The engagement of entrepreneurial fi rms with universities

Network formation, innovation and resilience

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This paper examines the role of entrepreneurial fi rms as agents of economic resilience. It focuses on the networks these fi rms construct with universities in order to access knowledge for innovation. Drawing on data from a cohort of entrepreneurial fi rms in the United Kingdom and the United States it is found that networks between entrepreneurial fi rms and universities are an important feature of the complex adaptive innovation systems associated with resilience. Furthermore, entrepreneurial fi rms play a role in open innovation practices through the establishment of both horizontal and vertical ties with universities. However, there are numerous challenges that entrepreneurial fi rms often face when seeking to connect with universities, which may stymie resilience.

Introduction

Innovative firms are increasingly recognised as significant contributors to economic development (Siegel *et al.*, 2003; Lambert, 2003; Acs *et al.*, 2008; Audretsch *et al.*, 2008; Stam and Wennberg, 2009). In times of economic stagnation policymakers increasingly frame innovation and innovative firms

as the key to future growth prospects (Cefis and Marsili, 2005, 2006; Pike *et al.*, 2010; Huggins and Thompson, 2014). Therefore, it is crucial to understand the complex and interactive processes underpinning innovation and how this process occurs during periods of economic decline. Innovation processes are increasingly moving beyond the internal structures of firms (Chesbrough, 2003), with knowledge being accessed through inter-organisational networks (Huggins *et al.*, 2010; Huggins *et al.*, 2008). Universities often play a prominent role in these networks and are viewed as key knowledge producers in the context of economic development (Saxenian, 1994; Premus *et al.*, 2002; Cooke, 2004; Bramwell and Wolfe, 2008). Furthermore, the role of external knowledge sources, including universities, may become increasingly important during periods of economic downturn when more market-based sources such as those related to customers and suppliers contract (Bristow and Healy, 2013; Boschma, 2014).

The aim of this paper is to explore how entrepreneurial firms promote economic resilience through the knowledge networks they establish with universities to foster innovation. The research questions the study explores are: (1) to what extent can entrepreneurial firms act as agents of economic resilience through accessing university knowledge?; (2) what types of relationships and ties do entrepreneurial firms establish with universities as a means of fostering innovation-led resilience?; and (3) what are the barriers and challenges entrepreneurial firms face when seeking to establish these relationships?

Entrepreneurial firms are those oriented toward growth, especially through an innovation-driven approach (Eisenhardt and Schoonhoven, 1996; Lechner and Dowling, 2003; Siegel *et al.*, 2003; Huggins and Johnston, 2010). Due to a lack of internal resources, however, entrepreneurial firms are often reliant on external sources of knowledge as a means of innovating (Almeida *et al.*, 2003; Anderson *et al.*, 2010; Cooke *et al.*, 2005; Clifton *et al.*, 2010; Huggins *et al.*, 2012). This paper examines entrepreneurial firms and their engagement with university-generated knowledge through a study of firms in the United States (US) and the United Kingdom (UK). The methodology underpinning the study is based on a qualitative case study approach (Denzin and Lincoln, 1994; Silverman, 2000; Yin, 2014), in particular the use of multiple case studies (Eisenhardt, 1989; Eisenhardt and Graebner, 2007). The paper is focused on theory building in relation to the role of entrepreneurial network formation in promoting innovation-led resilience. In recent years case studies approaches, especially those involving multiple cases, have become an increasingly popular and accepted approach to studying entrepreneurial networks and network formation (for a review see Jack, 2010).

Both the US and UK economies were severely hit by the 2008 downturn and represent an interesting arena for studying the role of university knowledge transfer during a period of economic crisis. In addition, both economies possess very strong similarities in terms of their formal institutional framework (North, 1990), possessing a similar legal and regulatory system focused on protecting private property rights and promoting free and competitive markets, i.e. 'liberal market economies' as described by Hall and Soskice (2001). The two nations are both ranked in the top ten of the World Economic Forum's Global Competitiveness Report and the World Bank's

Doing Business Report (World Economic Forum, 2013; World Bank, 2014), highlighting their broadly similar performance.

The remainder of the paper is structured as follows. The next section outlines the conceptual framework employed to understand the nature of the association between resilience and the knowledge networks formed by entrepreneurial firms and universities. This is followed by a brief overview of the national economic contexts underlying the study. Following a discussion of the methodology employed, the key empirical findings are presented. The final section discusses the theoretical and policy implications and conclusions arising from the study.

Networks, innovation and resilience

A vibrant community of entrepreneurial firms may play an important role in providing the diversity that helps dissipate shocks (Dawley *et al.*, 2010), particularly if supported by sources of knowledge creation such as universities (Garnsey and Heffernan, 2005). The benefits of such entrepreneurially-driven innovation may be seen in terms of the greater adaptability associated with the notion of economic resilience (Pike *et al.*, 2010; Williams and Vorley, 2014). In this sense, adaptability consists of the capability to pursue opportunities that are not part of previous development paths, allowing economies to respond to uncertainty (Garud *et al.*, 2010; Pike *et al.*, 2010; Huggins and Thompson, 2013). In general, entrepreneurial firms can potentially contribute to resilience by enabling economies to diversify, develop and exploit their innovative activities (Shane, 1993; Wennekers and Thurik, 1999; Van Stel *et al.*, 2005; Wennekers *et al.*, 2005; Huggins and Thompson, 2013).

Furthermore, the importance of entrepreneurial firms may increase in terms of the sources of innovative activity at a time of exogenous shocks, since a more uncertain economic environment is likely to favour diversity rather than scale within economies (Audretsch and Thurik, 2001; Wong *et al.*, 2005; Huggins and Thompson, 2013). In general, innovative firms have a higher chance of survival (Cefis and Marsili, 2005; 2006), particularly those firms characterised by higher technology intensity (Westhead and Cowling, 1995). This is important in the context of resilience at a firm (Hamel and Välikangas, 2003; Herbane, 2010), sector (Garmestani *et al.*, 2006) and spatial level (Sotarauta and Srinivas, 2006; Bristow, 2010; Simmie and Martin, 2010; Martin, 2012; Martin and Sunley, 2014). It has been argued that a well-connected and networked environment with global knowledge flows increases economic resilience (Martin and Sunley, 2011; Huggins and Thompson, 2014). Through their need to network, in order to collaborate and gather knowledge, entrepreneurial firms may increase the learning capacity of the economy within which they are situated, resulting in greater resilience (Grant and Baden-Fuller, 2004; Huggins and Thompson, 2013).

Knowledge, networks and innovation

Knowledge sourcing from external actors has long been acknowledged as a significant factor for successful innovation (Langrish *et al.*, 1972; Rothwell *et*

al., 1974), with such innovation increasingly viewed as a systemic undertaking between firms and other actors, i.e. firms typically no longer innovate in isolation but through a complex set of external interactions (Ahuja, 2000; Lechner and Dowling, 2003; Owen-Smith and Powell, 2004; Vanhaverbeke, 2006; Roper *et al.*, 2008; Sammarra and Biggiero, 2008; Tomlinson, 2010; Bergenholtz and Waldstrøm, 2011). This suggests that firms form networks with other organisations to allow them to access the knowledge they require to develop, and to facilitate innovation and foster resilience. In particular, the networks formed by entrepreneurial firms with universities through knowledge transfer have become increasingly important channels by which such firms can access external knowledge (Benneworth and Hospers, 2007; Huggins *et al.*, 2008).

Firms may use a variety of approaches when they source knowledge, with each potentially yielding different results, ranging from small short-term outputs to large long-term ones (March, 1991). In this context, March (1991) develops a distinction between explorative and exploitative organisational learning. The notion behind explorative learning refers to discoveries, new undeveloped ideas, with little emphasis on improving internal competencies; and is principally associated with the non-linearity of innovation. Conversely, exploitative learning is focused on improvements in knowledge by means of organic growth; resembling a more linear innovation path. The decision to adopt either approach will depend on the resource-base of firms, in terms of both their internal resources and more external network assets, with a good balance between explorative and exploitative learning usually associated with the highest levels of innovation (Gupta *et al*., 2006; March and Levinthal, 1993; March, 1991). In this respect it is important to consider the relational assets, especially network capital in the form of inter-organisational networks, underpinning the processes through which either form of learning occurs in an externalised environment (Huggins, 2010; Huggins and Johnston, 2010).

Emerging theories of the firm such as the knowledge-based view (Grant, 1996) and extensions of the resource-based view (Eisenhardt and Schoonhoven, 1996; Lavie, 2006) recognise that knowledge accessing, acquisition, exchange and creation are key reasons why firms build or enter networks with other organisations. These networks concern the interactions, relationships and ties existing between firms, and may arise through the need to access new assets and skills, and keep pace with competitors (Ahuja, 2000).

As such, inter-organisational networks are increasingly found to act as a conduit facilitating the flow of knowledge in the form of skills, expertise, technology, R&D and the like (Andersson and Karlsson, 2007; Weterings and Ponds, 2009). It is through these networks underpinning systemic innovation processes that organisations access knowledge they do not, or cannot, generate internally based on their own capabilities (Huggins, 2010; Almeida *et al.*, 2003; Lechner and Dowling, 2003; Thorpe *et al.*, 2005).

Knowledge takes many different forms, with one of the most familiar typologies suggesting that knowledge is either explicit/codified or tacit. In general, explicit knowledge refers to information that can be easily communicated and acted upon among individuals, whereas tacit knowledge – such as skills, competence, and talents – is more difficult to directly communicate to

someone else in a verbal or other symbolic form (Huggins and Izushi, 2007; Nonaka and Takeuchi, 1995). Jensen *et al.* (2007) further suggest that knowledge for innovation can be utilised through two key modes, often simultaneously, with the most innovative firms tending to be those combining both. First, the Science, Technology and Innovation (STI) mode, based on the production and use of codified scientific and technical knowledge, such as that most typically created by universities. Second, the Doing, Using and Interacting (DUI) mode, which relies on informal processes of learning and experience-based know-how. Jensen *et al.*'s (2007) typology is useful as it makes the connection between the accessing of different forms of knowledge and the different modes utilised to foster innovation.

Based on Nonaka and Takeuchi's (1995) knowledge creation framework, Popadiuk and Choo (2006) further define a link between knowledge creation and innovation, whereby tacit knowledge is related to more radical innovations, whilst explicit knowledge is more a characteristic of incremental innovation. Drawing on a range of innovation theories (Abernathy and Clark, 1985; Henderson and Clark, 1990; Tushman *et al.*, 1997; Chandy and Tellis, 1998), Popadiuk and Choo (2006) suggest that the tacit knowledge created through exploration relates to the type of new market knowledge linked to radical innovation, such as that associated with major product or service developments. Conversely, the explicit knowledge developed through exploitation relates to existing market knowledge, and is linked more with incremental innovation in products, services or processes (Popadiuk and Choo, 2006).

The internal capabilities and characteristics of firms are likely to either facilitate or hinder the effectiveness of their knowledge sourcing activities, in particular their absorptive capacity. Absorptive capacity is often history-dependent and reflects how much an organisation has invested in the area of expertise it specialises in, and largely depends upon an organisation's investment in innovation efforts (Cohen and Levinthal, 1990; Zahra and George, 2002). Good in-house capabilities in R&D, design, and engineering help to capture and appropriate knowledge, in both codified and tacit forms, through the process of learning from external sources (Howells, 1996). Following on from March (1991), it can be suggested that knowledge sourcing and absorptive capacity building form two broad types: (1) explorative knowledge sourcing, principally associated with new undeveloped ideas, and (2) exploitative knowledge sourcing, focused on more incremental forms of innovation. As Levinthal and March (1993) argue, firms must usually find the appropriate balance between explorative and exploitative learning in order to remain resilient.

Knowledge networks and resilience

In light of the economic recession of 2008–2010 many scholars have turned their attention to the concept of resilience (Simmie and Martin, 2010; Martin, 2012; Martin and Sunley, 2014). The focus of this work tends to be on territories, and there is little that integrates the territorial and organisational dimensions of resilience (Gilly *et al.*, 2013). The examination of organisational resilience is a relatively well-developed field of enquiry, focusing on the

capability of organisations to adapt to systemic shocks (Meyer, 1982; Hamel and Valikangas, 2003). These 'environmental jolts' are diverse in character (Meyer, 1982) and refer to external events that change the situation of firms (Gilly *et al.*, 2013). Resilience, therefore, is the ability of a firm to respond to an event and offer resistance and reinvention in order to survive (Hamel and Valikangas, 2003). Network creation and external knowledge sourcing can be viewed as types of firm behaviour that are designed to promote survival by innovation and to ensure survival in times of economic downturn (McKinley *et al.*, 2014).

Even in periods of economic growth, external knowledge sourcing activities may be subject to considerable uncertainty, which often pushes firms to go through a period of trial and error in order to build an understanding of the norms, habits, and routines concerning different external knowledge channels (Cohen and Levinthal, 1990; Laursen and Salter, 2006). Consequently, in periods of economic downturn, when uncertainty among firms is heightened due to lower levels of confidence, falling sales and the restricted availability of credit, external knowledge sourcing activities may become increasingly important as a means for ensuring the survival of firms due to increasing pressures to find new markets, update products and services and develop new sources of revenue (Cefis and Marsili, 2005; 2006; Bristow and Healy, 2013; Boschma, 2014). In other words, the overwhelming requirement in times of uncertainty is to find partners, and to ensure those partners are stable and reliable (Crespo *et al.*, 2014).

In general, the discourse on knowledge sourcing and transfer acknowledges that firms seek to invest in calculative and dynamic relations through which they are able to gain access to knowledge to enhance expected economic returns, which some have termed a form of network capital (Huggins, 2010; Huggins *et al.*, 2012; Kramera and Revilla Diez, 2011; Kramera *et al.*, 2011; Lawton Smith *et al.*, 2012). The importance of possessing higher levels of network capital, i.e. the ability to seek out and create effective inter-organisational networks, is thus potentially amplified in times of economic downturn.

The differing spatial dynamics of knowledge sourcing activity suggests that networks can be of either a local or global nature, with there being potentially some interdependency between the two (Huggins, 2010; Huggins and Thompson, 2014). In particular, successful connectivity in global spaces is often considered to be the outcome of an initial system of localised interaction, whereby it is the knowledge crossing hallways and streets that initially catalyses intellectual exchange and knowledge transfer across oceans and continents (Glaeser *et al.*, 1992). However, unless local networks keep abreast of the knowledge emerging outside of their respective locale, they run the risk of becoming rigid and outdated (Camagni, 1991; Izushi, 1997; Bathelt *et al.*, 2004; Ter Wal and Boschma, 2011). During economic downturns networks may become more calculative, resulting in more intentionally managed networks based on reputation and access to relevant resources and partners (Hite and Hesterly, 2001).

Knowledge networks and universities

Universities are increasingly portrayed as core knowledge-producing entities that can play an enhanced role in driving innovation and development processes by providing knowledge for business and industry (Foray and Lundvall, 1996; Garlick, 1998; Kitagawa, 2004; Thanki, 1999; Fritsch, 2002; Huggins, Johnston and Steffenson, 2008). Rather than just the knowledge possessed or generated by individual firms and organisations, knowledge sourced from external providers such as universities is considered to be a key factor within modern innovation processes and the formulation of innovation systems (Nelson and Rosenberg, 1993; Freeman, 1995; Freeman, 1987; Chesbrough, 2003; Cooke, Heidenreich and Braczyk, 2004; Lawton, Smith and Bagchi-Sen, 2006).

Universities as knowledge infrastructures may affect the knowledge flows between themselves and a range of organisations at different geographical scales. A growing body of work examining university knowledge transfer demonstrates that many institutions are developing policy initiatives designed to increase such activity (Tornatzky *et al.*, 2002; Paytas *et al.*, 2004; Palmintera, 2005; Perkmann and Walsh, 2007; Abreu *et al.*, 2008), but less is known about the nature and pattern of the networks and interactions emerging from such knowledge transfer practices, and what may be the appropriate enabling mechanisms (Pickernell *et al.*, 2009).

Firms making the best use of the academic knowledge created within universities form an important element of well-functioning knowledge networks, which to a large extent drive development and prosperity (Asheim *et al.*, 2003; Bathelt *et al.*, 2004; Rutten and Boekema, 2007; Zhang and Huggins, 2014). Intense interactions between universities and external organisations are clearly not confined to one single type of organisation, but may span a number of actors and processes (Huggins *et al.*, 2008), and the utilisation of university knowledge is likely to be influenced by the characteristics of firms such as size and sector (Santoro and Chakrabarti, 2002; Schartinger *et al*, 2002). With fewer resources to invest in innovation activity, or to generate their own knowledge, entrepreneurial firms may be more likely to benefit from spillovers from universities (Acs *et al.*, 1994).

Entrepreneurial firms are often able to enjoy a lower cost searching for partners when located near universities, with proximity also allowing firms to access crucial tacit knowledge from universities (Alcácer and Chung, 2007; Audretsch, 1998; Zhang and Huggins, 2014). However, rising levels of national and transnational academic–industry partnerships demonstrate that neither firms nor universities consider knowledge flows to be necessarily spatially constrained (Huggins *et al.*, 2008). The increased reliance on wider spatial knowledge pipelines is reflected by the growing number of firms choosing to work with the best universities regardless of location in order to take advantage of high talent pools, favourable intellectual property rules and government incentives for joint industry–university research (NSF, 2006; Polenske, 2007).

Knowledge suppliers may not always be willing, or in a position, to transfer knowledge across networks if there is a low expectation of a reciprocal return

(Huggins *et al.*, 2008). This is often the case with university–small firm networks, whereby the flow of knowledge, and subsequent value added, tends to be one directional (Meyer-Krahmer and Schmoch, 1998). Universities are sometimes wary of engaging with a business community dominated by small firms, which they often regard as inferior and less lucrative collaborators and partners in comparison to larger and more internationally focused firms. This barrier may impact on the ability of those firms demanding knowledge to effectively absorb and infuse it. For instance, a market transaction involving knowledge, for example technology or expertise, may lead to significant information asymmetries in terms of effectively applying or utilising it (Cohen and Levinthal, 1990; Mackun and MacPherson, 1997).

Spatial context: the UK and the US

Both the UK and the US suffered a severe recession during the economic downturn of 2008–10, with the UK economy averaging growth of -0.5% p. a. and the US only 0.37% during this period (OECD, 2013). Both economies also saw significant falls in investment during the recession (US: -6.95%; UK: -4.08%) (OECD, 2013). The recovery has been somewhat more sluggish in the UK with output forecast to surpass the pre-recession peak in mid-2014, while the US regained its pre-recession peak in 2011. In both cases, however, the impact of the downturn has been moderate compared to nations, such as Greece, Spain and Portugal, which are suffering from more long-term negative consequences (Bloomberg, 2011). The economies of both nations are dominated by the service sector, which has led the recovery in terms of both output and trade, demonstrating the resilience of this sector when compared with manufacturing (ONS, 2013; Borchert and Mattoo, 2010).

With respect to the role of universities within national innovation systems, in recent years the UK has started to catch-up with the US in placing universities at the centre of economic development policies designed to exploit the 'science base', with UK government policies increasingly promoting them as key nodes of the knowledge economy (Charles 2003; Sainsbury, 2007). These developments mirror those taking place elsewhere in the world, reflected in a burgeoning literature focused on concepts such as 'entrepreneurial universities' (Smior *et al.*, 1993; Slaughter and Leslie, 1997; Etzkowitz *et al.*, 2000; Powers, 2004; Huggins *et al.*, 2008) and 'academic entrepreneurs' (Meyer, 2003; Shane, 2004), highlighting the role of both institutions and academics in knowledge transfer activities, such as the establishment of spin-off firms, and the exploitation of intellectual property rights through the licensing of technology and patent registration (D'Este and Patel, 2007; Huggins *et al.*, 2008).

In general, the US has a more vibrant and decentralised system of university knowledge commercialisation due to the introduction of the 1980 Bayh-Dole Act, which gave universities, rather than individual researchers, title to innovations established in their confines, as well as allowing universities to own patents arising from federal research grants (Goldfarb and Henrekson, 2003; Phan and Siegel, 2006). While leading universities in the US annually spinout 2.8 new companies per institution, universities in the UK achieve an

average of only 1.3 spinouts per institution. Also, the mean average licenses granted to the US universities is 23.2 per annum, compared with only 3.8 per annum in the UK, resulting in an average annual license income of US$6.6m per US institution and US$365,000 per UK institution. Comparing license income as a percentage of total research expenditure, US universities generate 2.8% compared with 1.1% in the UK (HEBI, 2004).

One of the key explanations for the UK–US differential in knowledge transfer is experience and accumulated knowledge, since the US has been involved in knowledge transfer activities significantly longer than the UK, especially the establishment of technology transfer offices (TTOs) within universities to promote and manage these activities (Franklin *et al.*, 2001). In the UK, it is argued that government has failed to fully realise the significant direct and indirect contribution universities make to local, regional and national economies (Kelly *et al.*, 2002). On the other hand, it is also argued that the performance of many universities in the area of knowledge transfer and commercialisation activities has not matched their overall potential, partly due to the relatively low level of internal financial and human resources devoted to such activities (Charles and Conway, 2001; Charles, 2003; Wright *et al.*, 2006). The relative success of knowledge commercialisation activities in the US compared with most parts of Europe is underpinned by the development of strong networks facilitated through a rich infrastructure of intermediary organisations (Sapienza, 1992; Prevezer, 2001; Çetindamar and LaageHellman, 2003). In general, the US system of knowledge transfer is more bottom-up due to the experimentation it has facilitated in the way university policy can best exploit intellectual property.

Method

The findings presented in the following sections of this paper are based upon a series of case studies of entrepreneurial firms in the UK and the US with a high propensity for engagement in innovation-led growth. In total, 16 case studies are included in the analysis, consisting of eight in each location. The firms in the UK were identified via a larger scale postal survey (see Huggins *et al.*, 2010). A parallel survey (as yet unpublished) was also undertaken in the US (in the state of Illinois), and the US firms were identified from this sample. The data for the case studies was collected during 2009–10, with the studies aiming to facilitate a better understanding of the role of entrepreneurial engagement with universities, and the impact of this engagement in promoting innovation-led growth and resilience during a period of economic downturn.

The overall methodological approach on which the analysis is based is a qualitative case study data collection and analysis framework (Denzin and Lincoln, 1994; Silverman, 2000; Yin, 2014), in particular the use of multiple cases (Eisenhardt, 1989; Eisenhardt and Graebner, 2007). The analysis aims to build theory in relation to the role of entrepreneurial network formation in promoting innovation-led resilience, and case studies approaches, especially multiple case study analyses, have become an increasingly accepted approach to researching entrepreneurial networks and network formation (Jack, 2010). Examples of influential entrepreneurial network studies that have adopted a

similar approach include Krackhardt (1995), Franke (1999), Hite (2005) and Belussi and Sedita (2012), with studies such as Huggins (2000), Cooke and Huggins (2001) and Lockett *et al.* (2013) using similar techniques to examine the motivations for, and role of, network formation.

The cases presented in this paper emerge from an initial sample of 65 entrepreneurial firms identified as possessing the characteristics associated with innovation-led growth. Based on the survey indicated above, these firms were those showing above average outputs across a range of innovation measures relating to the introduction of new products, services, processes and organisational practices. The cases presented are those for which the best possible access was secured. The principal aim is to develop a series of network biographies for each of the firms focused on their engagement with universities. In general, the case studies aim to capture the following core areas: the rationale and motivation for engagement with universities; the types of networks formed and the interaction mechanisms underpinning them; and the type of knowledge accessed through the networks, as well as the barriers encountered. Invariably, the universities with which the firms engage are research-intensive institutions. Although it is not possible to profile each university in this paper, common characteristics are a strong science and technology emphasis and a significant level of entrepreneurial and commercial awareness and orientation relative to counterpart institutions.

The method employed consists of the following key activities: an initial review of publicly available company-level documentation (e.g. website, company accounts, marketing and promotional literature) to gain an overview of key activities and markets; a one-day visit to the firm to interview key executives; telephone interviews and email exchanges with those universities with which the case-study firms network; and follow-up telephone interviews with the firms to investigate any information gaps or to clarify any outstanding issues. Following the initial drafting of the case studies, each report was presented to the respective firm to ensure that they were an accurate portrayal of the firms and their activities. The names of the firms involved have been changed in order to respect the confidentiality of the individuals interviewed, although all other details are accurate. The network biographies were established using accepted qualitative case study data analysis techniques (Denzin and Lincoln, 1994; Silverman, 2000; Yin, 2014; Eisenhardt, 1989; Eisenhardt and Graebner, 2007), in particular those applicable to entrepreneurial network-based studies, consisting of: (1) iterative reviews of the collected data to elucidate emerging themes and concepts; (2) comparison and coding of the key themes across the cases in order to prioritise the most relevant; and (3) a final review of the data including frequency counts for certain characteristics and activities. In terms of the frequency counts, as reported for example in Tables 3 and 5, these emerge from the coding of responses based on questions that were asked to all interviewees and whereby multiple responses are possible. Overall, this approach to data collection and analysis is consistent and in line with the protocols and methods reported in comparable studies (Jack, 2010; Lockett *et al.*, 2013).

The sample of case-study firms is presented in Table 1, which shows that the majority of the firms sell their products/services globally, although unsurpris-

Table 1: Characteristics of the studied firms

Firm	Size	Latest turnover	Year of incorporation	Sector/activity	Location	Geographical market/customers	Location of key university knowledge sources
AES	5	none	2008	mechanical engineering	US	pre-revenue; in plans: US, Canada, South America, Europe	Local (Illinois)
Biotyst	5	n/a	2005	biotechnology	UK	global; key: US, Europe	Local (UK)
Bridgetools	n/a	n/a	1914	mechanical engineering	US	global; key: US, Africa, Middle East	Local (Illinois)
Crossmed	2	0.5m	1991	biotechnology	US	global; key: India, China, Eastern Europe	Local (Illinois), Interstate (Arizona, Michigan), Global (UK)
Food Life	30	5m	1983	enzyme manufacturing	UK	global	Local (UK)
Formbox	5	1.3m	2006	engineering	US	global; key: US, Canada	Local (Illinois), Interstate (New Jersey)
Geostruct	12	1.5-2m	1982	software & consultancy, structural geology	UK	global	Local (UK), Inter-EU (France)
Globaltrate	16	1m	2003	industrial biotechnology	UK	global; key: US, Europe	Local (UK)
Grandbio	15	1.5m	1999	biotechnology	US	global; key: US	Interstate (Wisconsin)
Healthprom	14	1m	2006	clinical trial management	UK	global; key: US, Europe	Inter-EU and Global (multiple institutions)
Illitech	2	n/a	2009	nanotechnology	US	key: US	Local (Illinois), Global (Germany, Asia)
Interware	22	1m	1989	software, web content management systems	UK	global; key: US, Europe	Local (UK), Inter-EU (Denmark), Global (US)
Mediworth	17	n/a	2006	pharmaceuticals, technology engineering	UK	US, Europe	Local (UK), Global (US)
Plastox	10	n/a	2002	biotechnology	US	global, key: Europe, Asia, US, Canada	Local (Illinois)
SEM	7	n/a	2004	scientific equipment manufacturing	UK	global; key: US, Far East, Europe	Global (multiple institutions)

ingly key markets are the US and Europe. Other important markets include Africa and Asia (particularly India and China). The majority of the firms are less than ten years old, with the key sectors of innovation being represented, resulting in a majority being technology-based firms (Granstrand, 1998; Dahlstrand and Jacobsson, 2003; Shane, 2004; Harrison and Leitch, 2010).

Although the recessionary context underlying the case studies is similar in both nations, a direct comparison between the two sets of firms in terms of their national location is not possible due to the differing industrial composition of the firms in each nation. Nevertheless, the approach adopted enables an examination of the behaviour of firms that provides greater depth than a single nation study.

Findings

Initially, the findings explore the forms of knowledge transfer utilised by firms. In general, a number of different methods of knowledge transfer are applied among the firms, with collaborative research and consultancy being the most prevalent types (Table 2). Although a number of firms tend to focus mainly on collaborative and/or contract research and consultancy, other firms are more diverse in their methods of accessing knowledge. Formbox is an illustrative example of a firm using a range of knowledge transfer modes: lab space, expertise, collaborative research, contract research, and student placement. For some firms knowledge transfer comes in form of: licensing; offering graduate internships; creating a spin-out company; or the provision of specialist equipment. This diversity of modes suggests that the association between entrepreneurial knowledge networks and resilience is both multi-dimensional and varied in terms of potential university-industry transfer mechanisms (Perkmann and Walsh, 2007; Huggins *et al.*, 2008). These knowledge network approaches further indicate that entrepreneurial firms are utilising universities as sources of innovation to remain resilient, highlighting the importance of university knowledge in providing entrepreneurial firms with the adaptability that is a key feature of approaches to ensuring resilience (Pike *et al.*, 2010; Williams and Vorley, 2014).

As indicated by Table 3, the key to successful engagement across firms is direct contact with academics. As suggested by Formbox, for example, the less rigid and developed the university commercialisation structure (including technology transfer offices) the easier it is for entrepreneurial firms to engage with key academics. In general, the importance of networks and good communication channels are found to be vital to firms. Biotyst, for example, uses a network of researchers from the university it originally spun-out from, allowing it to tap into a resource of nearly 30 academic researchers, allowing it to significantly and flexibly expand its core R&D activity. This highlights the importance of networks in facilitating innovation, with effective direct communication channels between entrepreneurial firms and universities being the key efficiency driver of these networks (Etzkowitz *et al.*, 2000; Lawton Smith, 2007; Anderson *et al.*, 2010; Huggins and Thompson, 2014). Furthermore, it confirms the emerging view that knowledge networks form part of the complex adaptive systems through which firms and other agents, including universities, maintain their economic resilience (Cooke, 2012; Bristow and Healy, 2013). Similarly, it suggests that networks between entrepreneurial firms and universities are a key means of avoiding the types of path-dependent lock-in that often erodes firm level competitiveness and innovation (Garud *et al.*, 2010; Crespo *et al.*, 2014; Dawley, 2013).

Table 2: Key modes of knowledge transfer

Mode of Knowledge Transfer										
Firm	**Collaborative research**	**Consultancy**	**Contract research**	**Expertise**	**Lab space**	**Licensing**	**PhD studentship**	**Specialist equipment**	**Spinout**	**Student hire/ internship**
AES		H								H
Biotyst		H	H						H	
Bridgetools		H								
Crossmed	H		H							H
Food Life		H	H							
Formbox	H		H	H	H					H
Geostruct	H	H								
Globaltrate	H								H	
Grandbio						H			H	
Healthprom		H								
Illitech	H								H	
Interware	H	H					H			
Mediworth	H									
Plastox	H									
SEM						H				
Westchem				H	H			H		H
Total Count	*8*	*7*	*4*	*2*	*2*	*2*	*1*	*1*	*4*	*4*

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Table 3: Key engagement channels (counts)

	Direct Contact	Networks	Communication	Technology Transfer Offices (TTOs)	Government Agents
AES	H		H		
Biotyst	H	H			
Bridgetools				H	
Crossmed				H	
Food Life		H			
Formbox	H				
Geostruct		H			
Globaltrate		H	H		
Grandbio		H			
Healthprom			H		
Illitech		H			
Interware	H				H
Mediworth	H				
Plastox	H				
SEM	H				
Westchem	H				
Total Count	*8*	*6*	*3*	*2*	*1*

Only two firms – Bridgetools and Crossmed – indicated that a TTO played an important role in the success of its engagement. This could point to some divergence among universities in how they facilitate access to their knowledge and the management of the bureaucratic burden associated with knowledge transfer (Huggins *et al.*, 2008; Goldstein, 2010), especially commercial exploitation strategies (Siegel *et al.*, 2007) and the identification of commercial opportunities (Lockett *et al.*, 2003). This is particularly well depicted by Formbox, which sources knowledge from more than one university. Working with a university TTO was described by Formbox as very difficult and bureaucratic, especially concerning negotiating contracts. Contrary to this picture, the firm stated that when collaborating with a university without a TTO there were fewer barriers, enabling better direct contact with the academics involved, suggesting that knowledge flows better when unconstrained in this way.

These issues were highlighted by a number of firms, demonstrating how potentially problematic it is for them to effectively source university knowledge. Evidently, the preferred method of direct contact is associated with the alleviation of university institutional bureaucracy and IP issues (see Table 5). Such findings strongly suggest that entrepreneurial networking best promotes resilience when it is given the space to evolve in a manner that is unfettered by

top-down interventions (Huggins, 2000). At times of exogenous shocks, entrepreneurial agents within particular economies are likely to require agility and streamlined access to effective knowledge if they are to capture the type of 'bounce back' associated with resilience (Weick and Sutcliffe, 2001; Zolli and Healy, 2012; Williams and Vorley, 2014).

In terms of the type of knowledge accessed, all the studied firms tend to focus on accessing research, or specifically the latest research, and the forms of knowledge generally associated with the STI mode of innovation (Jensen *et al.*, 2007). For instance, Mediworth focuses on the latest research concerning the therapeutic effects of crystals in pharmaceuticals, which reflects its business model – developing new technologies and licensing them to other businesses. Other firms source prototypes (Geostruct), research expertise (Healthprom, Interware), technology (SEM), and feedback/advice (Globaltrate). For these firms, resilience is clearly being nurtured through networks with universities focused on science and technology-based innovation, which represents new path-creating, rather than path-dependent, routes to ensuring entrepreneurial activity during periods of exogenous shocks (Garud *et al.*, 2010; Dawley, 2013). This is not to suggest that these networks would not be in existence during more economically buoyant times, but to indicate the important role they play in promoting entrepreneurial-driven adaptive resilience as well as the more acknowledged role of promoting innovation-driven economic growth (Huggins and Thompson, 2014).

For some firms, particularly those in the US, there is a more varied pattern of knowledge sourcing, manifested by a tendency for firms to be more diverse in terms of the knowledge they source, including: technology (Grandbio, Bridgetools), market intelligence (AES), designs and prototypes (Bridgetools), testing and analysis (Crossmed), lab space, new ideas and customer leads (Formbox), laboratory equipment and graduate students (Westchem), and developing products and improving production processes (Plastox). Formbox reported sourcing as many as five different types of knowledge, with US firms generally appearing to be more open in terms of accessing a broader base of knowledge. This diversity in entrepreneurial sources of knowledge chimes with evolutionary thinking on the nature of economic resilience, which highlights the need for a related variety of knowledge to promote continuous innovation (Boschma *et al.*, 2012; Boschma, 2014). The fact that approaches to accessing such a related variety of knowledge appear to be more embedded among US firms may reflect the fact that 'open innovation' practices, and the knowledge networks they are predicated upon, are usually considered to be relatively highly developed in the US compared with elsewhere (Chesbrough, 2003). However, existing evidence has mainly focused on open innovation in the context of large corporations, and the practices of firms identified above suggest that open innovation is a phenomenon equally applicable to a strata of more entrepreneurial firms (Laursen and Salter, 2006; Perkmann and Walsh, 2007).

Overall, the evidence suggests that entrepreneurial firms broadly follow one of two modes in terms of their engagement with universities. One group of firms is largely focused on knowledge related to the need for radical innovation, stressing a requirement for enhancing their competitiveness (Table 4).

These firms are strategically geared to improving their products and securing long-term prosperity in uncertain times (Cefis and Marsili, 2005; 2006). For example, Interware relies heavily on research, stressing that it needs to 'lead through excellence in innovation', being at the top of the next generation of software and technology, with the sourcing of university knowledge playing a very important role in this mission. This highlights the potential importance of entrepreneurial firms as agents of the type of disruptive innovation often associated with resilience (Christensen, 1997; Markides; 2006).

A second group of firms indicates a different mode and rationale for accessing university knowledge. In this case, entrepreneurial firms aim to augment their resource base in the most cost-efficient manner possible. These firms state that their key reason for sourcing university knowledge is related to resource limitations, with universities often being a lower price (AES, Westchem, Plastox) and well-equipped (Bridgetools, Crossmed, Formbox) supplier of resources and services compared to other organisations. This can be observed in the case of Westchem, which requires specialist equipment for its own research. However, due to related high costs, Westchem find it easier and more affordable to use university-owned equipment. This cost issue is also well-framed in the case of AES, which stated that for the knowledge it sources from universities it would need to pay at least three times more to a private industry supplier. In periods of economic stagnation, controlling operating costs becomes much more of a priority for firms (McKinley *et al.*, 2014), and here it can be seen that one way of achieving this is through university linkages. It further suggests that alongside their role in fostering resilience through disruptive innovation, entrepreneurial firms may take a parallel role by focusing on the adaptive innovation required to maintain market competitiveness (Ettlie *et al.*, 1984; Dewar and Dutton, 1986; Williams and Vorley, 2014).

The first mode of engagement indicated above consists largely of horizontal relationships with universities – resembling alliance networks, whilst the second mode concerns more vertical relationships – resembling supply chain contact networks (Contractor and Lorange, 2002; Huggins, 2010; Huggins *et al.*, 2012). In order to further confirm this difference, the location of universities engaged by firms is examined, with it being hypothesised that supply chain relations are likely to be more local in character for such entrepreneurial firms. Overall, firms engaged in horizontal relationships seem less constrained in accessing distant knowledge, with five firms stating they have engaged with overseas universities, of which four firms sourced knowledge from a different continent(s) (Table 1, final column). SEM, for example, revealed that both its knowledge sources and customer base belong to the global academic community. Part of this community helps it to develop its products, whilst others are the end users. SEM stresses that since its specialism is very narrow it needs to be globally connected to remain in business. These connections indicate that entrepreneurial firms take a role as agents of resilience through their engagement in the types of global communities of practice that are increasingly considered to form the key institutions of international knowledge exchange (Bathelt *et al.*, 2004; Benneworth and Hospers, 2007; Boschma, 2014).

Those firms involved in more vertical relationships all access university knowledge locally (Illinois in the case of the US firms and at a national level in the case of the UK), with only three firms accessing knowledge from other states (Crossmed, Formbox) or other nations/continents (Illitech, Crossmed) (see Table 1, final column). This more localised nature of networking suggests that while the prevalence of more global networks has become the focus of the geography of innovation, the ties embedded within more spatially proximate connections between entrepreneurial firms and universities remain an important source of economic resilience (Davenport, 2005; Lawton Smith, 2007; Huggins and Johnston, 2010).

Finally, through a categorical exploration of the case study firms it is possible to identify a number of key barriers related to knowledge transfer issues. As shown by Table 5, these are mostly concerned with three key aspects: the technology developed by the universities having little commercial value; intellectual property issues related to contractual terms, and university IP policies stifling collaboration; and bureaucracy, mainly reflected through large amounts of paperwork and red tape. Additionally, there are other issues reported that provide an interesting insight into the experience of firms when engaging with universities: a high focus on exploiting technologies regardless of commercial potential; the 'cost of engagement', with some universities preventing small firms from sourcing their knowledge; patenting orientation and unjustified costs; and the gap between academia and the 'real world' – with little commercial understanding and focus from academics. In general, the experiences of university knowledge transfer reported by the firms studied here confirms the findings of others, with a range of studies suggesting that despite the possibilities offered by connecting with universities, many entrepreneurial firms experience significant problems and often shy away from establishing these forms of networks (Cohen *et al.*, 1998; Lambert, 2003; Shane, 2004; Perkmann and Walsh, 2007; Huggins *et al.*, 2008).

Discussion and conclusion

This paper has sought to examine the role of entrepreneurial firms as agents of economic resilience by focusing on the networks they establish with universities to access knowledge for innovation. Drawing on data from a cohort of entrepreneurial and innovation focused firms in the UK and the US, a number of findings emerge, which can be summarised as follows: (1) entrepreneurial firms act as agents of resilience via a diverse number of routes each facilitating the transfer of a variety of forms of university knowledge; (2) universities have the capacity to provide entrepreneurial firms with the adaptability they require to innovate and promote resilience; (3) networks between entrepreneurial firms and universities are an important feature of the complex adaptive innovation systems upon which the resilience stemming from new path creation, as opposed to path-dependent lock-in, is considered to be formulated (Garud *et al.*, 2010; Cooke, 2012; Crespo *et al.*, 2014; Dawley, 2013); (4) entrepreneurial firms play a role in open innovation practices through the establishment of a variety of both horizontal and vertical ties with universities, including a mix of geographically proximate and more spatially

Table 4: Rationale for sourcing knowledge

Firm	Rationale for sourcing knowledge
AES	To concentrate on developing products (R&D; university was cheaper than private industry)
Biotyst	Continuous knowledge sourcing to maintain competitive edge, and develop new products
Bridgetools	Not having the expertise in a specific field; need to improve technology to make it more efficient and/or safer
Crossmed	Insufficient resources – universities have more resources, expertise and facilities
Food Life	Conducting basic research into new enzymes – leaving company scientists to concentrate on working on customers' problems
Formbox	Originally lab space, then developing technology; giving access to own lab to university also provides opportunities for new technologies developed to be commercialised
Geostruct	Continual development to maintain competitive edge
Globaltrate	Continuous development and innovation to offer best products, solutions, services
Grandbio	To exploit a specific technology commercially
Healthprom	Continuous knowledge development to stay at the top of the game
Illitech	Sharing of discoveries in young and emerging technologies; to complete the value chain – connect basic research to commercialisation
Interware	Excellence in innovation, being at the top of the next generation of software and technology, gaining accreditation for proprietary software
Mediworth	Continuous knowledge sourcing to maintain competitive edge
Plastox	Limited resources, need for knowledge to commercialise the research
SEM	To improve existing and develop new products – remain competitive
Westchem	High costs of specialist equipment

distant connections; and (5) there are numerous challenges that entrepreneurial firms often face when seeking to connect with universities, which can often become accentuated by highly bureaucratic university systems that stymie entrepreneurial agility and subsequently resilience. Furthermore, some entrepreneurial firms are likely to seek 'engaged universities' within their region or locality (Chatterton and Goddard, 2000; Benneworth and Hospers, 2007), whilst others are engaged in less proximate relationships based on collaborative and associational network activities (Lechner and Dowling, 2003; D'Este and Patel, 2007; Clifton *et al.*, 2010; Huggins *et al.*, 2010).

In general, when analysing the nature of the sourcing of university knowledge by entrepreneurial firms, it is possible to delineate a range of types of sourcing and transfer practices. There is a clear recognition by the case study firms that engagement with universities can not only stimulate innovation to improve competitiveness in a relatively buoyant economic environment, but also that it can augment these firms' capacity to improve their resilience during times of downturn. Therefore, the entrepreneurial firms studied here

Table 5: Key barriers to engagement (counts)

Barrier	Number of Firms (counts)
Technology of little commercial value	8
IP issues	7
Bureaucracy	6
Universities too expensive	3
Patent quantity focus	3
Academics will little commercial focus	3
Lack of resources	1

recognise the value of networks as a strategic asset – or network capital (Huggins, 2010; Huggins *et al.*, 2012) – that can continue to be leveraged regardless of the underlying economic climate. However, the rationale for network capital generation is often significantly different across firms, especially the degree of distinction between entrepreneurial firms engaging in radical or incremental innovation. Similarly, the studied firms may be involved in either explorative and exploitative knowledge sourcing, with those taking an explorative approach being more interested in seeking the latest research, which could lead to more radical innovation (Ettlie *et al.*, 1984; Dewar and Dutton, 1986; Andersson and Tushman, 1990; Ali *et al.*, 1993; Tushman *et al.*, 1997; Popadiuk and Choo, 2006; Johannessen, 2008; Forsman, 2011; Cheng and Krumwiede, 2012). Those taking an exploitative approach tend to be focused more on interacting with universities to improve their existing technologies or expertise.

The differences in the approaches adopted by entrepreneurial firms are synthesised in Figure 1, and from a policy perspective the evidence suggests there are a number of lessons that can usefully assist similar firms in sourcing university knowledge. For instance, it is clear that there is often much value in collaborative research projects at all points in the economic cycle, provided the correct universities with which to engage are selected. There is, therefore, a need for caution when engaging with the universities, with the need for university knowledge to be screened for commercial usefulness at the outset of engagement (Fontana *et al.*, 2006). Furthermore, the choice of university to engage with should not necessarily be based on spatial proximity, as the 'price tag' on knowledge does not follow any national or regional standard, but is rather independently set by each institution.

For academics, it appears to be essential that they overcome an historically cultivated perception that private businesses have 'deep pockets', and specifically to be understanding of the resource limitations of innovative entrepreneurial firms. From the university perspective, it is important that they take more account of the speed and effectiveness of the knowledge transfer process. This is especially significant as knowledge networks and markets are often controlled by the universities, which have the decision-making power on how fast, and if at all, knowledge should be shared (Huggins *et al.*, 2008). More

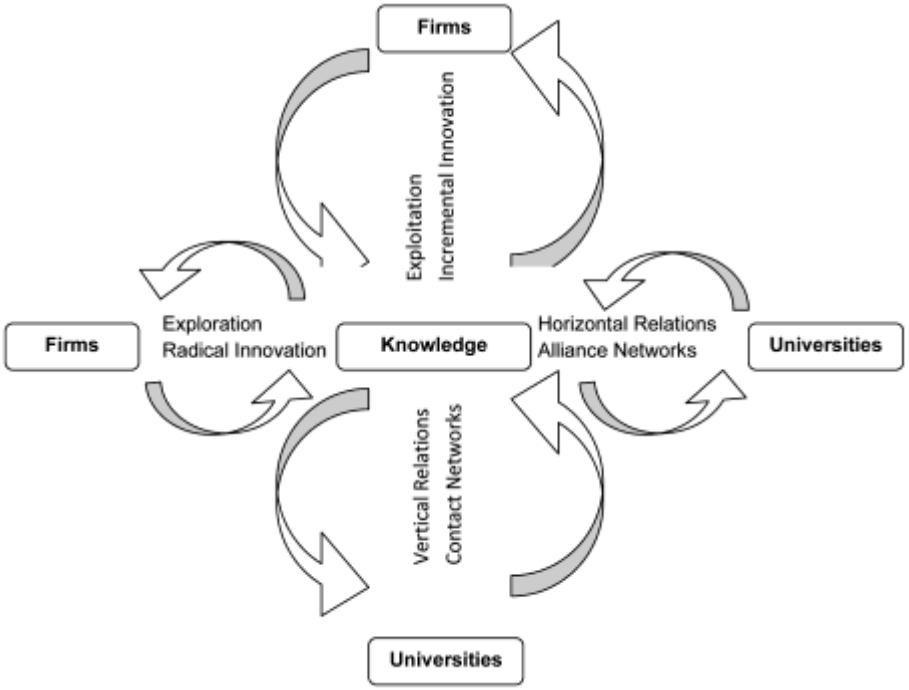

Figure 1: Forms of university knowledge transfer and innovation outcomes

generally, the findings draw attention to the potential specificities of the university knowledge sourcing activities of entrepreneurial firms, with there being a need to review existing policies, which are often limited to a uniform, and in the case of the UK, 'copycat' approach (Siegel *et al.*, 2003; Huggins *et al.*, 2008). The study suggests that more research is required in order to understand cultural differences in innovation practices across nations (Saxenian, 1994; Shane, 2004). In particular, further research should concentrate on the effects of different forms of networks and network practices on the innovation performance of entrepreneurial firms.

Finally, it should be noted that the paper is clearly not without its limitations, in particular the fact that it draws upon evidence from a relatively small sample of firms, which in the case of the US are located within one particular state. Although this does potentially raise issues of generalisability, as an exploratory study it does provide a useful starting point for examining how the relationships between entrepreneurial firms and universities may differ across national contexts. There are a number of issues suggested by this for further research, perhaps the most obvious being to investigate more fully the relative weights of the context effects versus firm sample effects (although the two are, of course, related). Such unpacking could be undertaken in a cross-sectional way via surveys allowing for a quantitative analysis that controls for these factors. An alternative approach could be longitudinal studies, which would be more complex in terms of obtaining reliable data, although an innovation/network biographies method may be useful here. This is particularly pertinent given that this paper is only observing behaviour at the point of a particular economic crisis, making it difficult to draw conclu-

sions on how this behaviour may have actually changed in response to these events. More longitudinal methods would allow for a fuller consideration of the dynamic elements concerning the relationship between entrepreneurship and resilience, including a more quantitative assessment of the role of entrepreneurial knowledge networks in terms of resistance to shocks, speed of recovery, hysteresis and longer-term evolutionary effects (Simmie and Martin, 2010; Martin, 2012; Martin and Sunley, 2014).

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