

Knowledge-intensive innovative entrepreneurship integrating Schumpeter, evolutionary economics, and innovation systems

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Abstract This article proposes a novel conceptualization of knowledge-intensive innovative entrepreneurship, which can capture the main characteristics of a vital phenomenon in the modern economy. Our conceptualization is based upon the integration of Schumpeterian entrepreneurship, evolutionary economics, and innovation systems approach. It consists of a theoretical definition and a stylized process model. According to this view, knowledge-intensive innovative entrepreneurs are involved in the creation, diffusion, and use of knowledge; introduce new products and technologies; draw resources and ideas from their innovation system; and introduce change and dynamism into the economy. In the article, we also offer an empirical definition of knowledge-intensive innovative entrepreneurship, which we then use to identify its key characteristics and relevance. We conclude with recommendations for a future research agenda.

Keywords Entrepreneurship · Innovation · Knowledge-intensive sectors · Innovation systems · Evolutionary economics

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1 Introduction

This article proposes a novel conceptualization of knowledge-intensive innovative entrepreneurship. Entrepreneurship as a domain of research is highly diverse and expanding, and one where leading scholars stress the need to continue developing underlying theories to better explain the phenomenon (Alvarez et al. 2016; Carlsson et al. 2013). We take an economic point of view on innovation and entrepreneurship. We propose a novel conceptualization of a particular type: knowledge-intensive innovative entrepreneurs are involved in the creation, diffusion, and use of knowledge; introduce new products and technologies; draw resources and ideas from their innovation system; and introduce change and dynamism into the economy.

Schumpeter stressed the role of entrepreneurs in relation to invention and innovation, and we are inspired by the modern Schumpeterian approach to understanding the processes of invention, innovation, and entrepreneurship. We will extend the Schumpeterian tradition by integrating insights from evolutionary economics and the innovation systems approach. This theoretical integration is necessary; we argue, in order to be able to conceptually understand, define, and measure knowledge-intensive innovative entrepreneurship, which we are convinced, is the most important type of entrepreneurship in the modern knowledge economy.

In claiming that entrepreneurship drives economic development, Schumpeter (1934, 1942) focused our attention on how and why the activities of entrepreneurs create a disruptive, disequilibrium force in the economy,

which in turn enables growth. More specifically, Schumpeter outlined the entrepreneurial function, whereby entrepreneurs play a key role in stimulating economic dynamism by using ideas and technical inventions, accessing finances, and transforming those ideas into technological, commercial, and organizational innovations (Kurz 2012; Andersen 2011; Swedberg 1991). Researchers in the Schumpeterian tradition in entrepreneurship and small business economics have been involved in a number of conceptual debates (Carlsson et al. 2013; Landström et al. 2012). These debates include whether opportunities are created or discovered (Alvarez et al. 2013; Ardichvili et al. 2003), whether entrepreneurs grasp existing opportunities or create new ones (Shane 2000; Buenstorf 2007), the extent to which new firms can challenge incumbents and transform the economic system by creating an entrepreneurial regime (Winter 1984, 2016), and the conditions stimulating entrepreneurial innovation (Acs et al. 2014; Autio et al. 2014; Acs and Audretsch 2003) and innovative entrepreneurship (Shane 2009). Moreover, parts of the modern entrepreneurship literature recognizes that knowledge—as gained through education, experience and so forth—affects how individual entrepreneurs are able to identify and react to opportunities (Shane 2003; Alvarez and Barney 2007b; Aldrich and Yang 2014). Therefore, the knowledge accumulated by the founders and teams within and across industries, as well as in scientific and research organizations, and in upstream or downstream activities, are vital for entrepreneurship survival and performance (Klepper 2015; Agarwal and Shah 2014; Adams et al. 2016). Along these lines, our conceptualization of knowledge-intensive innovative entrepreneurship articulates the relationships between the entrepreneur (the person), the entrepreneurial firm (the organization), knowledge, and the broader social and economic context (innovation system).

In this article, we specifically develop three key aspects of knowledge-intensive innovative entrepreneurship: (a) why and how processes related to knowledge and innovation drive knowledge-intensive innovative entrepreneurship; (b) why the innovation system enables and constrains the access of the knowledge-intensive innovative entrepreneurial venture to ideas, resources and opportunities; and (c) why it is correct to claim that this type of entrepreneurship has empirical relevance and distinctive characteristics. Section 2 articulates our novel conceptualization of knowledge-intensive innovative entrepreneurship, by including a

definition and a stylized process model. This conceptualization extends and integrates theoretical building blocks from Schumpeter, evolutionary economics, and innovation systems. Section 3 provides an empirical definition, used to analyze empirical evidence from a large-scale survey, in order to identify key characteristics of this type of entrepreneurial firm and to indicate their relevance in the economy. Section 4 summarizes our contributions and concludes with our suggestions for a future research agenda.

2 Theoretical building blocks and conceptualization of knowledge-intensive innovative entrepreneurship (KIE)

We integrate three theoretical building blocks: Schumpeter, evolutionary economics, and innovation systems. These three streams of literature are very closely related, but for analytical purposes, we separate them in order to identify their different theoretical insights in a clearer way. For the purpose of this article, we do not engage in a full literature review of each, but instead pinpoint and clarify what we consider to be the key theoretical insights for conceptualizing knowledge-intensive innovative entrepreneurship (KIE). Our conceptualization of KIE consists of a theoretical definition and a stylized process model.

2.1 Integration of three theoretical building blocks

2.1.1 Schumpeter and the Schumpeterian entrepreneur

The Schumpeterian tradition represents our first main building block, and provides insights into the conditions under which the entrepreneur acts, and into the function of entrepreneurship in transforming the economy.

In economic terms, important characteristics of the Schumpeterian entrepreneur are that she/he is a risk taker and develops new combinations, when engaged in the process of turning ideas and inventions into innovations. In one such definition, entrepreneurship “pertains to the actions of a risk taker, a creative venturer into a new business or the one who revives an existing business” (Hérbert and Link 1989: 39). A stream of literature has deepened further the discussion of the motivational, psychological, and organizational aspects of risk, by defining and examining the degree of entrepreneurial orientation (Lumpkin and Dess 1996;

Wiklund and Shephard 2003). Entrepreneurs gather capital and take risks, leading to the development of innovations—which may be seen as new combinations (Becker and Knudsen 2002). New combinations are “the systematic production of new, economically useful knowledge out of existing knowledge” (Kurz 2012:883). Our interpretation is that the Schumpeterian entrepreneur takes risks, makes new combinations, and accesses resources to turn ideas into innovations.

Another insight is how the individual entrepreneur and entrepreneurial team are able to create opportunities. Schumpeterian opportunities are interpreted as that the knowledge and business opportunities do not exist a priori but instead emerge and come together through the actions of entrepreneurs. Schumpeterian opportunities are generally contrasted with Kirznerian opportunities, where the entrepreneur discovers existing opportunities. A long series of debates exists, which contrasts the created and discovered opportunities (Kirzner 1997; Alvarez and Barney 2007a; Lachmann 1986; Short et al. 2010), including debates on epistemology and historical roots which impact characteristics of the knowledge involved in the opportunity formation process (Alvarez et al. 2013; Alvarez and Barney 2010). We take our position on opportunities as being created through the activities of the entrepreneur (and subsequently, the entrepreneurial firm).

Finally, in terms of the entrepreneurial function, Schumpeter identified that the entrepreneur challenges incumbents through creative destruction, and thereby transforms the economic system and fosters economic growth and development. The discussion in Schumpeter (1934), (1942) and (1949) portrays several characteristics and dimensions of this process. The role of the entrepreneur is to introduce new technologies, products, production processes, and organizational forms; in this way, he/she destroys common ways of doing things: established products and existing production processes (Andersen 2011; Swedberg 1991). Entrepreneurship thus leads to competition between entrants and incumbents as well as changes in market structure (Carlsson et al. 2013). More recently, the Schumpeterian tradition has linked entrepreneurship to economic growth, by pointing to its role as a knowledge filter (Acs et al. 2009). In this respect, knowledge becomes a key factor enabling the entrepreneurial function and creating opportunities (Audretsch and Keilbach 2007; Metcalfe 2002; Winter 2016). We adhere to this conceptualization of the entrepreneurial function; we are particularly interested in

how knowledge created in the economy is identified and exploited by the entrepreneur, and why this process helps to create new knowledge and innovative opportunities.

In sum, our analysis of the theoretical traditions inspired by Schumpeter regarding entrepreneurs leads us to these insights:

- The entrepreneur:
 - Takes risks and reaps profits
 - Turns technology and ideas into innovations in the market
 - Enables new combinations
 - Faces uncertainty about current choices in relation to future outcomes
 - Creates opportunities, by both driving and adapting to change in the external environment
- The key functions of the entrepreneur in the economy:
 - Acting as a disruptive, disequilibrium force, which arises endogenously in the economy
 - Driving wider processes of economic dynamism, which in turn lead to economic growth and societal well-being

2.1.2 Evolutionary economics

The second building block of our conceptualization is evolutionary economics. In the broad area of evolutionary economics community (see especially Witt 2008; Fagerberg 2003; Hodgson 2015; Dosi and Nelson 2011; Dosi et al. 2002; Nelson 2011; Nelson and Winter 2002) we draw specifically on the Nelson and Winter tradition and on the work by Metcalfe and colleagues regarding the role of knowledge in entrepreneurship and the economy.

A first set of insights coming from the evolutionary approach relates to a specific view of the processes underlying the interactions between innovation, technology institutions, and economic dynamics (Nelson and Winter 1982; Metcalfe 1998; Dosi 1988; Malerba 1992; McKelvey 1996; Metcalfe 2014). These processes drive the evolution of an economy, through the creation of variety, selection, and the retention of some key features. Innovation and entrepreneurship represent fundamental processes, which increase the variety of products, production processes and organizational forms,

and also influence the selection within industries. A strand in this theory also claims that different technological regimes—as related to various dimensions of learning and knowledge—characterize the environment in which innovative firms operate. The key distinction here is between an entrepreneurial setting and a routinized setting. The first type is characterized by high-technological opportunities, low cumulativeness of technological advance, and low appropriability, which generates high rates of new firms' formation and a highly turbulent sectoral environment. The second type is characterized by high-technological opportunities but also high cumulativeness and high appropriability, which leads to much lower entry of new firms and a more concentrated industrial structure. Sectors differ greatly in terms of technological regimes and consequently in industrial dynamics and the organization of innovative activities (Winter 1984; Malerba and Orsenigo 1997; Breschi et al. 2000). From these contributions, we derive that our analysis will include the creation and use of new knowledge through the exploration and exploitation of scientific and technological opportunities: the learning and knowledge context in which innovators operate, the specific learning by individual and organizations, and the search for new ways of doing things.

Moreover, evolutionary theory emphasizes the relevance of co-evolutionary processes in the economy, where co-evolution involves knowledge, organizations' industrial structure, and institutions (Nelson 1994; Metcalfe 2001; Murmann 2003; 2013). As far as entrepreneurship is concerned, the concept of co-evolution involves the knowledge of the entrepreneurs and the knowledge context that surrounds them. For example, McKelvey (1996) analyzes the co-evolution of scientific knowledge and innovation, which involves large firms and entrepreneurial ventures, in order to explain the emergence of a new industry, the biotechnology industry as a co-evolutionary process involving the creation, diffusion, and use of knowledge. Hence, from this literature, we derive that we put a focus upon co-evolutionary processes during the diffusion, use and creation of knowledge, and that these processes involves both individuals and organizations in their economic and social context.

Some specific contributions within the evolutionary tradition have focused on the role of knowledge in entrepreneurship and new firm formation (Loasby 1999; McKelvey 1998). In particular, entrepreneurs

create new knowledge over time (Metcalfe 2002) and change the opportunity sets available through the interaction with the context and the development of new knowledge (Holmén et al. 2007; Holmén and McKelvey 2013). Knowledge can be seen as new combinations (Krafft et al. 2014; Antonelli et al. 2010), closely linked to entrepreneurship and the cognitive basis of knowledge (Cantner 2016; Cantner et al. 2016; Göthner et al. 2012; Stuetzer et al. 2014). From this literature, we derive that knowledge creation is an individual as well a collective endeavor in its various dimensions and in its dynamics.

Our analysis of evolutionary economics leads us to these insights:

- Entrepreneurs
 - Are involved with others in the diffusion, use and creation of knowledge
 - Engage in learning and problem-solving activities
 - Use knowledge into new combinations for innovation
 - Are affected by education, knowledge and experience in their innovative activities
- Entrepreneurship
 - Is a process with emergent properties
 - Involves actors searching for opportunities and generating new knowledge
 - Is affected by of the learning, technological and knowledge context
 - Involves the co-evolution of knowledge, firms, industrial structure and institutions

2.1.3 Innovation system approach

Finally, the third theoretical building block is the innovation system approach, and specifically innovation systems as affecting entrepreneurship. Our perspective is that entrepreneurs do not act in isolation, but instead interact with a variety of other actors within specific institutional settings. Research within the innovation system approach has pointed out that in their innovation process, firms interact with a wide range of heterogeneous actors ranging from suppliers and users, scientific organizations, government agencies, and financial organizations (Edquist 1997; Edquist and McKelvey 2000),

each of which has specific knowledge and capabilities, and hence each contributes in a different way to learning and innovation (Lundvall 2007). Our view is that organizations and institutions more broadly within an innovation system shape entrepreneurs' cognition and action and also affect their interactions with other agents.

Innovation systems have been primarily studied as consisting of three types, each affecting entrepreneurship in various ways. A first type of innovation system is the national one. National innovation systems have a geographical dimension corresponding to a country including institutions and boundaries, and they were the first ones examined (Freeman 1987; Lundvall 1993; Nelson 1993). National innovation systems affect the generation and diffusion of knowledge and the formation of entrepreneurship through universities and the educational system, public policy, national regulation, and standardization. It has been shown that major differences exist in the national innovation system both among advanced countries and among emerging and developing countries (Lundvall 2007). The architecture of the national systems may vary in structure and composition: some actors may be missing or do not have the necessary capabilities, some links may not work properly, and mismatches among various parts of the systems may block change. All these factors may affect the innovation and entrepreneurship in a country.¹ Regional innovation systems represent another type of systems. Here, the term regional encompasses the regional, local, or cluster level. In regional systems, the focus is on the interaction among local firms, clusters, and institutions (Cooke and Piccaluga 2004; Boschma and Frenken 2011; Boschma and Martin 2010). In regional systems, knowledge is shared and exchanged in various ways, which in turn greatly affects the creation of entrepreneurship and the formation of industrial clusters.

Sectoral innovation systems are a third type. They highlight the major differences across sectors in terms of knowledge, non-firm actors, and the institutions that support innovation. These differences among industries generate quite different sectoral systems in terms of knowledge base of innovative activities, role of suppliers, users, universities, financial organizations, and government agencies, or institutions in terms of regulation, standards, or labor markets (Malerba 2002, 2004; Carlsson 1995). Therefore, entrepreneurship is affected by the specific

sectoral system in terms of availability of knowledge, technological opportunities, supporting actors, and institutional setting. The sectoral dimension of innovation system has been proven to be relevant in both advanced countries and emerging and developing ones (Malerba and Mani 2009; Lee and Malerba 2017; Malerba 2010).

From the innovation system approach, we derive that innovation systems matter in affecting the conditions and resources available to the entrepreneurs and the effectiveness of the entrepreneurial function. Moreover, we stress that the national, sectoral, and regional innovation systems interact in their effects on entrepreneurship, in terms of national policies and regulation, in terms of the specific sectoral knowledge actors and institutions, and in terms of specific industrial clusters or regional or local policies and institutions. Our interpretation is that innovation systems provide the context of learning in terms of sources of knowledge, capabilities that are shared, put together or integrated, and channels through which knowledge flows from one actor to another. Therefore, we argue that the links and networks of actors are of paramount importance in the innovation process, and hence also for the formation and development of entrepreneurship.

Our analysis of the innovation systems approach leads us to these insights:

- Entrepreneurs
 - Are highly dependent upon the knowledge infrastructure, the supporting actors and the institutional context
 - Create opportunities but are also bounded by the geographical and sectoral dimensions in which they operate and innovate
- Entrepreneurship
 - Is affected by the complementarities in knowledge and capabilities of actors linked within innovation systems
 - Relies upon existing and new networks and channels through which knowledge is communicated, shared or generated

Based on our above analysis of the three theoretical building blocks to derive the key insights, we now move on to propose our conceptualization of KIE, which consists of the theoretical definition and the stylized process model.

¹ Acs and Autio (2014) discuss national systems of entrepreneurship in a way that has some similarities but also differences from ours.

2.2 Conceptualization of knowledge-intensive innovative entrepreneurship: theoretical definition and stylized process model

Our conceptualization captures the notion that KIE entrepreneurship occurs as the result of a process of learning and problem-solving engaged by the entrepreneur (founder or founder team) and aiming to benefit from opportunity identification, creation, and exploitation. More broadly, our conceptualization captures the idea that KIE entrepreneurship involves individuals and organizations acting within knowledge networks and national, regional, and sectoral contexts. These networks and contexts define the key complementarities in capabilities and financial support, the knowledge sources to be used and the channels and types of possible innovative opportunities to be exploited or created.

Thus, our conceptualization of KIE consists of a theoretical definition as well as a stylized process model.

Our theoretical definition of KIE is

Knowledge-intensive innovative entrepreneurial firms are new learning organizations that use and transform existing knowledge and generate new knowledge in order to innovate within innovation systems

Our stylized process model of KIE is visualized in Fig. 1 below, which we use to identify and establish the key dimensions. Our stylized process model as represented in Fig. 1 helps to synthesize previous research in order to present a more complete and systematic understanding of KIE entrepreneurship.² Figure 1 also represents that how these dimensions fit together, in a co-

² Our purpose with the model is to provide only a first initial representation and illustration of the interactions: it is unfortunately beyond the scope here to discuss each dimension and the dynamic links in depth. Excellent discussions on specific topics can be found: in Aldrich and Yang (2014) on the role of habits heuristics and routines and of learning by nascent entrepreneurs; Bryant (2014) on the role of legacy of imprinted characteristics of the founding team; Klepper (2009) on the role of industry experience held by the entrepreneur; Winter (2013) on the dynamics of routines; Nelson (2016) on the role of human behavior and cognition in innovation and industrial dynamics; and Winter (2016) and Salter and McKelvey (2016) on cumulative causation underlying entrepreneurial action. Moreover, we acknowledge previous work on KIE entrepreneurs (McKelvey and Lassen 2013a; McKelvey and Lassen 2013b) and on academic entrepreneurship (Delmar and Wennberg 2010) and on low tech (Hirsch-Kreinsen and Schwinge 2014). Our view is that while each underlying process can be studied separately, there is a value in also identifying and understanding how each underlying process and dimension contribute and interrelate within the overall process of KIE entrepreneurship.

evolutionary process, occurring between the KIE founder, the KIE venture and innovation systems. This co-evolutionary process can be analyzed over time, in such a way that each of the underlying dimensions will be affecting each other, in various ways, and will impact the trajectory of development of the KIE venture over time.

We briefly describe each dimension in turn, in relation to Fig. 1 as the visualization of our stylized process model for KIE.

(a) Origins of the KIE venture and potentially leading to a firm

From the whole left hand side of Fig. 1, we represent the origins of KIE venture, and an arrow representing a potential path leading to a KIE firm, represented as a circle. The word “origins” represents quite broadly that the new knowledge-intensive ventures can have come from a variety of organizations—educational organizations, incumbent firms, firms in related industries, universities, public sector, NGOs, and other actors. At the top left hand side, we include resources which may be linked to the origins, with pertinent examples being ideas, insights, and financing. By financing, we would like to clarify that we include not only the formal sources like venture capital, banks and corporate venturing, but also more informal sources like personal and family savings. At the bottom left, we include founder and founder teams, to represent the individuals involved in creating the entrepreneurial ventures. We characterize the new ventures as being influenced by the entrepreneurs and teams with specific personal traits in terms of individual attributes: habits, heuristics, education, experience, and intentions.

(b) The role of knowledge, opportunities and market conditions in affecting learning in the whole KIE entrepreneurial process

To represent learning as surrounding the previous dimension, we have placed three boxes—knowledge above and opportunities and market conditions below. Knowledge in the top box represents not only what the entrepreneur and entrepreneurial venture knows, but especially that they have to learn in specific knowledge contexts. We thus define knowledge contexts, both in terms of knowledge bases needed for entrepreneurial activities and in terms of learning mechanisms that generate new knowledge. One area where the KIE

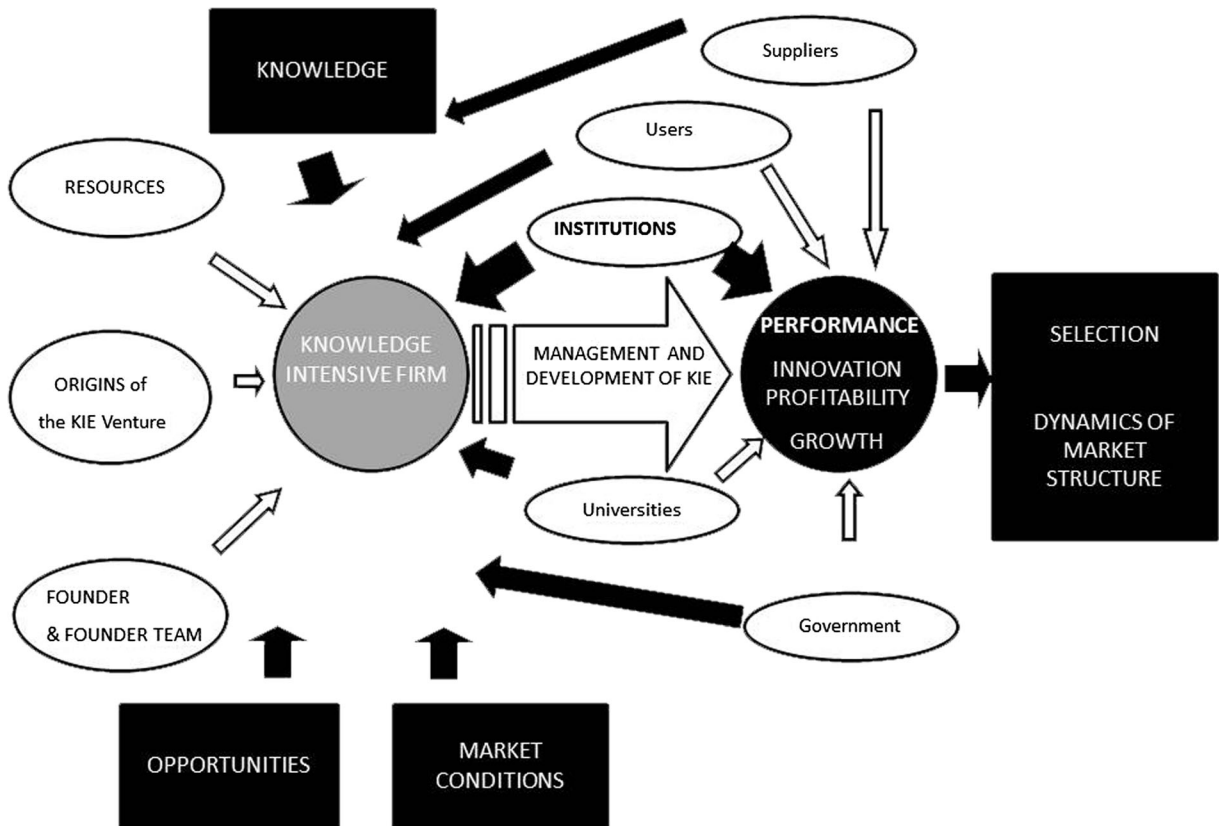


Fig. 1 A stylized process model of knowledge-intensive innovative entrepreneurship

founder and venture needs to develop their knowledge and learning is in relation to opportunities and market conditions, found as two boxes at the bottom. In relation to opportunities, we mean they must engage in learning about, identifying, and acting upon entrepreneurial, market, and technological opportunities—which we call innovative opportunities. We do wish to point out that opportunities continue to remain important during all the entrepreneurial life cycle, from entry and early development, through to later phases. Another vital area is market conditions, where sectoral systems of innovation help set the innovative opportunities potentially available to the KIE venture—but also where the KIE entrepreneur may create new ones.

- (c) The linkages between the management and development of the KIE firm, with many two-way interactions to institutions and actors in the innovation systems

This dimension is represented by the middle arrow of the management and development of the KIE firm,

which has two-way interactions seen as arrows with a variety of institutions and actors in the innovation system, represented as ovals.

Innovation systems are complex, but can be represented as influencing KIE entrepreneurship.³ The big arrow in the center of the Figure identifies the importance of many internal firm attributes, which affect how a specific venture will survive and grow, and also contribute to explain if and how the KIE firm may continue to maintain its original features and characteristics or it will evolve and change over time.

Within innovation systems, we identify first of the major actors as well as their role and ability to draw upon and create networks. This includes universities and research organizations that play a particular role in generating opportunities by creating advancements in new knowledge and technologies. Other key actors are users, who may stimulate or even create entrepre-

³ Figure 1 does not include a representation of different types of innovation systems, specifically national, regional, and sectoral. Later work could enrich the model by doing so.

neurship and innovation in various ways and degrees. They generally do so through knowledge related to market opportunities and customer demands. Suppliers also play a key role in creating knowledge and providing new technologies. One should recognize the importance of the government, which through various public policies exerts a significant influence during the whole entrepreneurial process. Finally, institutions defined in a broad way may provide opportunities or may establish enforcements as a result of the interactions among agents (such as contracts). Institutions can range from less binding to more binding, from less formal (such as traditions) to more formal (such as patent law or specific regulations).

- (d) Influence on different types of performance—innovation, profitability, firm growth

We assume that the previous co-evolutionary processes will also influence different types of performance, which is represented by the circle at the middle-far right hand side. Performance can be measured in different ways—innovation, profitability, firm growth, and so forth. Earlier dimensions can have an influence on performance, as linked both to origins, founder and founder teams as well as to the subsequent evolution of the KIE firms. Our view is that as a result of the factors related to KIE venture's initial characteristics, knowledge, innovation systems, as well as strategy and organization, the new venture ends up with a specific performance in terms of innovation, profitability and growth.

- (e) How KIE entrepreneurship in turn interacts with selection and the dynamics of market structure

The outcomes of KIE entrepreneurship are here identified as selection and dynamics of market structure, which are represented by the box at the far right-hand side. The representation in the model helps highlight that the origin, early development, innovation, performance, and growth of the KIE venture has an impact on the selection process, and also on the dynamics of market structure. Thus, as a more general effect, our argument is that KIE fosters competition, challenges established leaders, and increases the degree of variety of competences and firms in an industry. New technologies, products, and services

can also result in new consumption patterns and create new market opportunities in the form of new goods and services. The implications of selection and the dynamics of market structure are that some KIE ventures will survive and grow, while others will decline and disappear from the scene. Thus, our view is that KIE entrepreneurship contributes to the dynamism of the economy, and likely is more important than other types of entrepreneurship.

3 Defining empirically and analyzing knowledge-intensive innovative entrepreneurial firms

In order to analyze key characteristics and examine the relevance of KIE in the economic system, we have used a large-scale database. This database was created, based on our empirical definition of KIE firms (Malerba and McKelvey 2010, 2016), which was then turned into a series of survey questions in the EU project AEGIS (see AEGIS Research Project 2013).

There are other definitions of related topics, but our empirical definition differs from them. In empirical work, entrepreneurial firms reliant upon advanced technology have been the center of attention in many studies both in general (see for example Acs et al. 2009; Audretsch and Thurik 2001; OECD 2008) and also regarding specific typologies. Important ones include gazelles (Birch 1979; Henrekson and Johansson 2010); new technology based firms (for example Colombo et al. 2004; Colombo and Grilli 2005); academic entrepreneurship (Agarwal and Shah 2014); new engineering based firms (for example Autio 1997); and innovative entrepreneurship (Shane 2009). Many of these empirical studies focus upon particular types of sectors—such as high-tech sectors—or upon limited forms of entrepreneurship—such as academic entrepreneurship. Our proposed conceptualization overcomes these limitations, because we are not restricted to specific sectors or forms. Instead the following empirical definition was used to identify, and develop, a survey of relevant young firms, existing across high-tech and low-tech manufacturing sectors as well as knowledge-intensive business services. Finally, KIE ventures are not necessarily gazelles because we make no assumption (or empirical test) that they are always fast growing.

3.1 Empirical definition of KIE

Our empirical definition includes four key dimensions. These dimensions capture relevant aspects of the above conceptualization, and can be used in later empirical work, because they provide a measurable definition of KIE. A further discussion of conducting empirical studies in relation to future research can be found in (Malerba and McKelvey 2018a).

The first dimension is that KIE is a *new independent firm*. Given the theoretical role of entrepreneurs as stimulating change and given the need to exclude existing small business owners, a first element to define is the time of establishment, as well as status. An empirical focus on KIE may concentrate on the early stage of the venture. Moreover, the firm should be independent and not a subsidiary or part of an existing organization.

The second dimension is that KIE has to be *innovative*. This is in line with Schumpeter's original focus on entrepreneur as introducing innovations into the market for profit motives. This also excludes firms that are only imitative or that are selling standardized goods and services.

The third dimension is that KIE ventures are *knowledge intensive* in the innovative and competitive process. Given the articulated and multidimensional nature of the modern economy, and how KIE ventures compete, knowledge bases are defined broadly, in relation to scientific and engineering knowledge as well as to design and application knowledge. Moreover, we refer to firms, which use knowledge for systematic problem solving and for gaining a competitive advantage. In sum, we consider KIE ventures as knowledge operators, dedicated to the utilization of existing knowledge, the integration and coordination of different knowledge assets, and the creation of new knowledge.

The fourth dimension is that KIE *exploit innovative opportunity*. Opportunities may be driven by the rapid development of (potential) markets and of technology or by the combination of creative knowledge and design. Opportunities tend to emerge over time, as they are identified and tested in the market place. In particular, innovative opportunities can be defined as "the possibility to realize an economic value inherent in a new combination of resources and market needs, emerging from changes in the scientific or technological knowledge base, customer preferences, or the inter-relationships between economic actors" (Holmén et al. 2007).

By including these four dimensions, we propose the following definition of a KIE venture, which is useful for empirical work:

KIE ventures are new firms that are innovative, have significant knowledge intensity in their activity, are embedded in innovation systems and exploit innovative opportunities in diverse evolving sectors and contexts

This definition was used in a large-scale survey. The survey we use included a series of question, posed in native-language for each country, for 4004 new European firms (younger than 8 years) operating in a large variety of sectors of the economy in 10 countries, in the period 2007–2009 (see Malerba et al. 2016). This survey was thus explicitly designed, based on the above empirical definition of KIE. The survey includes new ventures from high-tech manufacturing (420 firms), low-tech manufacturing (1602), and services (1982) from 10 European countries. There were conceptual reasons for sampling across different sectors and countries, and a presentation of the survey, descriptive statistics, and analysis can be found in (Malerba et al. 2016; Caloghirou and Protoyerou 2016; Protoyerou et al. 2017; Gifford et al. 2018).

Two descriptive statistics relative to knowledge are interesting here. In these new ventures, education is fairly important, as seen in Fig. 2. Two out of three new firms (64.9%) have at least one employee with a university degree and half the firms of the sample employ post-graduates. In terms of sectors, the share of founders who do not have university degree is higher for low-tech sectors (60%) than for high-tech sectors (50%) and knowledge-intensive services (KIBS) (28%).

Figure 3 indicates that the founders do indeed bring different types of knowledge into the KIE venture, here representing the main knowledge of the entrepreneurs.

Having a degree may be positively related to the likelihood of survival of new firms and firm growth, or at least to learning.

3.2 Identifying characteristics of knowledge-intensive innovative entrepreneurial firms

In this article, we aim to evaluate whether all the key empirical dimensions of KIE (i.e., new firms that are innovative, have significant knowledge intensity in their activity, are embedded in innovation systems and exploit innovative opportunities in diverse evolving

sectors and contexts) can be coherently identified within a consistent group of young European firms. We have chosen to present a few relevant findings for the purposes of this article.

In order to identify the differences between KIE ventures and other types of new firms, we have isolated a set of questions from the survey in order to identify the main distinguishing characteristics, by separating out KIE firms from other young firms in the survey, specifically:

- Innovative firms: whether the company has introduced new or significantly improved goods or services during the past 3 years (question 27)
- Knowledge intensity: education: whether the educational attainment of the founder was at least a bachelor degree or more (question 5)
- Knowledge intensity: skills: Whether the main areas of expertise of the founder(s) were technical and engineering or product design (Q 8)

We thereafter divide the original population in the survey into two groups. We consider KIE ventures as those new firms whose founder has an education equal or greater than bachelor and have a technical and engineering knowledge or product design skills. In the total sample of 4004 firms, innovative firms include 2548 firms (Y/N indicator). Firms with education OR with technological and design skills include 3858 firms. The combination of these dimensions gives a total of 2454 new firms (out of 4004 firms sampled). We thus compare and contrast 2454 KIE ventures with 1550 other new firms. The relevant survey questions are reproduced in the [Appendix](#).

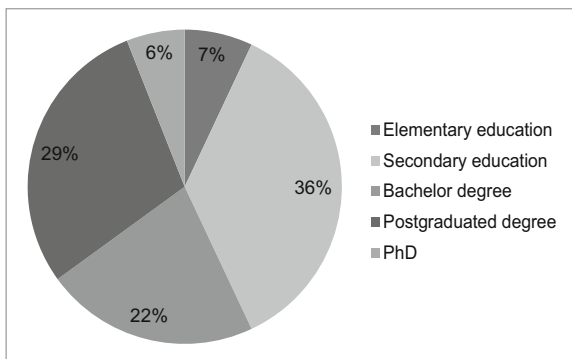


Fig. 2 Highest educational attainment of founders of new firms ($N = 7589$). Source: Aegis Survey, Caloghirou and Protođerou 2016

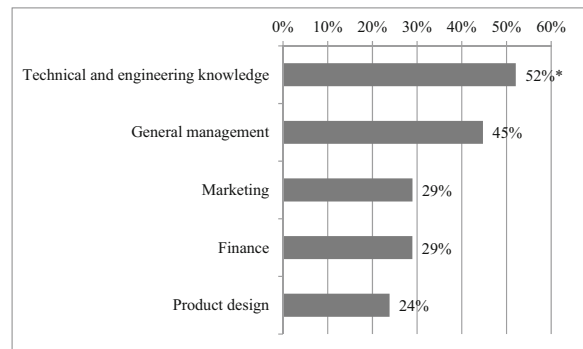


Fig. 3 Main areas of expertise of the founders of new firms ($N = 7792$). A single asterisk (*) indicates that the percentages do not add up to 100% due to multiple responses. Source: AEGIS Survey, Caloghirou and Protođerou 2016

Our analysis of the comparison follows, with three empirical findings, which are directly linked to our above conceptualization of KIE.

3.2.1 Knowledge-intensive innovative entrepreneurial firms are an empirically significant category of new firms

In our initial definition, we claimed that KIE ventures should be present not only in high-tech sectors or from academic entrepreneurship, but more widely across the economy. A first main result is that 61% of the population of young firms surveyed are what we classify as KIE firms. This is indeed a considerable share of the total population surveyed—which supports the empirical definition of relevance across sectors and countries. In Table 1, KIE represent a large share of new firms in more advanced European countries as well as in less advanced ones. Then, as one can see from Table 2, KIE are present in both manufacturing and business, as well as in high-tech and low-tech sectors.

Therefore, we can advance a first empirical finding:

FINDING 1: KIE firms are an empirically relevant phenomenon within new firms in Europe. They are present across all European countries and all sectors

3.2.2 In their activities, KIE ventures benefit greatly from two-way interactions with their innovation systems

In our conceptualization of KIE, we claimed that KIE benefit greatly from being part of innovation systems. In

order to prove this point, we perform our analysis by selecting three sets of survey questions that indicate the relationships with the innovation system.

They are

- Sources of knowledge that are relevant for exploring new business opportunities (question 24): The answers to this question are on a scale from 1 (not important) to 5 (extremely important). We have selected the following sources of knowledge that are external to the new firm and therefore part of the innovation system and that are also highly knowledge intensive: public research institutes; universities; external commercial labs and R&D firms.
- Participation to agreements (question 26). Again the scale of the answers is from 1 (not important) to 5 (extremely important). Among all the agreements, we have selected agreements in which the intensity of knowledge exchanged is high: Strategic

alliance, R&D agreement, and Technical cooperation agreements

- Contribution to create and sustain competitive advantage (question 19). Also in this case the scale of the answers is from 1 (not important) to 5 (extremely important). Among all the factors that create and sustain the competitive advantages of new firms, we have selected the ones that can be related to innovation systems in terms of interactions with other actors: Establishment of alliances; Networking with scientific research organization; partnership with other firms.

In the answers to most of the single items in the questions on external sources that are knowledge intensive (question 24), participation to agreements in which knowledge intensity is high (question 26) and contributions to competitive advantage given by interaction and networking with other actors (question 19), KIE ventures give answers equal or greater than 3 (on a scale from 1 not important to 5 extremely important), while the other new firms usually do not present such high values for each of the items.⁴

In order to present results that summarize the previous findings, we have created a synthetic indicator for each group of questions—Q24, Q26, and Q19.

As one can see from Tables 3, 4, and 5, the values regarding the relevance of these dimensions related to innovation systems are higher for KIE ventures than for other new firms.

In order to probe these results, we have also created a super-synthetic indicator of the relevance of innovation systems that provides a single measure by putting together questions 24 and 26. This super-synthetic indicator of the relevance of innovation systems for KIE and for other new firms is presented in Fig. 4.

The super-synthetic indicator confirms the results of the analysis done for the individual questions. Figure 4 indicates that for the super-synthetic indicator the difference between KIE and the other new firms is significant at 1% using the non-parametric rank-sum test (rather than the *t* test, because the population is non normal). Thus KIE firms interact more with the innovation system than other new firms.

Thus, we can advance the second empirical finding:

FINDING 2: KIE firms interact more with innovation systems than do other new firms

Table 1 KIE vs. other new firms in various countries

	Other new firms	KIE	Total
Croatia	64 4.13%	136 5.54%	200 5.00%
Czech Rep.	65 4.19%	135 5.50%	200 5.00%
Denmark	136 8.77%	194 7.91%	330 8.24%
France	262 16.90%	308 12.55%	570 14.24%
Germany	230 14.84%	327 13.33%	557 13.91%
Greece	114 7.35%	217 8.84%	331 8.27%
Italy	171 11.03%	409 16.67%	580 14.49%
Portugal	127 8.19%	204 8.31%	331 8.27%
Sweden	132 8.52%	202 8.23%	334 8.34%
UK	249 16.06%	322 13.12%	571 14.26%
Total	1550 100%	2454 100%	4004 100%

Source: AEGIS survey

⁴ Due to word limits, the tables with the results are not reported here.

Table 2 KIE vs. other new firms in various sectors. Source: AEGIS

	Other new firms	KIE	Total
Advertising	39 2.52%	77 3.14%	116 2.90%
Aerospace	1 0.06%	0 0.00%	1 0.02%
Architectural and eng	145 9.35%	172 7.01%	317 7.92%
Basic metals	10 0.65%	21 0.86%	31 0.77%
Chemical industry	15 0.97%	36 1.47%	51 1.27%
Computer and related	155 10.00%	363 14.79%	518 12.94%
Computers and office	7 0.45%	13 0.53%	20 0.50%
Fabricated metal prod	81 5.23%	133 5.42%	214 5.34%
Food, beverages and t	110 7.10%	187 7.62%	297 7.42%
Labor recruitment and	27 1.74%	17 0.69%	44 1.10%
Paper and printing	236 15.23%	382 15.57%	618 15.43%
Radio-television and	9 0.58%	26 1.06%	35 0.87%
Research and experiment	21 1.35%	50 2.04%	71 1.77%
Selected business ser	367 23.68%	465 18.95%	832 20.78%
Technical testing and	25 1.61%	35 1.43%	60 1.50%
Telecommunications	8 0.52%	16 0.65%	24 0.60%
Textile and clothing	87 5.61%	122 4.97%	209 5.22%
Wood and furniture	101 6.52%	132 5.38%	233 5.82%
Other	106 6.84%	207 8.44%	313 7.81%
Total	1550 100.00%	2454 100.00%	4004 100.00%

Source: AEGIS survey

In order to confirm the finding 2, we have conducted some additional analyses. One additional analysis is to consider all the external sources of knowledge for exploring business opportunities as reported in Fig. 5. We

use all external sources in question 24 namely: customers; suppliers; public research organizations; universities; external labs and R&D firms; participation in nationally funded research programs; participation in

Table 3 A synthetic indicator regarding the importance of external sources that are knowledge-intensive

	Not important	Important	Total
Other new firms	1292	258	1550
	83.35%	16.65%	100%
KIE	1860	594	2454
	75.79%	24.21%	100%
Total	3152	852	4004
	78.72%	21.28%	100%

These responses correspond to question 24 in the survey. Important means that all the items have answers of at least “Important” or more (greater or equal to 3)

Source: AEGIS Survey

EU funded research programs. Note that this extends external sources of knowledge to a wide variety, and not necessarily knowledge-intensive ones.

The results in Fig. 5 indicate that a difference between KIE and other new firms is confirmed: KIE rely more on external sources than the other new firms. The difference between the frequency distribution between KIE and other new firms is significant at 1%.

Other additional analyses are that we have changed the identification of KIE within our sample of firms, trying out both more restrictive and broader, in Fig. 6. On the one hand, the more restrictive indicator of KIE (which we label SUPER-KIE), we use the indicator of KIE includes firms that are innovative (2548 firms) and have education AND technological AND design skills (917 firms). The total of firms in the final sample of SUPER-KIE is 643 firms. On the other hand, the broader indicator of KIE (which we label BROAD-

Table 4 A synthetic indicator for the importance of participation to agreements that are knowledge-intensive

	Not important	Important	Total
Other new firms	1450	100	1550
	93.55%	6.45%	100.00%
KIE	2059	395	2454
	83.90%	16.10%	100.00%
Total	3509	495	4004
	87.64%	12.36%	100.00%

These responses correspond to part of question 26 in the survey. Important means that all the items have answers of at least “Important” or more (greater or equal to 3)

Source: AEGIS survey

Table 5 A synthetic indicator for all items regarding the importance of collaborations and networking as sources of competitive advantage

	Not important	Important	Total
Other new firms	1220	330	1550
	78.71%	21.29%	100.00%
KIE	1564	890	2454
	63.73%	36.27%	100.00%
Total	2784	1220	4004
	69.53%	30.47%	100.00%

These responses correspond to part of question 26 in the survey. Important means that all the items have answers of at least “Important” or more (greater or equal to 3)

Source: AEGIS survey

KIE), the indicator of KIE includes firms that are innovative (2548 firms) and have education OR technological OR design skills (3961 firms). The total number of firms in the final sample of BROAD-KIE is 2522 firms.

Figure 6 shows that there are no major differences in the results for the three indicators. Results do not change if we use either a more strict indicator of KIE (SUPER-KIE) or a broader indicator of KIE (BROAD-KIE).

3.2.3 Differences exist in the reliance on innovation systems for KIE belonging to different countries and sectors

Finally, we have explored empirically whether there are differences in the type and importance of innovation systems for KIE that belong to different countries and to different sectors. As argued above in the conceptual discussion in Section 2.1.3, national and sectoral innovation systems differ across countries and across industries in various ways. Therefore, our expectation is that KIE ventures should show differences in the two-way interaction with the respective innovation systems.

We have performed this empirical analysis for the survey questions on external sources of knowledge that are knowledge intensive, on participation to agreements that are knowledge intensive and on the role of collaborations and networking as sources of competitive advantage. Results (not reported here for reason of space) indicate that there are differences in the relevance of external sources of knowledge, participation to knowledge-intensive agreements, and networking as source of comparative advantage for KIE that are active in different national systems and in different sectoral systems. These results confirm the rich

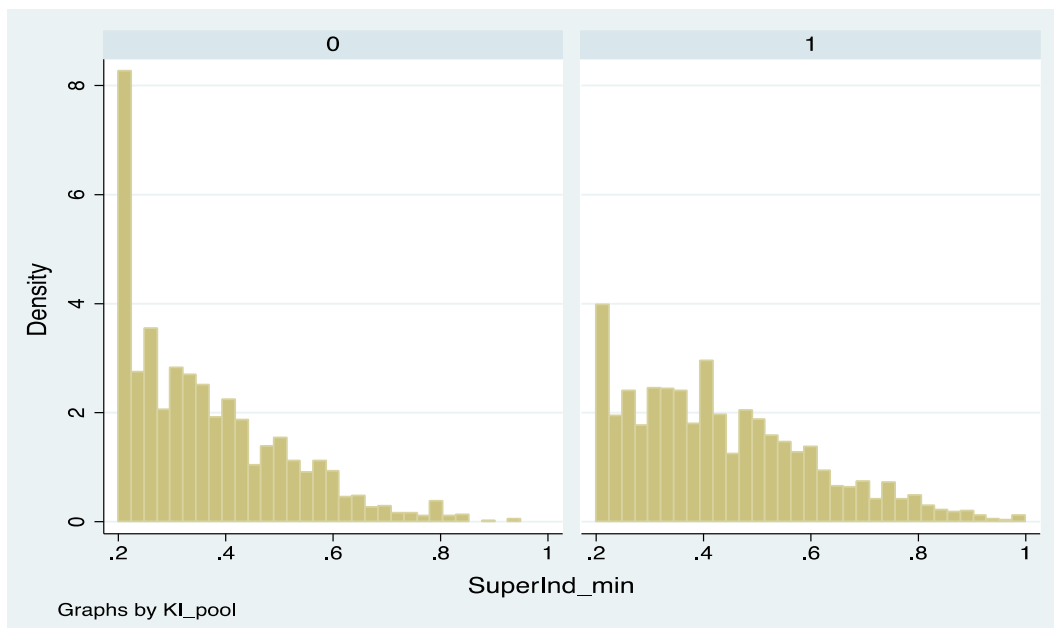


Fig. 4 A super synthetic indicator regarding the importance of external sources and of agreements that are knowledge-intensive. A single asterisk (*) indicator is based upon survey questions 24 (4, 5, 6, 11) and 26 (1, 2, 3). On the horizontal axis, the value of the

super synthetic indicator. On the vertical axis, the frequency of each value. Other new firms = 0; KIE = 1. The results of the rank-sum test indicate that the difference between KIE and other new firms is significant at 1%. Source: AEGIS Survey

empirical evidence that one may find in Malerba (2010) and in Malerba et al. (2016). Our interpretation of this result is that in order to develop competitive advantages, KIE ventures need to foster those types of links and tap into those external sources of knowledge that are specific to the national innovation system and sectoral

innovation system in which they operate. An exploration in the direction of creating a taxonomy of sectoral systems in which KIE takes place (in terms of knowledge sources, benefits from networking, types of formal agreements and methods of IP protection) has been developed by Fontana et al. (2016).

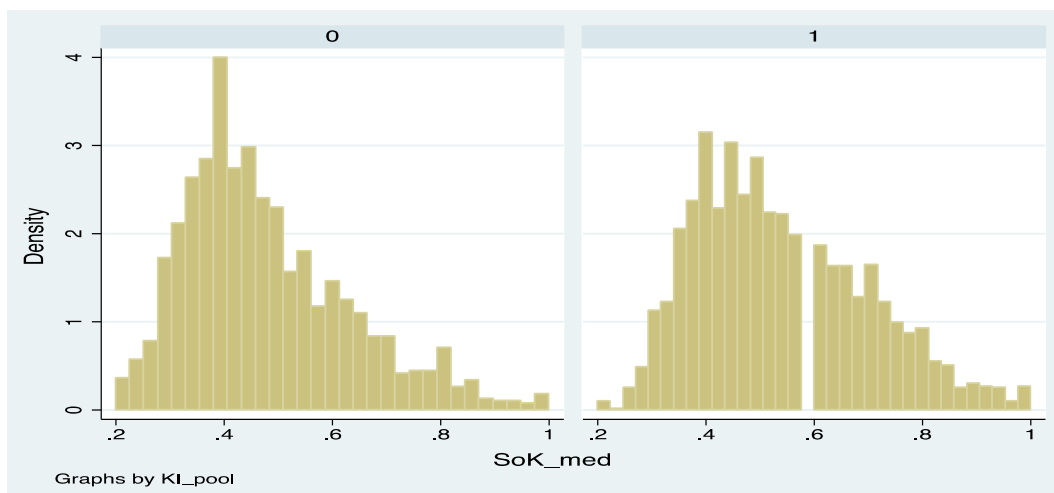
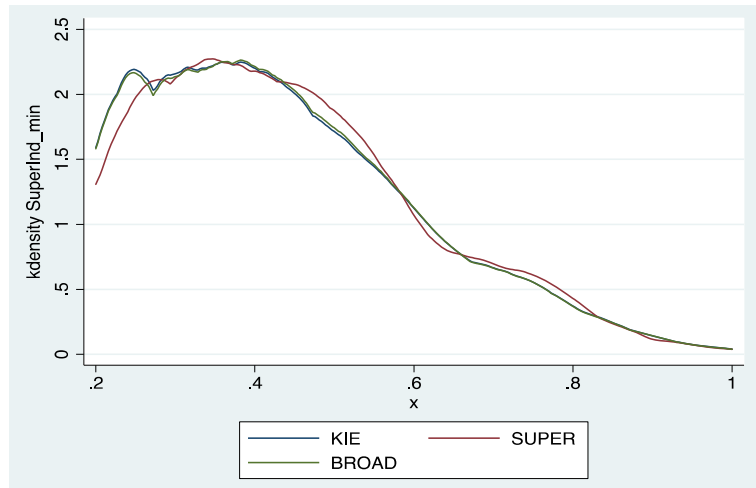


Fig. 5 An indicator regarding the importance of all sources of external knowledge to the firms. A single asterisk (*) indicator is based upon the survey question 24 (1, 2, 4, 5, 6, 9, 10, 11). On the horizontal axis, the value of the super synthetic indicator. On the

vertical axis is frequency of each value. Other new firms = 0; KIE = 1. The results of the rank-sum test indicate that the difference between KIE and other new firms is significant at 1%. Source: AEGIS Survey

Fig. 6 Comparison of the KIE, SUPER-KIE and BROAD-KIE indicators. A single asterisk (*) indicates the value of the super synthetic on the horizontal axis. On the vertical axis the frequency of the super synthetic indicator for KIE, SUPER-KIE, and BROAD-KIE. Source: AEGIS Survey



FINDING 3: Sectoral and national differences exist in the way KIE firms relates to innovation systems.

4 Conclusions and the way forward

In this article, we propose a novel conceptualization of knowledge-intensive innovative entrepreneurship, which extends and integrates theoretical building blocks from Schumpeterian entrepreneurship, evolutionary economics, and innovation systems. We define knowledge-intensive innovative entrepreneurial ventures as new learning organizations that use and transform existing knowledge and generate new knowledge in order to innovate within innovation systems. We thereby frame knowledge-intensive innovative entrepreneurship as a process of learning and problem-solving aiming to benefit from opportunity identification, creation, and exploitation, and which is conditioned by the linkages and networks related to innovation systems.

We also provide a highly stylized process model of knowledge-intensive innovative entrepreneurship, which consists of:

- a) origins of the KIE venture;
- b) the role of knowledge, opportunities and market conditions in affecting learning in the whole entrepreneurial process;
- c) the linkages between the management and development of the new venture and the innovation systems, with many two-way interactions to actors and institutions;

- d) the performance of the new firm in terms of innovation, profitability, and growth;
- e) the role of the entrepreneurial venture in selection and in the dynamics of market structure.

Following this conceptualization, we propose a measurable definition of knowledge-intensive innovative entrepreneurship in terms of new firms that are innovative, have significant knowledge intensity in their activity, are embedded in innovation systems and exploit innovative opportunities in diverse evolving sectors and contexts. On this basis, we examine a sample of 4004 new firms in Europe, and we show that knowledge-intensive innovative entrepreneurial firms are an empirically relevant phenomenon, are present across all European countries and across all sectors, benefit more from innovation systems than other new firms do and are characterized by national and sectoral differences in the way they relate to innovation systems. Along these lines, a more detailed and richer analysis of knowledge-intensive innovative entrepreneurship can be found in Malerba and McKelvey (2018b).

In conclusion, we propose that there are three promising trajectories for future research on knowledge-intensive innovative entrepreneurship.

One trajectory for this is to further develop theoretical analyses more systematically. Clearly, this article is only a first step, and more theoretical analyses are needed on the conceptual and theoretical foundations. One direction is to further link entrepreneurship more consistently to evolutionary theory and to the innovation system approach and thereby adopt a fully dynamic framework. Another direction is to focus upon the interactions between internal

learning by entrepreneurs and teams, the development of firm capabilities and the role external networks. In doing so, these theoretical and empirical analyses can be further developed with regards to the core dimensions of how and why knowledge-intensive innovative entrepreneurs are involved in the creation, diffusion, and use of knowledge; introduce new products and technologies; draw resources and ideas from their innovation system; and introduce change and dynamism into the economy.

A second trajectory is to concentrate on measurement issues and practical implications. There is a need for further development of reliable indicators and measurements that may link case studies, survey analyses, and indicators and that would allow extensive quantitative work at the firm, sector, and country levels, both over time and across countries and sectors. One direction is to focus upon the measurement of the effects of knowledge and innovation systems on the innovation, performance, and growth of knowledge-intensive innovative new ventures. Another direction is to further develop knowledge that is useful for practical implications, and so a lively dialogue with public policy-makers should be developed. We propose that policy recommendations should be centered on the support of knowledge and learning in young organizations and on the development of effective links and networks that help new venture to use and absorb the knowledge needed for their innovative activities.

A final trajectory for future research is to concentrate more systematically on empirical work, in relation to the theoretical and practical implications listed above. One direction is the identification of the main patterns of knowledge-intensive innovative entrepreneurship at the country, sectoral, and regional levels. Existing literature suggests that the context likely influences the probability of starting new ventures, but work should be done on the specifics of how different levels (country, regional, and sectoral) of the innovation system context affect the emergence and development of this type of entrepreneurship. More specific work can focus upon the two-way interactions and effects of innovation systems on knowledge-intensive innovative entrepreneurship, especially with regards to the creation of new innovative opportunities through market and technological opportunities. The co-evolution among the new venture, knowledge and innovation systems needs to be disentangled and examined in depth, also empirically.

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Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflicts of interest.

Appendix

Survey questions 24, 26, and 19

Sources of knowledge

Q24. Please evaluate the importance of the following sources of knowledge for exploring new business opportunities on a 5 point scale, were 1 is not important and 5 is extremely important.

Code	Description
1	Clients or customers
2	Suppliers
3	Competitors
4	Public research institutes
5	Universities
6	External commercial labs/R&D firms/technical institutes
7	In-house (know how, R&D laboratories in your firm)
8	Trade fairs, conferences and exhibitions
9	Scientific journals and other trade or technical publications
10	Participation in nationally funded research programmes
11	Participation in EU funded research programmes (Framework Programmes)

Agreements

Q26. Please indicate to what extent your company has participated in the following types of agreements? On a 5 point scale, were 1 is not at all and 5 is very often.

Code	Description
1	Strategic alliance
2	R&D agreement
3	Technical cooperation agreement
4	Licensing agreement
5	Subcontracting
6	Marketing/export promotion
7	Research contract-out
8	Other (please specify)

Success factors

Q19. Please, indicate the contribution of the following factors in creating and sustaining the competitive advantage of this company. On a 5 point scale, were 1 is no impact and 5 huge impact.

Code	Description
1	Capability to offer novel products/services
2	Capacity to adapt the products/services to the specific needs of different customers/market niches
3	Capability to offer expected products/services at low cost
4	R&D activities
5	Establishment of alliances/partnerships with other firms
6	Capability to offer high quality product/services at a premium price
7	Networking with scientific research organizations (universities, institutes, etc.)
8	Marketing and promotion activities

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