystem partners has been recognized across a range of scientific and technological networks (Kaufmann and Tödtling, 2001) that support the wider ecosystem.

Science-based SMEs

Participation in innovation ecosystems is a competitive necessity for science-based SMEs. Science-based SMEs are firms created to commercially exploit scientific knowledge and represent the principal form of science-based entrepreneurship (Colombo *et al.*, 2010). Science-based SMEs differ from other types of SMEs and larger organizations and face "unique challenges that require different kinds of organizational and institutional arrangements and different approaches to management" (Pisano, 2006, p.4), making ecosystem participation particularly challenging. For example, some science-based industries, including life sciences such as biotechnology, have distinctive characteristics that require industry-specific knowledge development (Stremersch and Van Dyck, 2009). Science-based innovation makes a significant economic contribution, providing jobs, fostering entrepreneurial spirit and creating value through the development of innovative new products and services (Estrin, 2009). Science-based business carries an inherently higher risk than other types of business because such firms "often face decades or more of highly risky and highly uncertain research before they even hope to earn a profit" (Pisano, 2010, p.467).

According to Pisano (2006; 2010), science-based businesses also suffer from additional issues related to integrating diverse scientific and related disciplines, such as engineering. Therefore, to overcome knowledge and commercial challenges science-based SMEs need to build innovation ecosystem relationships.

Science-based SMEs are secretive, operating within a culture of customer confidentiality making trust building difficult (Perren, 1998). Lack of trust is a strong constraining factor for knowledge sharing in SMEs where individuals fear losing their 'expert status' and organizations fear losing competitiveness (Harding and Pawar, 2000). To the best of the authors' knowledge, there have been no studies examining trust building in a science-based innovation ecosystem. Understanding how trust building occurs within innovation ecosystems is, therefore, fundamental to developing a clear understanding of the paradox of the knowledge and commercial economies identified by Jackson (2011). A healthy ecosystem acts as a mechanism for building trust relationships among actors within the innovation ecosystem (Maha and Levina, 2019). Adopting an actor-centric perspective (Adner, 2017) highlight the importance of relationships across the contexts of geography and platform within the innovation ecosystem of science-based SMEs. This view provided a useful lens for examining how science-based SMEs build trust in an innovation ecosystem.

Trust

For an innovation ecosystem actor to create value they must have some basis of trust with other innovation ecosystem actors. For science-based SMEs, means trust building with ecosystem partners is a competitive imperative (Adner, 2017). Morgan and Hunt (1994, p. 23) seminally define trust as a situation where "one party has confidence in an exchange partner's reliability and integrity." The notion of integrity, alongside reliability is an important semantic distinction to consider. Confidence denotes a situation where *dependable goodwill* as opposed to just *dependable competence* is expected (Blois, 1999, p. 200). Within and innovation ecosystem for science-based SMEs, this asymmetric dynamic is problematic when choosing to transfer knowledge to a potentially more powerful partner on the basis that greater value will be returned at a later date (Sawers *et al.*, 2008). In these situations, a smaller, weaker SME might be reticent to transfer information to a more powerful exchange partner within an innovation ecosystem. Indeed, Ulhøi *et al.*, (2012) argue a lack of trust increases small firms' need to guard against opportunistic behaviour, and the resulting excessive formalization and monitoring can create conflict, leaving the SME feeling vulnerable. Trust also refers to integration of knowledge/expertise/know-how, linked to the

notion of *pre-experiential trust* (Davies and Prince, 2005), which relies on competency inferred from third party endorsements or associations prior to first-hand experience, reputation and information. This may result in science-based SMEs no being able to overcome knowledge and commercial challenges. Therefore, this lessens their network capability within an innovation ecosystem (Pierrakis and Saridakis, 2019).

Trust Building

As an informal coordination mechanism, Autio and Thomas (2014) suggest that trust building influences the evolution of an innovation ecosystem. Ulhøi *et al.,* (2012) illustrate that trust can be institutionalized, but only if it can be transferred from the personal to the organizational level. Top-down measures are likely to diminish existing relationships. The use of contractual agreements (Jacobides *et al.,* 2018), including extended contracts or guarantees, that arguably constrains trust building. The transferability of trust building relies heavily on proof sources and, in the innovation ecosystem context, existing trusted members may be utilized as trusted sources. However, dependable goodwill could also be evident in a situation where an exchange partner's motives are selfish. The long-term selfish best interests of a firm may be served by demonstrating dependable goodwill. Individuals also have internalized values that may mean they have a greater propensity to work towards earning an exchange partner's trust (Mayer *et al.,* 1995).

Trust building is a laborious but valuable process (Pattinson *et al.,* 2018) and might be difficult for science-based SMEs, which can be secretive about their processes and are often generating novel ideas innovations in their field (Pattinson and Preece, 2014). Irrelevance, linked to the degree of novelty and uniqueness of the knowledge base, or distrust (Saunders *et al.,* 2014), can make innovation ecosystem participation difficult. For science-based SMEs, trust building is an issue because small firms fear opportunistic behaviour from competitors, which prevents reciprocal behaviour (Bacon *et al.,* 2019). Science-based firms developing innovations have a high degree of appropriability from patents, secrecy, and tacit knowledge and trust (Gibb, 2006), which they need to protect (Kitching and Blackburn, 1998). The need for secrecy, in particular, presents a significant barrier to building trust for science-based SMEs.

Therefore, science-based SMEs need to balance the competitive necessity to collaborate with other ecosystem actors to overcome knowledge and commercial challenges, with taking different relationship approaches to build trust within an innovation ecosystem. Trust building in an innovation ecosystem is enabled through the ability to build strong personal

relationships and effective networks (Ulhøi *et al.*, 2012). However, trust is also constrained through reliance on contractual agreements (Jacobides *et al.*, 2018) and the distinctiveness of industry-specific knowledge and individuals' fear of losing 'expert' status (Harding and Pawar, 2000). The degree of novelty can also be an enabler or constrainer of trust building. Where the degree of novelty is high, trust building is difficult because firms seek to protect their innovations (Saunders *et al.*, 2014). Conversely, where the degree of novelty is low, firms are more comfortable sharing their expertise (Pattinson and Preece, 2014).

Methodology

Sample

The study used critical case sampling, a subset of purposive sampling techniques, to select a small number of important cases likely to provide the greatest insight central to addressing the research questions (Myers, 2009). Critical case sampling focuses on selecting cases on the basis they make a point dramatically or, in this study, because the selected companies and interview participants (Table 1) are important to the research questions. The empirical sample was restricted to science-based SMEs based in North East England. The study adopts the EU definition of SME as a business with fewer than 250 employees, a turnover of less than €50 million, or a balance sheet total of less than €43 million. A combination of desk based research and industry expertise as used to identify six cases that represented a broad range of science-based activities including, chemical extrusion, water treatment, biotechnology, nanotechnology, semiconductors and gas analysis. The experts comprised of academics and researchers across the science, engineering and management disciplines able to identify science-based SMEs and act as gatekeepers to make introductions on behalf of the lead author. This enabled data collection across a broad range of science-based disciplines.

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However, for small samples heterogeneity can be problematic if, as in this study, the individual cases and interviewees are so different from each other. To mitigate this, a cross-section of key informants were purposively selected based on the overall research aim, and who were likely to 'yield the most information and have the greatest impact on the

development of knowledge' (Patton, 2005, p. 236). The strength of this sampling approach is that it captures the range and diversity of experience, beliefs, and opinions from a broad range of participants, instead of providing a quantitative summary of findings.

Procedure

A total of 17 in-depth, semi-structured interviews were conducted, each lasting around 90 minutes. The interview protocol included 13 questions. A copy of the interview protocol as given to interviewees and any questions addressed before the interview commenced. Interviews were recorded and transcriptions analyzed using thematic template analysis (King, 2012), employing a hierarchical coding process, initially using some broad *a priori* themes before encompassing additional themes generated through an iterative analysis of the data (Table 2).

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King (2012) supports three positions when generating *a priori* codes. Firstly, obtain some *a priori* codes based on the theoretical position of the research and in line with the research question; secondly, develop codes after initial coding of a subset of data; thirdly, use a combination of these two approaches - start with some predefined codes and refine these after initial exploration of the data. The authors identified five *a priori* themes (relationships, novelty, innovation protection, adding value and risk) from an initial review of the literature and based on their relevance to the research question and overall aim of the research. These *a priori* codes provided the Level 1 Themes (see Table 2). The Level 2 and 3 themes subsequently emerged from the iterative process of coding the data. The coding process revealed that trust building within the innovation ecosystem broadly occurred across geographic relationships and platform contexts.

Adopting a processual sensemaking approach (Dawson, 2019), providing the authors with invaluable insights into how trust building evolved in an ecosystem context, aiding the iterative development of the thematic template (King, 2012). Employing an inductive approach to developing the coding structure supported the authors' social constructionist position, that understanding is constructed from the social and physical environment of the participants (Strauss and Corbin, 1994). Acknowledging that although not strictly a grounded approach, combining template analysis with sensemaking enabled the authors to focus on the

means by which interviewees make sense of their experiences (Gioia *et al.*, 2013), particularly given the unique organisational characteristics of science-based SMEs with respect to secrecy. Next, the findings discuss implications for trust building in a science-based innovation ecosystem.

Findings

Two different, but complementary, trust-building approaches emerged within the innovation ecosystem; namely, those aligned with *geographic relationships* and those aligned with *platform relationships*.

Geographic relationships

During the early stages of trust building, some 4 out of 6 of the science-based SMEs in the study use geographic relationships in establishing trust, focusing on connections between individual actors to help them understand customer and supplier needs in order to create value.

Establishing personal relationships

Initial relationship building with ecosystem stakeholders stemmed from the desire to establish strong trust based personal connections with other stakeholders and actors. These initial efforts supported network building through recurring social interactions. Initial trust building often involved knowledge transfer activities within an innovation ecosystem. As one participant in ExTech observed:

> "[Customer X] are very, very particular and everything takes a very long time and they have to go through this trust building exercise which involves quite a few visits, before the point they get to when they say 'Right, okay we're now going to go with [you]" (Operations Director, ExTech).

For example, the Technical Manager in BioTest had built a strong personal relationship with a supplier providing them with the freeze-drying equipment, to the point where it trusted the Technical Manager to service and repair the equipment himself. In this instance, the supplier relied on the elicitation of tacit knowledge and expertise of the Technical Manager to improve the performance of its equipment on behalf of other customers who had issues using the equipment. Such geographic relationships were crucial in building shared language founded on recurring social interactions associated with trust building. Through a process of knowledge transfer related to optimizing the reliability and performance of the freeze-drying

equipment, a form of incremental innovation through which new knowledge was created within BioTest that both parties in the ecosystem benefitted from. The Managing Director (MD) of BioTest confirmed: "Good personal relationships are critical" when selecting partners. Good personal relationship meant the MD was confident the relationship would not be exploited. By sharing expertise, the pros and cons of sharing and transferring knowledge become more transparent:

> "If [Customers] seem to come to you for advice… then I think you're in a strong position for building on the future with them. Same with suppliers. I think with all my suppliers I'm on a fairly good personal footing with them, [it's] just how I do business" (Technical Director, NanoCom).

This approach, supported by dependable goodwill, supported the emergence of trust in an innovation ecosystem that added value to the customer.

Maintaining personal relationships

For some science-based SMEs, established relationships were maintained through regular face-to-face engagement between individuals within the ecosystem. For example, the MD of BioTest had established relationships with a range of innovation ecosystem actors, including hospital doctors and nurses, GP Practice Managers and academics in several universities. The MD highlighted one example where, from the initial point of contact, he established and maintained a strong personal relationship with one a customer: "When [name omitted] came over… he'd… have a meal and chew the fat... discuss how we can help - and through that relationship building we help them develop solutions" (Managing Director, BioTest). Individuals in other SMEs adopted similar behaviours in developing incremental innovations on behalf of ecosystem partners. In another example, GasLab provided support and advice to customers as a way to reinforce their capabilities and expertise:

> "Certainly in the last year or so we've started to try and do more in terms of getting out [and] visit customers. We certainly tag along to sales calls now… and we do pop out and see people when we feel there might be something we can chat to customers about in… a more sort of technical way really" (Design Engineer, GasLab).

These individuals leveraged personal relationships, often informally, and sometimes these trust-based, geographic relationships support the wider ecosystem. Once the MD of BioTest, for example, had identified a company he wanted to work with, he would initiate contact and then build on this initial engagement. The MD of BioTest displayed a high propensity for risk

and used visits as opportunities to build personal relationships with existing and potential customers and, as the Technical Manager explained, the MD: "used these visits as opportunities to build personal relationships with existing and potential customers". The MD used personal connections with customers to gather intelligence about their intentions and exploit gaps in their competence. The ability to leverage personal trust-based relationships helped build geographic-based relationships that supported incremental innovation with a range of ecosystem stakeholders, including customers and suppliers.

Network building within the innovation ecosystem

Four types of networking building were identified amongst different groups of ecosystem actors, including suppliers, competitors, partners and customers. For ExTech, network building focused on suppliers, sub-contractors and sometimes competitors. Network building was often initiated because ExTech needed to pass on work it was unable to do at that time. The Operations Director explained: "Yes, generally it will be work we *could* do ourselves but we don't have the capacity for the particular time". By passing on work within the ecosystem helped ExTech to build its network. Similarly, by providing free, informal advice and guidance, the MD of BioTest established trust with customers and suppliers:

> "We're now dealing more and more with GP's and pharmacy driven units. These customers require a lot of support to use our products [so] we meet up or visit them regularly… to chat about their needs [and] share our expertise" (Managing Director, BioTest).

Although offering on-going advice and support was a high-risk strategy, increasing opportunities for knowledge leakage, it did encourage cross-organizational informal interaction that supported networking and incremental innovation within the wider ecosystem. Trust building was also evident in other companies, such as NanoCom, who offered free testing facilities. NanoCom provided a report of the results as a way to build its network of potential customers:

> "… it's just to prove that the system at least has some effect on their particular [innovation]… and after that I would probably go with a brief report presentation and then meet them at that point. That seems to work quite well" (Technical Director, NanoCom).

These reciprocal arrangements were used to contact new customers and suppliers, or to maintain contact with existing ones within the innovation ecosystem. As another interviewee observed: "If we need some help or advice, then [the university is] more than happy to help

us. It's mostly [the Managing Director] building connections that way" (R&D Manager, BioTest). Showcasing expertise, a form of tacit knowledge was founded on geographic relationships that relied on informal, trust building interactions in an ecosystem context. Building tacit knowledge enabled BioTest to exploit incremental innovation opportunities.

Strong personal relationships

The findings demonstrate the ability to build trust and leverage personal relationships helped bring innovation ecosystem actors together. It created interconnectedness between innovation ecosystem actors. Relationships were built through repeated social interactions between actors within the ecosystem. Strong relationships were reinforced through firms providing advice and scientific expertise, as one interviewee explained: "once the personal relation[ship] is fairly strong, trust is then quite difficult to break" (Purchasing Manager, ExTech). ExTech provided a small range of gas sensor equipment in comparison to its main competitors and due to its limited offerings; trust building was tempered by the need to protect its innovations. Adding value in this way was closely linked to building the strong personal relationships required in supporting a robust innovation ecosystem, as one interviewee observed: "It does make life an awful lot easier when you have a better personal arrangement in there, rather than going in there totally cold. It gets you so much further down the line" (Managing Director, NanoCom).

Here it was observed that, similarly to BioTest, trust building developed through repeated social interactions within the innovation ecosystem. SMEs pooled expertise, a kind of incremental innovation, providing advice to customers and suppliers. Knowledge transfer within the ecosystem was reinforced through strong personal relationships, as one interviewee observed: "People need to trust [in your knowledge]" (Technical Director, CatLab). Building trust was often achieved through the elicitation of tacit knowledge, where providing advice and scientific expertise was reinforced relationships with customers and suppliers. These activities enabled CatLab to project an image founded on consistent, rational behaviour in its dealings with customers and suppliers, which supported trust building.

Platform (Non-geographic) relationships

A second approach emerging from the analysis by which companies used platform relationships as an alternative to trust building and contingent to the exploitation of a particular technological innovation rather than relying on knowledge transfer via geographic

relationships. Firms in the study used platform relationships in a strategic way that was driven by commercial necessity and market demands.

Degree of novelty

The findings showed the degree of novelty associated with an innovation determined the strategies the SMEs pursued in relation to trust building. The high degree of novelty associated with RadTech's production method for ZCT was a platform innovation that provided capability advantages. Trust building was also constrained because of the lack of shared language with other innovation ecosystem actors. Similarly, GasLab relied on its expertise in blending novel, science-based technologies as an alternative to trust building. For GasLab, the high degree of novelty was more about how it brought together existing technologies to create a unique market offering, or 'system':

> "I don't really think that we do a lot of innovation… it's a case of buying tried and tested technology off the shelf and, sort of, putting it together, testing it a bit more, making sure it's fit for our application, then building it into a system" (R&D Engineer, GasLab).

RadTech had developed a novel method for growing Zinc Cadmium Telluride (ZCT) crystals to use in the manufacture of semiconductors and claimed that it was the only company able to produce crystals in this way. The highly novel element of this radical innovation was a new chemical vaporization technique, enabling the production of larger, better quality crystals than its competitors and which, therefore, had a wider range of uses and subsequently appealed to a larger market, or even to previously untapped new markets. The company saw its process as a platform for radical innovation that could not be replicated by competitors, as one interviewee explained: "We're not making a BMW and someone else is making a Volkswagen, this is, you know, we are the only company making this in the world, you know, *like* this" (Materials Manager, RadTech). The initial intention had been to grow the ZCT crystals and sell them to other product manufacturers. Thus, through its platform relationships, RadTech's intention was to provide a platform for other firms within the ecosystem to develop complementary products.

In addition, although novelty provided capability advantages, some interviewees described the novelty associated with of radical innovation as a barrier to trust building because uniqueness constrained the development of platform relationships that is other firms wishing to develop complementary new products. As one interviewee observed: "I think trust is important [but] I'm not sure how well we measure it. I mean if you've got someone from an

existing network then that's easier to measure" (Chief Technical Officer, RadTech). In these circumstances, the expectation was that an individual could be relied on to 'perform' as another interviewee observed: "Going into the unknown with someone new is much more difficult I think" (New Technology Manager, RadTech). Here, it can be argued, pre-experiential trust becomes necessary in order to kick-start a trust based relationship. Companies with a lower degree of novelty, such as BioTest and NanoCom, were more comfortable sharing knowledge that supported trust building. BioTest built trust based relationships by providing free advice and NanoCom by offering complimentary validation testing to potential customers.

Value adding activities

Companies with a high propensity for adding value were more closely associated with platform relationships within the ecosystem. RadTech, for example, viewed its production of ZCT as a platform for radical innovation for other firms to develop complementary new products. GasLab, on the other hand, added value through providing solutions to customers. RadTech had quickly realized that by offering additional functionality to the crystals, or incorporating them into its own products, it could improve on the original novel aspects of its radical innovation business model, adopting an incremental approach to new product development:

> "Really it was the 'roast chicken' model. If you cook it, you get more. Make it into sandwiches you get even more… and that's exactly what we realized we can do. We can sell ZCT as a little square and get a certain value for it. We can put electrodes on it and get more money. We can put it in some electronics and get even more money, or we can put it into a device that can be bought by someone who's completely non-technical and get even more money" (Materials Manager, RadTech).

The propensity to add value within the ecosystem via its new business model, combined the original idea of selling ZCT crystals with plans to develop and manufacture its own range of new products (called systems) incorporating ZCT crystals, e.g. radiation detectors, airport security scanners and medical x-ray devices. Similarly, GasLab used its product development expertise to blend novel combinations of existing science-based technologies. Effectively creating a relationship platform to provide gas sensing solutions for customers, as one interviewee observed: "We think our skills are really in integrating gas sensing solutions into niche applications… really understanding the particular requirements of a customer in their

application, then building them a system with gas sensing in it" (R&D Engineer, GasLab). For GasLab, added value was achieved by using its gas sensing technology as a platform to develop new and innovative solutions: "We do a lot of 'specials', bespoke products for customers who do come to us [with a problem]… usually the likes of a commercially fully integrated atmosphere monitoring system" (Design Engineer, GasLab). Other companies exhibited a low propensity to add value, for example, ExTech felt the need to protect its limited offering restricted its ability to share knowledge, thus restricting its added value.

Problem solving

Science-based SMEs involved in radical innovation, where the degree of novelty was high, relied on the development of platform relationships that exploited problem solving on behalf of customers. Initial reliance on reassurances of knowledge/expertise/know-how associated with the concept of pre-experiential trust (Davies and Prince, 2005), linked to promissory or implied problem solving activities often associated with rare skills and/or expertise, as exemplified by RadTech. Similarly, GasLab was engaged in a number of 'special development' projects with customers, which it saw as a way to build platform relationships and stimulate innovation. For these two companies, in particular, expertise offered through platform relationships facilitated trust building, in which integrity was allowed to grow. Difficulty in trusting others, based on estimating their integrity, was a particular issue for both RadTech and GasLab, and related to the novelty of their respective innovation platforms. This made it difficult to assess trust building processes, which are founded on the ability to assess the consistent, rational behaviour of individuals, who were often sourced for their rare skills:

> "I'm looking for a solution to an area that I've never dealt in before, so then I've got to find someone completely new, and… if you're scouring for a particular skill and it's a rare skill then I think you do end up with people who don't fit the… criterion" (Chief Technical, Officer, RadTech).

This made assessing the target's ability to fulfil his or her promises, difficult for RadTech.

Protecting innovations

Similarly, assessing an individual's capability within the innovation ecosystem was problematic for RadTech who relied on NDA's as a form of protection for its unique and therefore radical innovation. Paradoxically, it also relied on pre-experiential trust, often based on third party reputation, when sourcing individuals with rare or distinctive skills.

Nevertheless, on occasion, trust building was constrained by the uniqueness, or degree of novelty, of the innovation:

> "I think [uniqueness] should be an advantage in as far as the capability goes. I think it's [also] a disadvantage because there aren't that many [other companies] that… they're either not quite the same so we would have to change and alter stuff, or we have to go back to… fundamentals" (Material Manager, RadTech).

A potential challenge that arises in protecting intellectual property from potential innovation ecosystem actors is that it could reduce speed-to-market for SMEs' involved in radical innovation and, therefore, some way of reconciling conflicting objectives may be required. One interviewee commented that it was prudent to also have formal contractual agreements and the use of non-disclosure agreements (NDA's) was not uncommon: "Well, I think, you know, trust is pretty important, and obviously as I said collaborations have to be under NDA's from our point of view" (Technical Manager, RadTech). Nevertheless, switching costs, in terms of changing supplier or manufacturer might be significant, risky, and open to opportunism, insofar as SMEs' proprietary knowledge might be openly revealed to potential competitors. Such guarding or custody of information acts as a barrier to entry for ecosystem competitors.

In addition to a desire to protect its intellectual property, RadTech displayed a low propensity for risk. The company had patents pending on inventions that it was in the process of commercializing, which it perceived as a form of vulnerability, particularly in combination with its uncertainty about the patent process and potential for competitive rivalry. The fear of losing expert status was a barrier to trust building and the development of platform relationships with potential ecosystem partners. This supports the view that contractual agreements might constrain trust building activities and reduce the potential for reconciling conflicting objectives, especially in the early stages of relationship building, or where firms are seeking rare skills. Both RadTech and GasLab used platform relationships as an alternative to trust building rather than rely on knowledge transfer via networking activities associated with successful geographic relationships.

The next section discusses the significance of the findings for trust building in a science-based innovation ecosystem.

Discussion

From analysis of the findings, five exigent factors were identified that enable or constrain trust building in a science-based innovation ecosystem at the micro-level (Table 3).

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The SMEs involved in radical innovation, where the degree of novelty was high (RadTech and GasLab), relied on the development of platform relationships by exploiting value adding activities such as problem solving on behalf of customers. Where the degree of novelty was high, SMEs could not always rely on the reassurances of knowledge/expertise/know-how associated with the concept of pre-experiential trust (Davies and Prince, 2005). Rather they relied, initially at least, on relationships built on personal connections generated through recurring social, face-to-face interactions (Tseng and Johnsen, 2011). In SMEs lacking formal institutional structures, established networks often support the social activities necessary for supporting a robust innovation ecosystem. Significantly, the findings support the view that actors are capable of reproducing the institutional features of inter-organizational trust (Ulhøi *et al.*, 2012) through their network activities such as providing informal advice and guidance, or offering free testing facilities.

Organizations with a high propensity for adding value (for example, RadTech and GasLab) used their products as platform innovation, or rare skills to leverage pre-experiential trust. GasLab, for example, used its product development expertise to blend novel combinations of existing science-based technologies to create a relationship platform to provide gas-sensing solutions for customers. Propensity for risk was higher in the SMEs where the degree of novelty was low. BioTest, for example, displayed a high propensity for risk and used these visits to customers as an opportunity to share expertise and build relationships with customers. Previous network success with other ecosystem actors was associated with SMEs that had built strong geographic relationships where trust developed through relationship building. This was achieved through showcasing expertise, a form of tacit knowledge. On the other hand, some SMEs, such as RadTech and GasLab, used their platform relationships as an alternative to trust building. Rather than rely on knowledge transfer via networking activities associated with successful geographic relationships they leveraged value from exploiting their novel innovations.

Where the degree of novelty was high, a lack of shared language constrained trust building. Here, pre-experiential trust was essential to help kick-start ecosystem relationships based on inferred competency from third party recommendations. The SMEs whose products had a low degree of innovation novelty and therefore a low requirement for innovation protection were more comfortable sharing and exchanging knowledge, enabling them to showcase expertise that provided opportunities to build strong personal relationships with existing/ potential customers. Here, a strong trust-based innovation ecosystem was built through recurring social interactions.

SMEs whose products had a high degree of innovation novelty and were concerned about protecting their intellectual property. This created a reluctance to share knowledge, due to greater uncertainty associated with radical innovation. These SMEs relied on building trust founded on reassurances that organizational structures are in place to enable them to protect their innovations. Paradoxically, some firms were also reliant on pre-experiential trust, potentially backed up with institutional trust (e.g. contractual agreements/NDAs/sanctions to protect its innovations) linked to promissory or implied problem solving activities often associated with rare skills and/or expertise.

Conclusion

The findings provide a unique exposition of trust building in an innovation ecosystem across geographic and platform relationships that has remained neglected in the literature. While the context of previous research studying interconnectedness has been that of the network, this research addresses the more helpful context of the innovation ecosystem. In doing so, the findings highlight factors outside of contractual agreements that enable or constrain trust building in an innovation ecosystem.

Theoretical implications

This paper makes two key contributions. First, appreciating the study limitations, the findings provide evidence of how geographic and platform relationships facilitate trust building within a science-based innovation ecosystem at the micro level. The SMEs pursuing radical innovation relied on platform rather than geographic relationships and thus the study moves our understanding beyond the current focus on tools that SMEs use to undertake radical innovation (Nicholas et al, 2015). The study also affirms the need for science-based SMEs pursuing radical innovation to have an openness and capability for knowledge sharing within

an innovation ecosystem context (Pattinson and Preece, 2014) to maximise value creation. Furthermore, the study highlights that resources constrains do not prevent science-based SMEs pursuing radical innovation, diverging from the argument put forward by Wosche *et al.*, (2017). Moreover, the study highlights that SMEs pursuing innovation are not bound by geography for collaboration purposes and affirms the advantages of having capability to drawn on wider collaborations that are not location bound support radical innovation (Sarpong and Teilinck, 2018). The findings also demonstrate that trust building has been an invisible aspect of the empirical evolution of innovation ecosystem. The ability of science-based SMEs to build trust through geographic and/or platform relationships supports wider access to knowledge necessary to bring radical innovation into the market (Kapetaniou and Lee, 2019).

Second, the study identified exigent factors that enable or constrain trust building for science-based SMEs in an innovation ecosystem context at the micro-level. These factors include the degree of novelty associated with an innovation, the level of protection required for an innovation, propensity for adding value from innovation, the propensity for risk across the SMEs, and firms' previous network success. Where the degree of novelty was high, as with radical innovation, building trust took precedent over pre-experiential trust building, built through personal contacts (Davies and Prince, 2005). Much of the burgeoning research on innovation ecosystems takes a macro and meso-level perspectives (Nieth *et al.,* 2018) but also acknowledges the need for innovation ecosystems stakeholders to collaborate to create value. The study advances understanding of innovation ecosystems at the micro-level and provides new insights into the factors that influence science-based SMEs engagement with other innovation ecosystem actors. Building of trust between innovation ecosystem actors contributes to overall to innovation ecosystem vibrancy (Roundy and Bayer, 2019). Furthermore, these exigent factors extend our understanding of the conditions for knowledge transfer at a micro-level within an innovation ecosystem and thereby extending the conditions posited by Bacon *et al.*, (2019).

Managerial implications

The findings have significant implications for managers in science-based SMEs. First, within science-based SMEs there is a need to support the trust building activities of individuals by providing time to establish and maintain connections and build networks. For science-based SMEs, it is essential to engage in a systematic and consistent manner with innovation ecosystem stakeholders to build trust, irrespective of the form of innovation being pursued. Second, innovation ecosystem actors should engage in value adding activities, such as

problem solving on behalf of customers, to support trust building. Managers should focus on how to replicate this approach across with innovation ecosystem actors to develop their network capability. Third, managers should encourage cross-organizational informal interaction that supports in order to encourage trust building and build a healthy innovation ecosystem (Maha and Levina, 2019). Fourth, manager need to be aware that, where there is a high degree of innovation novelty, reassurances of knowledge/expertise/know-how associated pre-experiential trust cannot be relied on (Davies and Prince, 2005). To mitigate this situation, managers should be aware that technological expertise acts as a platform for building trust (Ardichvili *et al.*, 2003) by encouraging the sharing of expertise with customers and suppliers to build a robust innovation ecosystem.

Limitations and future research

Deciding the extent of the thematic template and number of codes was subjective. To mitigate potential subjectivity the data was reviewed at various stages by the authors. Sampling bias was more difficult to overcome because the science-based firms represented a heterogeneous group of SMEs. Nevertheless, they were all involved in using science at the core of their business and, represented a variety of typical, not necessarily representative, cases that were useful in illustrating key findings. A fruitful avenue for future research is to study situations where science-based SMEs failed to build trust through geographic and or platform relationships. In particular, what alternative strategies where used by such science-based SMEs to establish and build trust within an innovation ecosystem. Further studies are also required on how other actors within an innovation ecosystem build trust and confidence. There is a need for studies to examine types of confidence, and factors that build confidence for science-based SMEs in an innovation ecosystem.

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Table 1. Companies and participants

Company	Employees	Turnover	Sector	Participants
ExTech	80	£5 million	Chemical extrusion	Operations Director Purchasing Manager
BioTest	14	£1.2 million	Biotechnology	Managing Director Technical Manager R&D Manager
CatLab	2	Not available	Photocatalysis wastewater treatment	Managing Director Technical Director
NanoCom	2	Not available	Nanoparticulate dispersions and emulsions	Managing Director Technical Director
RadTech	60	£2.4 million	Semiconductor manufacture	Materials Manager New Technology Manager Chief Technical Officer Technical Manager
GasLab	40	£5.2 million	Gas sensors and analyzers	Managing Director R&D Engineer Service Manager Design Engineer

Table 2. Thematic template

Level 1 Themes	Level 2 Sub-themes	Level 3 Sub-themes
Relationships	Establishing/maintaining personal relationships (Geographic relationship)	Recurring social interactions (face-to-face) Exploiting existing networks Dependable good will
	Exploiting a technological innovation (Platform relationship)	Kick start for early network formation Complementary products Technology integration
Novelty	Radical innovation (Platform relationship)	Capability advantage Language barrier Sourcing rare/distinctive skills
	Incremental innovation (Geographic relationship)	Collaboration Pooling expertise
Innovation Protection	Knowledge sharing (Geographic relationship)	Eliciting tacit knowledge Fear of losing expert status Lack of sharing mechanisms
	Intellectual property rights (Platform relationship)	Appropriability of innovations Need for secrecy Culture of customer confidentiality Use of NDCs
Adding value	Problem solving (Platform relationship)	Providing solutions Special development projects
	Reciprocal behaviour (Geographic relationship)	Validation testing Providing 'free' advice Service and repair services
Risk	High levels of uncertainty (Platform relationship)	Long lead in times for science-based innovations Challenge integrating diverse disciplines Difficulty estimating integrity
	Opportunistic behaviour (Geographic relationship)	Knowledge leakage Vulnerability to others' actions Restricted reciprocity Showcasing expertise

Table 3. Exigent factors that enable or constrain trust building in a science-based innovation ecosystem at the micro-level

Exigent factor (EF)	**EF (High levels of innovation novelty)**	**EF (Low levels of innovation novelty)**
Building network relationships	Previous success of networks associated with *geographic relationships* Enables trust building ● Successful network engagement which enhance perceived integrity and supports the ecosystem ● Knowledge sharing encouraged informal, trust building interactions commonly associated with geographic relationship	Lack of success with networks associated with *platform relationships* Constrains trust building ● Reluctance to invest in relationship building to support networking and ecosystem development ● Reliance on pre-experiential trust linked to promissory or implied problem solving activities often associated with rare skills and/or expertise
	Illustrative Case Examples	
	BioTest – success of the MD in building extensive inter-organizational networks	RadTech and GasLab used platform relationships as an alternative to trust building rather than rely on knowledge transfer via networking activities
	RadTech - reliant on pre-experiential trust, possibly backed up with institutional trust (e.g. contractual agreements/NDAs/sanctions)	

Degree of novelty	High degree of novelty associated with *platform relationships* Constrains trust building ● Language barrier reduces elicitation of tacit knowledge ● Pre-experiential trust essential in order to kick-start relationships and instigate the early ecosystem development	Low degree of novelty associated with *geographic relationships* Enables trust building ● Comfort conversing in same language makes it easier to elicit tacit knowledge ● Strong trust-based ecosystem built through recurring social interactions
	Illustrative Case Examples	
	RadTech – novel production method for ZCT constrained trust building for platform innovations GasLab – problem solving through integrated gas solutions platform	BioTest – shared knowledge by providing free advice NanoCom – complimentary validation testing
Protection of innovations	High level of desire to protect innovations associated with *platform relationships* Constrains trust building ● Reluctance to share knowledge (due to greater uncertainty associated with radical innovation)	Low requirement to protect innovations associated with *geographic relationships* Enables trust building ● More comfortable in sharing and exchanging knowledge (since less to lose) across geographies

	● Reliance on trust building founded on reassurances that the necessary organizational structures are in place	● Trust building underpinned the expectation that an individual could be relied on to 'perform'
	Illustrative Case Examples	
	RadTech – conflicted between desire for external knowledge and protection of novelty	BioTest - showcasing expertise underpinned by knowledge sharing
Propensity for adding value	High propensity to add value associated with *platform relationships* Enables trust building ● Value adding to other companies' products within the ecosystem (also via problem solving activities) ● Pre-experiential trust essential in sourcing rare/distinctive skills	Low propensity to add value associated with *geographic relationships* Constrains trust building ● Less willing to share knowledge due to concern for protecting intellectual property rights where offering is limited ● Need to protect intellectual property
	Illustrative Case Examples	
	RadTech – ZCT viewed as a platform innovation for other firms to develop complementary new products GasLab – added value by providing solutions	ExTech – need to protect limited offering restricted ability to share knowledge

Propensity for risk	High propensity for risk associated with *geographic relationships* Enables trust building ● Showcasing expertise provides opportunities to build strong personal relationships with existing/ potential customers ● Informal knowledge sharing and exchange with customers/suppliers	Low propensity for risk associated with *platform relationships* Constrains trust building ● Uncertainty about the patent process and potential for competitive rivalry ● Desire to maintain protected relationships ● Use of NDA's and contractual arrangements to protect intellectual property (IP)
	Illustrative Case Examples	
	BioTest – MD willingness to share expertise with customers	RadTech – uncertainty surrounding protection of patents pending on new inventions