Advancing conceptualisation of university entrepreneurial ecosystems: The role of knowledge-intensive entrepreneurial firms

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Abstract:

University entrepreneurial ecosystems are increasingly important in facilitating innovation and entrepreneurial opportunities in today's knowledge-based economies. However, we have an incomplete understanding of the demand side of university entrepreneurial ecosystems regarding the role of the entrepreneurial firm as the key user of university knowledge. We propose that use of university knowledge positively influences entrepreneurial firm performance and that the entrepreneurial firm's resources and capabilities facilitate its ability to create value from university knowledge. We test our hypotheses on survey data of 3853 knowledge-intensive entrepreneurial firms from 10 European countries. Our study contributes to an increased understanding of the economic, societal and technological contributions of universities by empirically illustrating the role of firm resources and capabilities as moderators of value in university entrepreneurial ecosystems.

Keywords: entrepreneurship | European Union | strategic behaviour | university-based knowledge

Article:

Introduction

Knowledge is an important factor of production that contributes to economic growth (Audretsch and Link, 2018a, 2018b; Romer, 1986). Therefore universities, as knowledge-intensive contexts, play an important role in today's knowledge-based entrepreneurial economies (Acs et al., 2009; Audretsch, 2014). Accordingly, several interrelated bodies of literature have examined contributions of universities to the economy, including knowledge spillover theory of entrepreneurship (Audretsch, 2014; Audretsch and Keilbach, 2007; Ghio et al., 2015), regional innovation ecosystems (Asheim and Coenen, 2005), entrepreneurial ecosystems (Brown and Mason, 2017), academic entrepreneurship (Hayter et al., 2018; Siegel and Wright, 2015) and entrepreneurial universities (Guerrero et al., 2016; Kirby et al., 2011). Although these streams of research differ in their theoretical underpinnings and emphasis, a common thread emerges

around the importance of university entrepreneurial ecosystems – defined as educational programmes, infrastructures, regulations, culture and relationships with economic agents (Guerrero and Urbano, 2012) – in the knowledge-based entrepreneurial economies as facilitators of innovation and entrepreneurial opportunities.

However, important gaps remain in our understanding of university entrepreneurial ecosystems, which consequently limit understanding of the economic, societal and technological contributions of universities (Guerrero et al., 2015, 2016). Guerrero et al. (2016), for example, criticise prior studies on university knowledge that 'tend to take a narrow view of industry-university relations focusing on the commercialization of research results and on mechanisms of technology transfer such as science parks and incubators, liaison offices, or intellectual property' (p. 556). This view suggests that research has taken a university-centric perspective of knowledge flows, with a focus on the role of the university as the knowledge producer. Accordingly, much emphasis has been put on direct inputs of university knowledge (such as resource and development (R&D) expenditures leading to patents) and university infrastructures (such as technology transfer offices and incubators) as the primary facilitators of outward university knowledge flows.

While this line of research has considerably expanded our understanding of university entrepreneurial ecosystems in important ways, its focus on the knowledge producer represents only the supply side of university knowledge flows. What have been overlooked in the evolving university entrepreneurship ecosystem literature are firm-related factors. However, research on interorganisational knowledge flows emphasises not only the role of the knowledge supplier but also the crucial role of the knowledge receiver (Minbaeva et al., 2003) as the demand side. The resources and capabilities of entrepreneurial firms – defined as start-ups and young firms (Block et al., 2018) – as the users of university knowledge, determine the extent to which they are able to leverage university knowledge and use it to create entrepreneurial value. Agarwal et al. (2010) argue that knowledge investments by existing organisations – including universities – need to be combined with entrepreneurial action by entrepreneurial firms that act as co-creators of knowledge in the economic value creation. This emphasises the role of the entrepreneurial knowledge user in the process that creates value for the entrepreneurial firm and ultimately contributes to the growth of industries, regions and economies (Agarwal et al., 2010).

Accordingly, it is important to consider university entrepreneurial ecosystems from the perspective of an entrepreneurial firm. Taking firm-related factors into account introduces a demand side to an understanding of a university entrepreneurship ecosystem. Hence, the goal of this article is to examine the role of university knowledge in the entrepreneurial firm's value-creation process to answer the following research question:

> To what extent does university knowledge create value to the entrepreneurial firm and which entrepreneurial firm resources and dynamic capabilities facilitate its ability to do so?

Based on arguments from knowledge-based perspectives (Audretsch, 2014), and their applications to the context of university entrepreneurial ecosystems (Guerrero and Urbano, 2012), we hypothesise that the entrepreneurial firm's use of university knowledge has a positive impact on entrepreneurial firm performance. This relationship, however, is moderated by firm

organisational capabilities for knowledge integration (Rasmussen and Borch, 2010; Rasmussen et al., 2014).

Our empirical analyses illustrate that university knowledge has an indirect effect on entrepreneurial firm performance, and that the indirect effect depends on the firm's ability to combine university knowledge with knowledge derived from other sources, as well as on the firm's own capabilities. In our post hoc analyses, we compare the applicability of our theoretical model across 10 European Union countries. While the empirical model applies to the majority of the countries in our sample, we also identify some important differences. These differences imply boundary conditions on our model, which serve as motivation for future research on the national-level determinants of a firm's ability to use university knowledge in the creation of entrepreneurial value.

In the following sections, we discuss the literature related to the role of universities in entrepreneurial ecosystems. We then turn our attention to a discussion of firm capabilities. Our argument is that firm capabilities affect the way in which university characteristics impact entrepreneurial competencies. These arguments facilitate our presentation of hypotheses about the direct and indirect impact of universities as a source of knowledge for enhancing entrepreneurial opportunities. Finally, we test our hypotheses empirically using survey data on 3853 knowledge-intensive entrepreneurial (KIE) firms from 10 European countries.

The role of universities in entrepreneurial ecosystems

Universities play a multifaceted role in contemporary knowledge-based entrepreneurial economies (Audretsch, 2014); they are recognised as producers of knowledge and, thus, of economic dynamism (Audretsch, 2014; Audretsch and Link, 2018a, 2018b). In addition to the traditional activities of teaching and research, universities have progressively taken on a more entrepreneurial role in order to respond to the 'third mission', which requires them to contribute to the economic development of regions and even, of nations (Brown, 2016; Guerrero et al., 2016). The third mission represents a social contract for the university with society (Hayter and Cahoy, 2018; Siegel and Wright, 2015) where they can assist with challenges such as unemployment and public budget deficits.

Analyses of the role of universities have evolved within the literature. For example, Bradley et al. (2013) find that the transfer of new knowledge within, and from a university, follows the path from invention, invention disclosure, patenting and then, to either licencing of the technology to other firms or to a university spin-off firm. Such linear pathways may not always be the most effective way for university knowledge of spill over (Link et al., 2007) and may even be socially irresponsible (Grimaldi et al., 2011; Hayter, 2016a; Hayter and Cahoy, 2018). In response to criticism regarding the linear path of technology transfer, that many universities embrace, extramural programmes have developed to enhance the flow of university knowledge. These include venture funds (Brown, 2016; Croce et al., 2013), incubators (Brown, 2016), programmes focused on entrepreneurial action (Siegel and Wright, 2015) and the establishment of proof-of-concept centres (Bradley et al., 2013). However, not all scholars agree about the effectiveness of such programmes. For example, Guerrero et al. (2016) is critical: those who support these programmes 'take a narrow view of industry-university relations focusing on the

commercialization of research results and on mechanisms of technology transfer such as science parks and incubators, liaison officer, or intellectual property' (p. 556).

However, there are more advanced conceptualisations of entrepreneurial universities. These move away from presenting them as isolated economic institutions or agents towards a more systematic view of universities as part of entrepreneurship systems (Clarysse et al., 2014). Furthermore, scholars have yet to conceptualise fully university entrepreneurial ecosystems, which Hayter (2016a) defines as 'the strategic and collective actions of various organisational components … to maximise both the entrepreneurial and innovative contributions of universities' (p. 634). What is important is how the components of the ecosystem interconnect. Alvedalen and Boschma (2017) make the case that the performance of a university entrepreneurship ecosystem depends on interactions between individuals, firms and institutions arguing 'The entrepreneur has a central place in the entrepreneurial ecosystem and is the core actor in building and sustaining the ecosystem' (p. 891). Overlooked in this evolving university entrepreneurship ecosystem literature are firm-related factors. Taking firm-related factors into account introduces a demand side to an understanding of a university entrepreneurship ecosystem. Within this article, we explore how firm-related factors impact upon university-centric entrepreneurial ecosystems.

Organisational capabilities within entrepreneurial ecosystems

Capabilities are a well-accepted framework for understanding organisational performance but have yet to be applied to university entrepreneurial ecosystems (Helfat et al., 2007). Recent studies apply a capabilities framework to understand the extent to which universities fulfil their social responsibilities (Hayter, 2016b; Hayter and Cahoy, 2018), while Rasmussen and Borch (2010) suggest that university capabilities are particularly important to the formation of new academic spin-offs. Although these authors do not frame their findings in terms of ecosystems they, nevertheless, posit that capabilities are critical for enabling networks with external resource providers such as industry investors and public funding sources. A related literature examines how university characteristics may influence firm-level entrepreneurial competencies (Rasmussen et al., 2014) that evolve over time and enable ventures to obtain and build resources critical to their development (Danneels, 2002). Rasmussen et al. (2014) argue that discovery and development of opportunities, the role of individual characteristics and the acquisition of resources – such as new knowledge produced in universities – are critical elements of employing a competencies-based framework.

Research has yet to reconcile conceptualisations of the organisational capabilities of research universities with competencies-based views of entrepreneurial firms. This article addresses this issue by drawing upon Rasmussen et al.'s (2014) notion of competencies as capabilities, assuming that all organisations, from universities and entrepreneurship support programmes, to KIE firms must possess capabilities important to their success (Helfat et al., 2007).[1] Following this literature, we examine how an entrepreneurial firm's capabilities may moderate the extent to which ventures can take advantage of new knowledge in universities. We motivate our empirical analysis in the following section by drawing insights from the management literature regarding how entrepreneurial firms take advantage of new knowledge such as that produced within universities.

The role of university knowledge and entrepreneurial firm capabilities in entrepreneurial firm performance

Audretsch (2014) argues that

> As the factor of knowledge became more important while the role of physical capital receded, the role of universities in the economy shifted from being tangential and marginal to playing a central role as a source of knowledge … A new role for the university emerged as an important source of economic knowledge. (p. 316)

Accordingly, universities have become an integral part of the new economic knowledge infrastructure (Etzkowitz et al., 2000) as both knowledge creators and depositories in knowledge-based economies (Guerrero et al., 2016). Audretsch and Keilbach (2007) explain how universities – as knowledge-rich contexts – contribute to the creation of entrepreneurial opportunities:

> The theory of knowledge spillover entrepreneurship posits that those contexts rich in knowledge will inherently be (following Arrow (1962)) characterised by a greater degree of uncertainty, leading to greater entrepreneurial opportunity … [and thus] entrepreneurship is an endogenous response to opportunities generated by investments in new knowledge made by incumbent firms and organisations [including universities] but which are unable to completely and exhaustively commercialise. (p. 1244)

Agarwal et al. (2007) explain that '[m]uch of the knowledge created may lay dormant within the organisational boundaries, since the constraints that result from existing organisational capabilities, orientation, or cognition may prevent them from pursuing all potential opportunities' (p. 266).

As an endogenous response, entrepreneurship is about understanding, discovering and pursuing entrepreneurial opportunities by coordinating university knowledge and turning it into heterogeneous firm outputs (Alvarez and Busenitz, 2001). Entrepreneurship is the conduit facilitating the spillover and commercialisation of university knowledge (Audretsch and Keilbach, 2007) and ensuing innovative activity and growth (Ghio et al., 2015). Consequently, an entrepreneurial firm that is able to act on unexploited opportunities by using universities as an important source of knowledge should experience positive performance effects. 'The cognitive ability of entrepreneurs to frame situations in an opportunistic manner is a heterogeneous resource that can be used to organise other resources' (Alvarez and Busenitz, 2001: 760) explains why entrepreneurial firms can successfully pursue new ideas based on dormant university knowledge overlooked or ignored.

Accordingly, we posit the following hypothesis:

> **Hypothesis 1:** The entrepreneurial firm's use of university knowledge is positively related to entrepreneurial firm performance.

Heterogeneous resources are created by firms primarily through what Grant (1996) describes as 'the role of the firm as a knowledge-integration institution' (p. 112). The essence of the argument is that producing a good or service requires applying many different types of knowledge and, therefore, value creation depends on the firm's ability to combine knowledge that emanates from different sources (Grant, 1996; Kogut and Zander, 1992). Kogut and Zander (1992) refer to this process as being the 'combinative capability' of the firm (p. 384). Stated differently, the process of combinative capability – the ability to combine homogeneous inputs into heterogeneous outputs – is the heart of the entrepreneurial firm's value creation (Alvarez and Busenitz, 2001).

Kogut and Zander (1992) emphasise that knowledge 'is of little value if it results in products that do not correspond competitively to consumers wants' (p. 393). This is an excepted problem with university knowledge as, at its core, it tends to be focused on basic research which eventually generates tacit knowledge. Several spillover mechanisms, such as the creation of more applied university programmes that focus on interdisciplinary fields, have been suggested to facilitate the application of scientific knowledge to market needs (Audretsch, 2014). We propose that the entrepreneurial firm's combinative capability is a powerful spillover mechanism in itself that increases the firm's value capture capacity and adds more value to the original knowledge, so that the entrepreneur not only captures but also creates opportunities.

Alvarez and Busenitz, (2001) argue that '[i]f the application of knowledge requires coordinating many types of specialised knowledge then the firm [rather than the entrepreneur] is required for the integration of knowledge' (p. 762). It is the entrepreneurial firm's simultaneous use of knowledge from clients and customers, for example, that allows adjusting university knowledge to the needs of the market. In this way, we argue that from the knowledge-based perspective, university knowledge does not simply spill over to the entrepreneurial firm, but that the entrepreneurial firm integrates university knowledge with knowledge sourced from the clients and customers. Therefore, the entrepreneurial firm's use of university knowledge combined with the use of external knowledge about clients and customers will enhance value creation from the university knowledge.

Thus, we propose the following:

> **Hypothesis 2:** The positive relationship between the entrepreneurial firm's use of university knowledge and entrepreneurial firm performance is positively moderated by the entrepreneurial firm's use of client and customer knowledge.

We point to the entrepreneurial firm's internal knowledge creation as a mechanism that, when combined with university knowledge makes the resulting knowledge combinations more complex and causally ambiguous and, thereby, functions as a barrier to imitation. Causal ambiguity makes it more difficult for competitors to know what aspects of the knowledge processes to imitate and how to do this (Alvarez and Busenitz, 2001). Accordingly, Kogut and Zander (1992) argue that the firm's ability to build on current knowledge is vital in deterring imitation of a firm's knowledge.

An important mechanism to create knowledge internally is through development of the firm's R&D activities. The connection between the firm's own R&D activities and external knowledge

is well documented through the concept of absorptive capacity (Cohen and Levinthal, 1990; Schildt et al., 2012). Cohen and Levinthal (1990) define absorptive capacity as the ability to recognise, assimilate and apply external knowledge. Cohen and Levinthal (1990) argue that

> a firm's ability to exploit external knowledge is often generated as a by-product of its R&D. We may therefore, consider a firm's R&D as satisfying two functions: we assume that R&D not only generates new knowledge but also contributes to the firm's absorptive capacity. (p. 138)

Applied to the context of university knowledge use in university entrepreneurial ecosystems, the entrepreneurial firm's emphasis on R&D allows it to absorb university knowledge more effectively. This is important for understanding university knowledge use and entrepreneurial firm R&D activities that expand the firm's internal knowledge base as complementary mechanisms, rather than considering university knowledge use as a substitute for the entrepreneurial firm's internal R&D activities.

We propose that the entrepreneurial firm's ability to create value from university knowledge will be greater if the firm is able to build on university knowledge through its internally created knowledge. Combining university knowledge with internal knowledge facilitates understanding of university knowledge and results in more complex knowledge combinations, which are consequently rare and more difficult to imitate than the components of knowledge alone. Schildt et al. (2012) argue that firms with high levels of R&D activities are 'well positioned to exploit the more challenging technological opportunities' in the partner's knowledge base (p. 1160). It is these unique knowledge combinations that allow the entrepreneurial firm potential to tap into entrepreneurial opportunities (Barney, 1991) in university entrepreneurial ecosystems.

Accordingly, we suggest the following:

> **Hypothesis 3:** The positive relationship between the entrepreneurial firm's use of university knowledge and entrepreneurial firm performance is positively moderated by the entrepreneurial firm's use of in-house know-how from internal R&D.

Rasmussen and Borch (2010) describe the importance of organisational capabilities of universities to encourage and support university entrepreneurial ecosystems. Organisational capabilities refer to the ability to adapt the use of resources (Helfat and Peteraf, 2003). We suggest that capabilities are essential determinants of the entrepreneurial firm's ability to adapt and act strategically, which Hitt et al. (2001) argue is required for entrepreneurial firms to create the most value from entrepreneurial opportunities. We propose, therefore, that entrepreneurial firms with strong organisational capabilities, such as the ability to 'sense and seize' emerging market opportunities, will be able to utilise university knowledge more effectively, thus creating value for the entrepreneurial firm.

Hence, we propose the following:

Hypothesis 4: The positive relationship between the entrepreneurial firm's use of university knowledge and entrepreneurial firm performance is positively moderated by the entrepreneurial firm's capabilities of 'sensing and seizing'.

We argued that adaptability of the entrepreneurial firm can be increased through capabilities of sensing and seizing that enable the firm to make better use of university knowledge. However, adaptability of an entrepreneurial firm is also strongly determined by the adaptability of the mental models of the founder. Based on the concept of imprinting, we propose that young founders are more likely to have more adaptable mental models because they are more likely to be in a 'sensitive stage'. While it is possible to experience multiple sensitive periods over time, the early-career stage is a key sensitive period for an individual (Marquis and Tilcsik, 2013). During sensitive periods, individuals are especially receptive to influences (Marquis and Tilcsik, 2013). Thus, a young founder is more likely to adjust the firm's strategy, structures and culture, so that it supports the use of university knowledge and also corresponds with the requirements of the market. Based on the theory of imprinting, an older founder is likely to be more rigid in his or her mental models because they were developed during prior sensitive periods. Yet, those mental models are likely to be a less perfect fit with the current internal and external environment of the firm. Inexperienced young founders cannot turn to prior experience as a solution to a current problem, so they need to improvise to find solutions (Zahra et al., 2006). Improvising can bring about ways to use university knowledge that are not apparent to other firms. Therefore, we propose that entrepreneurial firms led by young founders will be more adaptable and, thereby, better able to make use of university knowledge in ways that create value.

Accordingly, we hypothesise the following:

Hypothesis 5: The positive relationship between the entrepreneurial firm's use of university knowledge and entrepreneurial firm performance is positively moderated by young founders.

These five hypotheses are represented through the theoretical model in Figure 1.

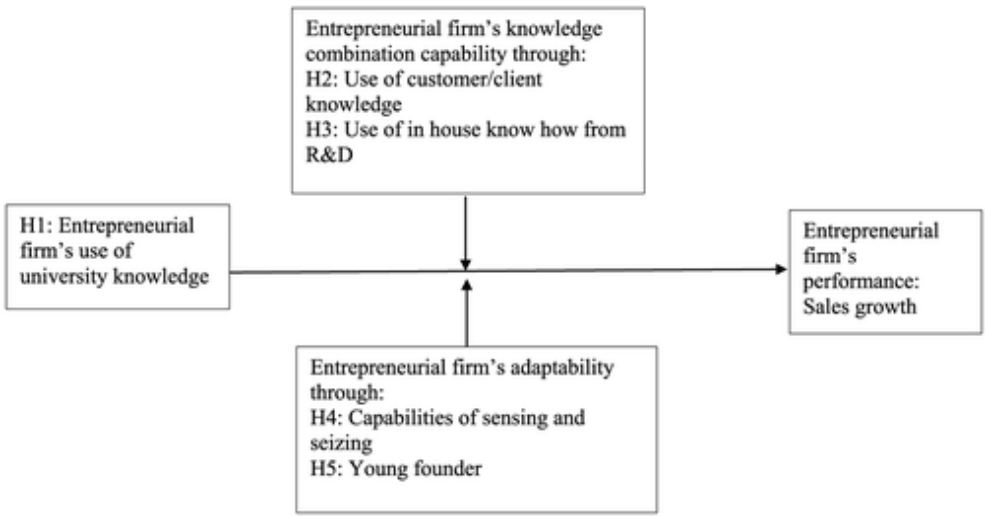

Figure 1. Theoretical model of the impact of university knowledge use on the entrepreneurial firm's performance in university entrepreneurial ecosystems.

Empirical analysis

Statistical model

We test the hypotheses regarding the relationship between entrepreneurial firm performance and university knowledge in two stages. In the first, we estimate a parsimonious model of performance measured in terms of sales growth, *salesgr*. We focus on sales growth because of the centrality of this concept in entrepreneurship research (Stenholm et al., 2016). Sales growth represents entrepreneurial performance by reflecting the capturing of entrepreneurial opportunities and generation of cash flow for the exploration of future entrepreneurial opportunities (Collins and Clark, 2003; Helfat et al., 2007; Rice et al., 2015).

Following our theoretical arguments above, sales growth is posited to be a function of the importance of universities to the entrepreneurial firm as a source of knowledge for enhancing entrepreneurial opportunities, *univ*. This initial model is appropriate to test Hypothesis 1: *The use of university knowledge is positively related to firm performance*, and it can be represented as equation (1):

$$salesgr=f(univ,\mathbf{X}) \tag{1}$$

where **X** is a vector of firm, country and sector controls.

The second stage of our analysis is to estimate four models based on Hypotheses 2 through 5. The estimation of these models allows us to identify internal and external characteristics of the entrepreneurial firm, *character*, that positively moderate its ability to benefit from its involvement with universities. These models can be represented as

$$salesgr=f(univ\times character,character,\mathbf{X}) \tag{2}$$

where *univ* × *character* is an interaction term between the importance of universities as a source of knowledge to the firm, *univ*, and the hypothesised characteristics of the entrepreneurial firm, *character*.

The models represented by equations (1) and (2) are estimated using entrepreneurial firm data from the AEGIS database.

Description of the data

The AEGIS project was funded by the European Commission (EC) under Theme 8 'Socio-Economic Sciences and Humanities' of the Seventh Framework Programme for Research and Technological Development.[2] The project focused on KIE firms. According to AEGIS (2012),

Knowledge-intensive entrepreneurship is [the] core interface between two independent systems: the knowledge generation and diffusion system, on the one hand, and the productive system, on the other. Both systems shape and are shaped by the broader social context – including customs,

culture and institutions – thus also pointing at the linkage of entrepreneurship to that context. (p. 4)

Knowledge-intensive entrepreneurship includes 'new ventures that introduce innovations in the economic systems and that intensively use knowledge' (Malerba, 2010: 4).

This EC project supported, among other things, a 2011 survey of 4004 KIE firms, established between 2002 through 2007, from 10 European countries (alphabetically: Croatia, Czech Republic, Denmark, France, Germany, Greece, Italy, Portugal, Sweden and United Kingdom) in three sectors (high tech, low tech and knowledge-intensive business services). The firms in the AEGIS database are not a random sample of European firms; smaller country firms were sampled at a higher rate than larger country firms as described, along with the sampling weights, in Caloghirou et al. (2011). Table 1 shows the distribution of KIE firms by countries and by sector.

Table 1. Distribution of KIE firms, by country and sector.

Country	**Sector**			**Total**
	High tech[a]	**Low tech[b]**	**KIBS[c]**	
Croatia	35	115	50	200
Czech Republic	25	92	83	200
Denmark	34	69	227	330
France	68	196	306	570
Germany	67	160	330	557
Greece	22	184	125	331
Italy	57	316	207	580
Portugal	31	170	130	331
Sweden	34	108	192	334
United Kingdom	47	192	332	571
Total	420	1,602	1,982	4,004

Source: Caloghirou et al. (2011) and the AEGIS database.
KIE: knowledge-intensive entrepreneurial; KIBS: knowledge-intensive business services.
[a] High-tech sector includes aerospace; computers and office machinery; radio–television communication equipment; manufacturer of medical, precision and optional instruments; pharmaceuticals; manufacturer of electrical machinery and apparatus, manufacturer of machinery and equipment, chemical industry.
[b] Low-tech sector includes paper and printing; textile and clothing; food, beverage and tobacco; wood and furniture; basic metals; fabricated metal products.
[c] KIBS sector includes telecommunications, computer and related activities, research and experimental development, selected business services activities.

With reference to equations (1) and (2) above, Table 2 defines each of the relevant variables, and descriptive statistics for the variables are in Table 3. A correlation matrix for these variables, plus for the interaction terms, is in Table 4.

Table 2. Definition of variables.

Variable	**Definition**
Dependent	
salesgr	Percentage increase/decrease in firm sales during 2010
Independent	
univ	Importance of universities as a source of knowledge for the firm to explore new business opportunities as measured on a Likert-type scale of 1=*not important* to 5=*extremely important*
Characteristics	

prevsalesgr	Average percentage increase/decrease in sales of firms from 2007 to 2009
custknow	= 1 if the firm evaluated the importance of clients or customers as an important source of knowledge for exploring new business opportunities as measured by a response of 4 or 5 on a Likert-type scale of 1 = *not important* to 5 = *extremely important*. Otherwise the variable equals 0
internalknow	= 1 if the firm evaluated the importance of in-house know-how from internal R&D as an important source of knowledge for exploring new business opportunities as measured by a response of 4 or 5 on a Likert-type scale of 1 = *not important* to 5 = *extremely important*. Otherwise, the variable equals 0
dynamiccap	= 1 if the firm's average response to the following six statements was greater than 3 on a Likert-type scale of 1 = *strongly disagree* to 5 = *strongly agree*: Our firm actively observes and adopts the best practices in our sector; our firm responds rapidly to competitive moves; we change our practices based on customer feedback; our firm regularly considers the consequences of changing market demand in terms of new products and services; our firm is quick to recognise shifts in our market (e.g. competition, regulation, demography) and we quickly understand new opportunities to better serve our customers. Otherwise, the variable equals 0
agefounder[a]	= 1 if the age of the primary founder is less than 40. Age is measured in yearly deciles. Decile 1 = 18–29, Decile 2 = 30–39, Decile 3 = 40–49 and Decile 4 = 50 or older
Controls	
Croatia	= 1 if the firm is in Croatia. Otherwise, the variable equals 0
Czech Republic	= 1 if the firm is in the Czech Republic. Otherwise, the variable equals 0
Denmark	= 1 if the firm is in Denmark. Otherwise, the variable equals 0
France	= 1 if the firm is in France. Otherwise, the variable equals 0
Germany	= 1 if the firm is in Germany. Otherwise, the variable equals 0
Greece	= 1 if the firm is in Greece. Otherwise, the variable equals 0
Italy	= 1 if the firm is in Italy. Otherwise, the variable equals 0
Portugal	= 1 if the firm is in Portugal. Otherwise, the variable equals 0
Sweden	= 1 if the firm is in Sweden. Otherwise, the variable equals 0
United Kingdom	= 1 if the firm is in the United Kingdom. Otherwise, the variable equals 0
High tech	= 1 if the firm is in the high-tech sector. Otherwise, the variable equals 0
Low tech	= 1 if the firm is in the low-tech sector. Otherwise, the variable equals 0
KIBS	= 1 if the firm is in the KIBS sector. Otherwise, the variable equals 0

R&D: resource and development; KIBS: knowledge-intensive business services.

[a] The AEGIS data provide information on each of up to four founders of a firm. However, the overall mean number of founders is 1.4 (when a respondent reported 0 founders, that value was changed to 1 founder). Thus, we assumed that the first-listed founder is the primary founder, as have others (e.g. Amoroso et al., 2018; Amoroso and Link, 2018).

Table 3. Descriptive statistics on the variables in Table 2 ($n = 3853$).

Variable	**Mean**	**Standard deviation**	**Range**
salesgr	14.020	52.455	–300 to 1000
prevsalesgr	26.168	127.50	–200 to 6000
univ	2.118	1.255	1–5
custknow	0.858	0.350	0/1
internalknow	0.530	0.499	0/1
dynamiccap	0.828	0.377	0/1
agefounder	0.307	0.461	0/1
Croatia	0.051	0.219	0/1
Czech Republic	0.050	0.218	0/1
Denmark	0.078	0.269	0/1
France	0.142	0.350	0/1
Germany	0.139	0.346	0/1
Greece	0.085	0.279	0/1

Italy	0.146	0.353	0/1
Portugal	0.085	0.278	0/1
Sweden	0.085	0.279	0/1
United Kingdom	0.140	0.347	0/1
High tech	0.104	0.306	0/1
Low tech	0.398	0.490	0/1
KIBS	0.498	0.500	0/1

KIBS: knowledge-intensive business services.
Note: Missing observations from the population of 4004 firms are due primarily to responses that the age of the founder is 'don't know'.

Statistical findings

The regression results from equations (1) and (2) are presented in Table 5. The binary variables *Croatia* and *Low-tech* are subsumed in the intercept term. The estimated coefficients from the parsimonious model represented by equation (1) are in column (1) in the table.

The regression results in column (1) support Hypothesis 1: *The use of university knowledge is positively related to entrepreneurial firm performance.* The estimated coefficient on *univ* is positive and highly (.01 level) significant. The greater the importance of university knowledge for the entrepreneurial firm to explore new business opportunities, the greater the increase in sales growth. Held constant in equation (1), and below in the variants of equation (2), is the previous sales growth of the entrepreneurial firm. The performance variable in the equations refers to sales growth in 2010. Because most EU firms experienced the effects of the financial crisis in 2009, perhaps those entrepreneurial firms that grew in 2010 are those that also grew, or contracted the least, in previous years. The variable *prevsalesgr* controls for the entrepreneurial firm's average sales growth from 2007 to 2009, and the estimated coefficient on that variable is positive and highly significant in the model in column (1) (Amoroso and Link, 2018). The estimated coefficients on the variable *prevsalesgr* are also positive and highly significant in all the models presented in Table 5.

The regression results in column (2) in Table 5 support Hypothesis 2: *The positive relationship between the entrepreneurial firm's use of university knowledge and entrepreneurial firm performance is positively moderated by the firm's use of client and customer knowledge.* The estimated coefficient on the interaction term, *univ* × *custknow*, is positive and highly significant. The magnitude of the estimated coefficient on *univ* × *custknow*, or the economic significance of the variable, is greater than the estimated coefficient on *univ* in column (1).

Table 4. Correlation matrix for key variables ($n = 3853$).

	salesgr	***prevsalesgr***	***univ***	***custknow***	***internalknow***	***dynamiccap***	***agefounder***	***univ* x *custknow***	***univ* x *internalknow***	***univ* x *dynamiccap***	***univ* x *agefounder***
salesgr	1										
prevsalesgr	.336***	1									
univ	.046**	.055***	1								
custknow	.016	–.024	.084***	1							
internalknow	.041**	.049***	.219***	.079***	1						
dynamiccap	.089***	.049***	.050***	.114***	.078***	1					
agefounder	.063***	.058***	.001	–.003	.029*	.031*	1				
univ x *custknow*	.046***	.010	.830***	.542***	.209***	.010***	–.003	1			
univ x *internalknow*	.055***	.071***	.657***	.089***	.775***	.072***	.013	.569***	1		
univ x *dynamiccap*	.092***	.075***	.771***	.129***	.204***	.579***	.028*	.668***	.532***	1	
univ x *agefounder*	.086***	.087***	.312***	.022	.086***	.055***	.820***	.251***	.215***	.273***	1

***Significant at .01 level; **significant at .05 level; *significant at .10 level.

Table 5. Regression results from equations (1) and (2); standard errors in parentheses, $n = 3853$.

Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
prevsalesgr	0.133*** (0.006)	0.134*** (0.006)	0.133*** (0.006)	0.132*** (0.006)	0.131*** (0.006)
univ	2.075*** (0.657)***	—	—	—	—
univ x *custknow*	—	2.563*** (0.699)	—	—	—
univ x *internalknow*	—	—	1.975** (0.836)	—	—
univ x *dynamiccap*	—	—	—	2.258*** (0.721)	—
univ x *agefounder*	—	—	—	—	4.334*** (1.189)
custknow	—	–2.106 (2.709)	—	—	—
internalknow	—	—	–1.265 (2.551)	—	—
dynamiccap	—	—	—	3.104 (2.935)	—
agefounder	—	—	—	—	–2.770 (3.025)
Czech Republic	12.674** (5.020)	12.969*** (5.011)	12.509** (5.017)	13.019*** (5.017)	11.787** (5.004)
Denmark	16.710*** (4.598)	16.871*** (4.589)	17.283*** (4.649)	17.723*** (4.604)	16.874*** (4.570)
France	18.177*** (4.156)	18.386*** (4.145)	18.281*** (4.166)	18.832*** (4.158)	18.142*** (4.120)
Germany	21.442*** (4.158)	21.595*** (4.153)	21.656*** (4.168)	22.376*** (4.165)	21.546*** (4.141)
Greece	3.731 (4.440)	3.998 (4.439)	3.932 (4.446)	10.615** (4.889)	4.128 (4.431)
Italy	15.634*** (4.077)	15.438*** (4.073)	15.290*** (4.078)	16.183*** (4.077)	15.311*** (4.065)
Portugal	8.993** (4.436)	8.424* (4.443)	10.014** (4.457)	9.209** (4.432)	7.669* (4.439)
Sweden	28.450*** (4.487)	28.439*** (4.482)	28.575*** (4.493)	29.293*** (4.490)	28.931*** (4.474)
United Kingdom	18.501*** (4.171)	18.495*** (4.169)	18.544*** (4.175)	18.888*** (4.169)	18.499*** (4.138)
High-tech	7.290*** (2.760)	7.335*** (2.757)	6.990** (2.768)	6.967** (2.759)	7.980*** (2.757)
KIBS	3.171* (1.738)	3.173* (1.735)	3.014* (1.743)	2.855 (1.739)	3.139* (1.734)
Intercept	–12.039*** (3.969)	–10.644*** (4.070)	–9.504** (3.763)	–15.158*** (4.301)	–9.520 (3.630)
R^2	.135	.136	.134	.137	.138
F level	45.89***	43.05***	42.57***	43.39***	43.94***

KIBS: knowledge-intensive business services.
***Significant at .01 level, **significant at .05 level, *significant at .10 level.

Ideally, we would have liked to hold constant the model in column (2), and in the remaining models, the variable *univ* to test explicitly for moderating effects. However, as shown in the

correlation matrix in Table 4, the variables *univ* and *univ* × *character* are highly significantly correlated. The inclusion of *univ* in the models in columns (2) through (5) would result in biased estimates of the coefficient on *univ* or on the coefficients on the *univ* × *character* variables, or both. The extent of the collinearity issue between *univ* and *univ* × *character* varies among the specifications with the different interaction variables. The calculated variance inflation factors range from a low of 4.4 (mild collinearity) when *univ* × *agefounder* is included with *univ* to a high of 11.8 (severe collinearity) when *univ* × *custknow* is included with *univ*. In the former case, the coefficient on *univ* remains positive but its significance decreases from a .01 level to a .15 level. Thus, for consistency, we compare the estimated coefficients on the *univ* × *character* variables in columns (2) through (5) to the estimated coefficient on *univ* in column (2).

The regression results in column (3) in Table 5 support Hypothesis 3: *The positive relationship between the entrepreneurial firm's use of university knowledge and entrepreneurial firm performance is positively moderated by the entrepreneurial firm's use of in-house know-how from internal R&D.* The estimated coefficient on the interaction term *univ* × *internalknow* is positive and moderately (.05 level) significant. However, the estimated coefficient on *univ* × *internalknow* is numerically less than the estimated coefficient on *univ* in column (2). Our finding that internal know-how through R&D has less of an effect on sales growth and university knowledge, in general, may reflect a timing issue. The variable *univ* captures many dimensions of university knowledge, some of which have a more immediate effect on firm performance than does the tacit knowledge from R&D that culminates only over time and, thus, affects entrepreneurial firm performance with a lag.

The empirical test of Hypothesis 4 – *the positive relationship between the entrepreneurial firm's use of university knowledge and entrepreneurial firm performance is positively moderated by the entrepreneurial firm's dynamic capabilities of sensing and seizing* – is represented by the model in column (4) in Table 5. The estimated coefficient on the interaction term *univ* × *dynamiccap* is positive and highly significant. And, the estimated coefficient on *univ* × *dynamiccap* is numerically greater than the estimated coefficient on *univ*, thus supporting the positive moderating effect of entrepreneurial firm's capabilities.

Finally, the regression results in column (5) in Table 5 correspond to the empirical test of Hypothesis 5: *The positive relationship between the entrepreneurial firm's use of university knowledge and entrepreneurial firm performance is positively moderated by younger founders.* The estimated coefficient on the interaction term *univ* × *agefounder* is positive and highly significant. Recall from the definition of the variables in Table 2 that *agefound* equals 1 for younger founders; thus, the moderated influence of younger founders is greater than for older founders. The numerical size of the estimated coefficient on *univ* × *agefounder* is more than twice the size of the estimated coefficient on *univ* in column (2), and it is nearly twice as large as the estimated coefficients on *univ* × *internalknow* and on *univ* × *dynamiccap*. This finding emphasises the importance of the theory of imprinting upon performance. Held constant in the models represented in columns (1) though (5) are country- and sector-fixed effects. With the exception of Greece, the country and sector variables are all positive and significant.

While the regression results in Table 5 control for cross-country differences in sales growth through fixed effects, also of interest are the cross-country effects on the influence of university knowledge use on sales growth. To explore this issue, we considered the following model:

$$salesgr = f(univ \times country, univ \times character \times country, \mathbf{X}) \quad (3)$$

where *univ* and the four *univ* × *character* variables are interacted with a country binary variable. **X** remains a vector of controls including previous sales growth and sector variables. The regression results from the estimation of equation (3) are in Table 6.

Table 6. Regression results from equation (3); standard errors in parentheses, $n = 3853$.

Independent variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
prevsalesgr	0.134*** (0.006)	0.135*** (0.006)	0.135*** (0.006)	0.133*** (0.006)	0.135*** (0.006)
univ x *Croatia*	–2.695** (1.274)	—	—	—	—
univ x *custknow* x *Croatia*	—	–2.476* (1.325)	—	—	—
univ x *internalknow* x *Croatia*	—	—	–2.620* (1.353)	—	—
univ x *dynamiccap* x *Croatia*	—	—	—	–1.945 (1.128)	—
univ x *agefound* x *Croatia*	—	—	—	—	–1.931 (2.051)
univ x *Czech*	–0.460 (1.874)	—	—	—	—
univ x *custknow* x *Czech*	—	0.018 (2.012)	—	—	—
univ x *internalknow* x *Czech*	—	—	–1.885 (2.218)	—	—
univ x *dynamiccap* x *Czech*	—	—	—	–0.524 (1.866)	—
univ x *agefound* x *Czech*	—	—	—	—	1.759 (2.898)
univ x *Denmark*	0.812 (1.448)	—	—	—	—
univ x *custknow* x *Denmark*	—	1.650 (1.504)	—	—	—
univ x *internalknow* x *Denmark*	—	—	–2.034 (2.110)	—	—
univ x *dynamiccap* x *Denmark*	—	—	—	1.338 (1.478)	—
univ x *agefound* x *Denmark*	—	—	—	—	–2.130 (2.920)
univ x *France*	4.136*** (1.211)	—	—	—	—
univ x *custknow* x *France*	—	4.899*** (1.227)	—	—	—
univ x *internalknow* x *France*	—	—	5.254*** (1.431)	—	—
univ x *dynamiccap* x *France*	—	—	—	5.331*** (1.193)	—

univ x *agefound* x *France*	—	—	—	—	10.538*** (2.123)
univ x *Germany*	3.255*** (1.048)	—	—	—	—
univ x *custknow* x *Germany*	—	3.571*** (1.065)	—	—	—
univ x *internalknow* x *Germany*	—	—	3.337*** (1.174)	—	—
univ x *dynamiccap* x *Germany*	—	—	—	4.441*** (1.049)	—
univ x *agefound* x *Germany*	—	—	—	—	3.132* (1.773)
univ x *Greece*	–2.181* (1.131)	—	—	—	—
univ x *custknow* x *Greece*	—	–2.112* (1.192)	—	—	—
univ x *internalknow* x *Greece*	—	—	–2.871** (1.133)	—	—
univ x *dynamiccap* x *Greece*	—	—	—	–1.165 (2.681)	—
univ x *agefound* x *Greece*	—	—	—	—	–1.613 (1.918)
univ x *Italy*	2.486*** (0.917)	—	—	—	—
univ x *custknow* x *Italy*	—	2.740*** (0.900)	—	—	—
univ x *internalknow* x *Italy*	—	—	2.529*** (0.908)	—	—
univ x *dynamiccap* x *Italy*	—	—	—	3.254*** (0.894)	—
univ x *agefound* x *Italy*	—	—	—	—	4.708*** (1.311)
univ x *Portugal*	–0.396 (0.983)	—	—	—	—
univ x *custknow* x *Portugal*	—	–0.452 (0.959)	—	—	—
univ x *internalknow* x *Portugal*	—	—	–1.347 (1.157)	—	—
univ x *dynamiccap* x *Portugal*	—	—	—	0.180 (0.963)	—
univ x *agefound* x *Portugal*	—	—	—	—	–0.623 (1.276)
univ x *Sweden*	6.222*** (1.302)	—	—	—	—
univ x *custknow* x *Sweden*	—	6.707*** (1.311)	—	—	—
univ x *internalknow* x *Sweden*	—	—	5.122*** (1.515)	—	—
univ x *dynamiccap* x *Sweden*	—	—	—	6.824*** (1.315)	—
univ x *agefound* x *Sweden*	—	—	—	—	17.908*** (2.729)
univ x *United Kingdom*	2.574** (1.180)	—	—	—	—

univ x *custknow* x *United Kingdom*	—	2.773* (1.162)	—	—	—
univ x *internalknow* x *United Kingdom*	—	—	1.909 (1.357)	—	—
univ x *dynamiccap* x *United Kingdom*	—	—	—	2.984*** (1.137)	—
univ x *agefound* x *United Kingdom*	—	—	—	—	2.797 (2.032)
High-tech	7.759*** (2.759)	8.021*** (2.754)	8.422*** (2.763)	7.665*** (2.758)	9.050*** (2.741)
KIBS	3.968** (1.726)	4.025** (1.717)	4.824*** (1.709)	4.089** (1.712)	5.668*** (1.685)
Intercept	4.012** (1.822)	3.797** 1.634	5.565*** (1.397)	2.744* (1.566)	4.665*** (1.328)
R^2	.131	.132	.130	.132	.136
F level	44.69***	45.02***	43.94***	45.03***	46.51***

KIBS: knowledge-intensive business services.
***Significant at .01 level, **significant at .05 level, *significant at .10 level.

The major finding presented in Table 6 is that the importance of universities, as a source of knowledge for the entrepreneurial firm to explore new business opportunities on sales growth, varies across countries. In some countries, the impact is positive; in others, it is negative; and in still others, universities have no statistical impact. For example, with reference to the regression coefficients in column (1) of the table, universities have a positive and significant impact on sales growth in entrepreneurial firms in France, Germany, Italy, Sweden and the United Kingdom. Generally, but not always (i.e. entrepreneurial firms in the United Kingdom), entrepreneurial firms in these countries also have a greater ability to combine knowledge sources through obtaining and using customer and client information as well as internal know-how to positively moderate the impact of university knowledge. Also, entrepreneurial firms in these countries are, on average, more adaptable as measured through their capabilities and the youthfulness of their founders. This raises at least two questions: Is the context for entrepreneurial firms in these countries systematically different from other countries? Are the entrepreneurial founders of firms in these five countries systematically different from those in the other countries? Albeit beyond the scope of this article, these are important questions for future research.

Conclusion

Firm-related factors have been overlooked in the evolving literature on university entrepreneurial ecosystems. Taking firm-related factors into account introduces a demand side to understanding university entrepreneurship ecosystems. Therefore, the goal of this article was to understand how firm-related factors impact university entrepreneurial ecosystems. Testing our hypotheses with survey data on 3853 knowledge-intensive European entrepreneurial firms from 10 European countries, we found that an entrepreneurial firm's use of university knowledge is positively related to entrepreneurial firm performance in university entrepreneurial ecosystems. Furthermore, this relationship is moderated positively by the entrepreneurial firm's organisational capabilities.

Our analysis contributes to the theorising of university entrepreneurial ecosystems in several important ways. First, we show the interplay of university knowledge and entrepreneurial firms in university entrepreneurial ecosystems. This contributes to our knowledge of university entrepreneurial ecosystems in terms of how the economic, societal and technological contributions of these ecosystems (Guerrero et al., 2015, 2016; Guerrero and Urbano, 2014) take place not only directly by the university but also indirectly through entrepreneurial firms. Taking firm-related factors into account introduces a demand-side perspective to an understanding of a university entrepreneurial ecosystem (Guerrero and Urbano, 2012). Rather than considering universities as isolated economic institutions or agents, building on the perspective of university entrepreneurial ecosystems and in line with the theory of knowledge spillover entrepreneurship (Audretsch and Keilbach, 2007), we illustrate how the benefits of universities to the economy accrue through the entrepreneurial firm dimension, so that the entrepreneurial firm emerges as a powerful co-creator of value from university knowledge.

Accordingly, we call for studies that take a broad view of the impact of university entrepreneurial ecosystems (Hayter et al., 2018) by including the demand side. In addition, it would be important to consider the role of different formal intermediaries, such as offices of technology transfer (Swamidass, 2013) and pre-incubators and incubators (Youtie and Shapira, 2008). Furthermore, research should look further into informal intermediaries, such as social networks (Hayter, 2016a) that may influence interactions between the demand and supply side in university entrepreneurial ecosystems. For example, researchers may examine how networks and intermediaries among ecosystem stakeholders, including knowledge-intensive firms, evolve over time to help explain dynamic phenomena, such as industry emergence (Hayter, 2013, 2016b; Swamidass, 2013; Youtie and Shapira, 2008).

Second, we show how knowledge and capabilities of the entrepreneurial firm (Kogut and Zander, 1992; Rasmussen and Borch, 2010; Rasmussen et al., 2014) help determine how effectively the entrepreneurial firms within the university entrepreneurship ecosystem utilise university knowledge. Prior research has called for an examination of how capabilities influence university entrepreneurial ecosystems (Siegel and Leih, 2018). Yet most prior work is focused on examining capabilities of universities (Hayter and Cahoy, 2018; Rasmussen and Borch, 2010). Our study contributes to a more detailed understanding of university entrepreneurial ecosystems by illustrating how the effectiveness of ecosystems is dependent not only on the resources and mechanisms of the research university to disseminate knowledge but also on the organisational capabilities (Helfat et al., 2007) of the recipient entrepreneurial firms that turn university knowledge into entrepreneurial opportunity creation and capture its value (Hitt et al., 2001). Our key contribution is to empirically show that capabilities of the ecosystem participants matter in the university ecosystem, a finding that has not been sufficiently acknowledged in prior literature (Siegel and Leih, 2018). Accordingly, entrepreneurial firms must possess knowledge and capabilities important to their success (Helfat et al., 2007). Future research should examine these capabilities even further.

Third, our post hoc analyses contribute to the understanding of university entrepreneurial ecosystems as a context-specific phenomenon that is itself dependent on broader environmental factors (Brown, 2016; Guerrero–Cano et al., 2006). We contribute by identifying national-level factors as boundary conditions of knowledge spillovers in university entrepreneurial ecosystems

(Agarwal et al., 2010; Audretsch and Keilbach, 2007). Asymmetries may exist across countries regarding firm-level capabilities that can influence creating value from university knowledge. Also, knowledge spillovers may be less effective in resource-constrained environments because entrepreneurial firms may stop building or maintaining capabilities required to university knowledge. Furthermore, policymakers under fiscal constraints may not provide sufficient resources to existing or potential intermediaries and institutions that facilitate value creation in university entrepreneurial ecosystems.[3] For future research, including national-level factors provides an opportunity to combine literature on university entrepreneurial ecosystems (e.g. Etzkowitz et al., 2000; Guerrero et al., 2016; Kirby et al., 2011) with the more macro-focused literature on regional innovation ecosystems (e.g. Asheim and Coenen, 2005; Cooke et al., 1997).

Our study has limitations that should be considered in the interpretation of the empirical results. We focused on the entrepreneurial firm and its organisational capabilities. We argue that the firm implicitly holds constant the quality of the university source when determining how valuable a source it is. However, it would be interesting to examine variation both in the supply side, in terms of the characteristics of the university as the knowledge producer, and in the demand side, in terms of the characteristics of the entrepreneurial firm as the recipient of knowledge. In addition, we focused on firm-level factors in our hypotheses. Yet, the variance across countries that we discovered in the post hoc analyses suggests that there may be differences across countries in the ability of the entrepreneurial firms to make use of university knowledge. Furthermore, there can be interactions that might also impact the degree to which knowledge flows to entrepreneurial firms, such as the role of students, faculty or innovation intermediaries (Hayter, 2016a; Hayter et al., 2018).

Finally, our results also have important policy and managerial implications. For innovation policies, our analysis indicate that the demand side of university knowledge – in this case, entrepreneurial firms – should be an integral part of the equation when policies to support university entrepreneurial ecosystems are designed. There is a need to focus not only on university-level solutions for innovation policy but also on firm-level solutions that focus on building and enhancing the capabilities of entrepreneurial firms (Brown, 2016). For managers, our results point to the importance of understanding the complementary role of entrepreneurial firm capabilities in the value-creation process in university entrepreneurial ecosystems. Entrepreneurial firm managers are the key to building, developing and maintaining such capabilities.

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Notes

1. We use the term *knowledge-intensive entrepreneurial* (KIE) *firms* because our data analyses are based on a large sample of EU firms referred to by the European Commission as KIE firms.

2. In Greek mythology, the word *Aegis* refers to the powerful shield carried by Athena and Zeus. While not documented, Amoroso and Link (2018) suggest that the use of the word *Aegis* by the European Commission to describe its project title is meant to suggest that the database contains powerful information for understanding knowledge-intensive entrepreneurship. Specific details about the AEGIS database are in the excellent annotation by Caloghirou et al. (2011). On request, we will share our detailed descriptions of the database, including elements of the survey instrument.

3. We would like to thank an anonymous reviewer for advancing our thinking on these points.

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