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Determinants of young firms' innovative performance: Empirical evidence from Europe

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ABSTRACT

This paper explores the effect of diverse firm resources and competences such as founders' human capital, workforce human capital and acquisition of knowledge from external sources on the innovation performance of young firms. The empirical analysis is based on data from a rich European survey that examined small firms between three and ten years of age across a wide industrial spectrum of knowledge-intensive services and manufacturing sectors in ten countries. The study provides evidence that aspects of both internal factors, especially those encapsulated in the human capital of founders such as prior exposure to R & D, team functional diversity and educational background, and external firm characteristics, such as technology collaborations and networking with universities are important in explaining young firms' innovative activity.

1. Introduction

New firms have been identified as engines for growth, innovation and wealth creation. While a good share of young, small firms are expected to be short lived, exiting the market within a few years from their formation (Headd, 2003; OECD, 2014), surviving young firms, and especially a relatively small share of them that manages to grow, account for a significant share of new job creation (Criscuolo et al., 2014; Coad et al., 2014). Young, small firms that innovate successfully increase their chances of survival, and are highlighted as the main drivers for introducing new technologies and products as well as increasing long-term productivity (Aghion and Howitt, 2005), stimulating, therefore, economic development and growth. The low share of young innovative firms within European industries, both manufacturing and services, have attracted greater attention on this group of firms among scholars and policy makers alike (Audretsch et al., 2014). However, little is known about their innovative activities compared with those of established firms (Criscuolo et al., 2012).

Despite the enormous growth in literature on the economics of technological change and innovation during the last 20 years (e.g. Fagerberg et al., 2005; Stoneman, 1995; Hall and Rosenberg, 2010) the progress in advancing our empirical understanding of the determinants of innovative activity of firms has been uneven. There is a need for more and better data on the range of the independent variables considered to affect the innovative performance of firms, i.e. industry-level variables, firm attributes, and most importantly, individual-level variables (Cohen, 2010). In comparison to our understanding of the influence of industry-level variables, our understanding of the role of firm-level variables on firm innovation is less developed, perhaps reflecting the challenge of collecting suitable data. In particular, the suggestion that individuals' characteristics may matter for industrial innovation even after controlling for firm effects could fruitfully expand the consideration of the determinants of industrial innovation beyond the features of industries and firms (Cohen, 2010).

In addition, the methodological difficulty involved in integrating existing theoretical perspectives −mainly from the fields of industrial organization and strategic management- has led researchers to analyse industry characteristics and firms' internal features separately and pay little attention to identifying the links or complementarities between different groups of factors (Vega-Jurado et al., 2008). Furthermore, the literature on the innovative activity of firms has traditionally focused on the role of firm characteristics such as size, cash flow, and diversification especially in large established enterprises (see Cohen, 2010 for an overview). Few empirical studies have broadened the scope to also consider managerial or human capital characteristics especially in conjunction with firm-level attributes and even fewer have employed such characteristics to examine the innovative activity of small young firms (Lynskey, 2004; Arvanitis and Stuchi, 2012).

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Against this backdrop, the present research departs in several aspects and aims to extend the empirical knowledge on the determinants of firms' innovative performance by offering primarily four new elements. First, it refers to young firms which are not necessarily start-ups but newly established firms that have survived the first round of shakeout in their lifecycles. Second, it focuses on one type of resource that is particularly relevant for the innovative performance of young firms, which is the human capital encapsulated in its founders (Davidsson and Honing, 2003; Eisenhardt, 2013). In doing so, it uses multiple measures that capture heterogeneous but also complementary aspects of the founders' knowledge and skills. Specifically, the study not only employs traditional (e.g. founders' generic and specific human capital) or more sophisticated human capital measures (e.g. functional and occupational team diversity), but most importantly attempts to capture certain combinations of functional expertise (e.g. coexistence of technical and marketing expertise) that may be particularly conducive to young firms' innovation. Third, it considers the joint effect exercised by factors external and internal to the young firm's innovative performance by complementing founder-specific characteristics with a wide spectrum of firm-specific and industry-specific factors. Forth, it uses a unique, particularly rich dataset, from a wide range of sectors (high-tech and low-tech manufacturing, knowledge-intensive business services) which pertains to 10 European countries with different institutional contexts so as to ensure a wide generalizability of our findings.

Young enterprises suffer from the liability of newness compared to older more established firms, a phenomenon which is partially due to skill gaps and information (Stinchcombe, 1965). Founders' characteristics, including their educational attainment, prior experience, age, and expertise, can constitute an important strategic asset for such firms because a) they develop firm strategies and coordinate the required resources to implement them, and b), as these firms are small, the capabilities of founders themselves serve disproportionately as critical resources to the creation of competitive advantage and early growth (Arvanitis and Stuchi, 2012; Miozzo and DiVito, 2016). In addition to the human capital of founders, firms require an adequate stock of qualified manpower to absorb new technological and market knowledge, as well as create and transfer new technological information that may foster innovative activity (Romijn and Albaladejo, 2002).

Moreover, although knowledge stock encapsulated in a young firm's human capital is crucial for innovative activity, young firms 'cannot rely only on internal capabilities; rather they establish formal and informal networks which allow them to obtain knowledge and expertise' (Malerba and Torrisi, 1992). Access to external information and knowledge are pivotal elements of a firm's absorptive capacity and hence for its innovative activities (Caloghirou et al., 2004). This paper empirically explores the determinants of product innovation and R & D intensity of young firms by defining a model that considers the joint effect exercised by factors that are both internal and external to the firm on its innovative performance. The analysis is supported by detailed survey information on a large sample of small companies 3–10 years old from diverse sectors pertaining to 10 European countries.

The rest of the paper proceeds as follows: Section 2 provides a brief literature review relating to the determinants of innovative activity of young firms and derives the main research hypotheses. Section 3 describes the dataset, the dependent and explanatory variables and the econometric framework. Section 4 presents the results of the empirical analysis. Finally, section 5 offers a discussion of the main findings along with some interesting policy implications.

2. Theoretical background and hypotheses

The resource-based view of the firm focuses on the importance of firm resources and the circumstances under which these can be a source of sustainable competitive advantage (Amit and Schoemaker, 1993; Barney, 1991). Following this perspective, the human capital of top management teams, encapsulated in their strategic decisions, composition, ability to learn and organizational skills, can have a significant influence on the performance of entrepreneurial firms. Most importantly, in such young and small firms, these teams often have more opportunities to shape the course of their firms compared to managers of large, well-established firms (Eisenhardt, 2013).

Human capital characteristics, including education, knowledge and skills, have long been considered as a critical resource for success in entrepreneurial firms (e.g. Unger et al., 2011 Maschke and zuKnyphausen-Aufseβ, 2012; Klotz et al., 2014). Due to the idiosyncratic, non-contractible nature of entrepreneurial judgment and the high costs of coordinating knowledge dispersed among different individuals, the distinctive capabilities of young firms are closely related to the knowledge and skills of their founders (Colombo and Grilli, 2005).

An important dimension of a young firm's human capital also includes the knowledge and skills brought into the firm by the workforce. Firms require an adequate stock of qualified manpower to sense new market and technology opportunities and to absorb new knowledge that might be turned into innovative products and services. The inability to recruit high quality staff (e.g. engineers, scientists) can be a serious impediment to a firm's subsequent growth and innovation (Romijn and Albaladejo, 2002).

It is essential for young small firms to overcome the liability of newness and smallness by using external sources of knowledge and networking activities in order to identify innovative opportunities and complement their limited resource base with additional resources and new knowledge. More specifically, knowledge emanating from universities can be very important to innovative firms, especially those that have not accumulated enough R & D assets through their own in-house efforts, such as newly-established companies (Lynskey, 2004). Furthermore, various types of collaboration appear to play a special role for new firms in developing or acquiring the resources and capabilities required for new product development, R & D and innovation (Haeussler et al., 2012; Yli-Renko et al., 2001).

2.1. Determinants of innovative performance

2.1.1. Founders' human capital

Most young companies have to deal with initial and ongoing resource limitations and need to make trade-offs. Furthermore, it is not clear whether an abundance of resources necessarily results in increased performance outcomes and success (Baker and Nelson, 2005). Therefore, as inadequate resources are common in young firms, it is important to gain better knowledge on what founders' characteristics are most important and thus should be prioritized when establishing new firms or forming entrepreneurial teams (Klotz et al., 2014). In addition, as founders can directly shape the initial structure and processes of their firms, their impact has long-lasting imprinting effects that continue to influence firm strategy, often long after most members of a founding team may have decided to exit the team or have been replaced (Beckman and Burton, 2008). Thus, increased understanding of the characteristics of founders or founding teams may help strategy researchers acquire "a fuller understanding of how firms evolve and what factors influence their ability to develop and maintain competitive advantages in their industries" (Klotz et al., 2014).

A distinction is often made in the literature between generic and specific dimensions of human capital (Becker, 1964). Generic human capital relates to the general knowledge acquired through formal education and professional experience. Specific human capital includes capabilities of individuals that can directly be applied to the

entrepreneurial practice in the newly established firm (Colombo and Grilli, 2005). The generic human capital of the founders of a new firm is usually approximated by their educational attainments and by the years of work experience before establishing the new firm or simply by the founders' age. The entrepreneurs' higher educational attainment can be expected to positively affect the innovative performance of new ventures. Through formal education, people acquire skills that may help them sense and seize innovative opportunities in the surrounding environment (Shane, 2000; Davidsson and Honing, 2003). In addition, the conceptualization of higher education as a source of skills and abilities with substantial value for entrepreneurial venturing appears to be relevant to contexts where continuous absorption of complex, specialized knowledge forms a basis for competitiveness and thus favours innovation (Backes-Geller and Werner, 2006; Unger et al., 2011).

Work experience supplements the entrepreneur's education, and is assumed, both in terms of depth and broadness across markets, to increase human capital (Becker, 1964; Cooper et al., 1994). Through work experience individuals acquire tacit knowledge and develop skills that assist the formulation of entrepreneurial strategy, the acquisition of resources, and the process of organizing. In this way experience increases human capital and at the same time decreases uncertainty about the value of opportunities. In addition, breadth in work experience, i.e. participation in more markets, provides access to diverse types of information required for opportunity identification. Therefore,

Hypothesis 1. Founders' generic human capital, i.e. educational attainment and professional experience, is positively related to innovation performance.

As to the specific component of human capital, founders' knowledge and capabilities are very much connected to what entrepreneurs have learned in the organization they were previously employed (Van de Ven et al., 1984). In particular, prior industry-specific experience may yield valuable knowledge regarding technologies, customer needs, strengths and weaknesses of competitors which can be profitably used in the new entrepreneurial setting (Reagans et al., 2005) and affect considerably the ability to detect innovative opportunities (Shane, 2000). Moreover, founders' endowments of social capital are more beneficial if the industry of the new firm and the one of the incubating organization are relevant, as the new firm can more directly exploit the personal relationships network developed by the founders in their previous occupations (Colombo and Grilli, 2005).

Innovative activities also imply mastering a certain level of specific know-how. Prior work experience in a scientific working environment appears to be conducive to innovation. The public science base can be found useful both in nurturing fruitful ideas that later on may be turned into important innovations in a specific business context and in maintaining networking relations with previous employers that can be of great value to the new firm (Romijn and Albaladejo, 2002). Founders with previous research experience − e.g. prior work experience in university or research institute − will impact the small firm's ability to grow and be innovative and may be in part substitute for the firm's lack of a track record. This is because this type of knowledge is required to appraise the potential of competing research streams, to develop R & D strategies, to organize and coordinate research projects and to orchestrate research resources towards the development of more valuable capabilities (Lynskey, 2004; Arvanitis and Stuchi, 2012).

The following hypothesis is therefore specified:

Hypothesis 2. Founders' specific human capital, i.e. prior industry and R & D experience, is positively related to innovation performance.

Heterogeneity in an entrepreneurial or top management team conveys alternative interpretations and broader perspectives, more experience, knowledge, skills, improved decision-making and leaves room for constructive conflict. Thus founders' heterogeneity may benefit the firm and organizational outcomes can be assumed (Klotz et al., 2014; Maschke and zuKnyphausen-Aufseβ, 2012). The heterogeneity of founders' human capital can be particularly important for new ventures, because as the venture evolves and develops, certain human capital attributes may be more essential than others and there is less room for duplication in the management's skill set (Hmieleski and Ensley, 2007). On the other hand, higher levels of team heterogeneity may be associated with higher costs of integration and coordination of team members and higher levels of affective conflict which is considered dysfunctional as it may have a negative influence on team cohesion (Ensley et al., 2002). Literature review suggests that no clear relationship between heterogeneity in founding teams and performance of young firms has emerged (Klotz et al., 2014; Zhou and Rosini, 2015). Although some studies have produced mixed results, in their majority they have found no significant relationship between team heterogeneity and performance outcomes (Klotz et al., 2014). Moreover, while some diversity of expertise and knowledge is considered as prerequisite of effective entrepreneurial teams, our knowledge of the appropriate nature of diversity is fragmentary at best (Ben-Hafaïedh and Cooney, 2017).

Team diversity is often measured by individual's demographic attributes since they are considered as a proxy for different attitudes, knowledge bases and cognitive models (Williams and O'Reilly, 1998; Harrison and Klein, 2007). Although studies focusing upon top management teams in larger organizations have generally used demographic measures, the functional background of team members can be understood as a more appropriate surrogate measure of the heterogeneity of the human capital required to venture development (Ucbasaran et al., 2003; Cantner et al., 2011). A firm which is young and small may have limited access to a broad array of resources, therefore, heterogeneity in team member's functional experience provides a diverse stock of knowledge, capabilities and expertise upon which it can draw when pursuing entrepreneurial activities. Entrepreneurial teams characterized by low functional heterogeneity may be associated with skill shortages or may experience a duplication of function skills within the team (Ucbasaran et al., 2003). Differing viewpoints, expertise and opinions may also trigger disagreements about team tasks, igniting cognitive or task-related conflict among team members. However, this cognitive conflict can be beneficial to new firm performance as it promotes the open and deliberate debates on ideas which may enable team members to find creative and effective solutions and reach improved strategic decisions (Ensley et al., 2002).

As a consequence, team heterogeneity may create synergistic effects based on the founders' specific cognitive and human capital resources and foster innovative performance. Empirical evidence indicates that top management team diversity in terms of educational, industry, functional and organizational background enhances firm performance by facilitating an innovation strategy that triggers product portfolio innovativeness (Talke et al., 2010).

Furthermore, empirical research also suggests that when both technical and commercial skills are combined within the founding team, young technology-based firms enjoy highest growth and innovative performance (Colombo and Grilli, 2005). Yet in the context of innovative firms technical skills are often prioritised at the expense of complementary managerial skills required to bring new products successfully in to the market (Siepel et al., 2017). On the other hand, the presence of diverse but yet complementary knowledge and expertise in the founding team, where technical knowledge is balanced with business expertise (e.g. general management, marketing and finance knowledge) can be vital for the successful exploitation of a technological innovation in the market place (West and Noel 2009; Ganotakis,

2012). In addition, as young firms may operate in a continuously changing environment, e.g. one where short life-cycle products are produced or frequent institutional reforms take place, the managerial challenge of such companies is even bigger. This practically means that the existence of technical skills with an understanding of the customers and the markets is essential so as to allow future innovative products to evolve according to customer needs). Therefore the coexistence of different but complementary types of functional experience can have a positive effect on innovative performance.

We additionally take into account whether team founders have a diversified professional background, as different professional backgrounds of individuals in an entrepreneurial team might increase the existing stock of knowledge and enhance the perception of opportunities. Thus, heterogeneity, in terms of occupational background and experience, implies that a new firm may have access to a wider range of practices, routines and norms, based on the collective distinct experiences of the team. Thereby, founders with different occupational backgrounds might be expected to have a higher probability to produce innovation. From the above, the following statement can be made:

Hypothesis 3a. Greater heterogeneous functional and occupational experience on the young firm's founders is expected to be positively associated with innovative performance.

The issue of gender and innovation has only been put on the research agenda during the last decade (e.g. Alsos et al., 2013; Foss and Henry, 2016) and studies that analyse the effect of gender diversity in top management teams on innovation are rather limited (Ruiz-Jimenez and Fuentes-Fuentes, 2016). Nevertheless, empirical research suggests that gender diversity is positive for firm innovation (e.g. Østergaard et al., 2011; EY, 2016) while female representation at top management teams is found to increase the range and number of available ideas and perspectives, promote creativity and improve board diligence, independence and informativeness leading, therefore, to increased innovation performance (Dezsö and Ross, 2012; Chen et al., 2015). In addition, a recent empirical study based on US venture capital data points out that investments in companies with at least one female founder meaningfully outperformed investments in all-male founding teams highlighting that women can be add value to technology entrepreneurial teams (Marion, 2016). On the other hand, empirical evidence indicates that female directors are less likely to undertake high risk and unpredictable innovation activities compared to their male counterparts (e.g. Croson and Gneezy, 2009; Dwyer et al., 2002) suggesting a negative effect of board gender diversity on firm innovation (Quintana-Garcia and Benavides-Velasco, 2016; Hirshleifer et al., 2012). Most importantly, published research also indicates that gendered understandings of innovation[1] lead policy makers and scholars to overlook women's engagement in innovative activities (Alsos et al., 2016). Therefore, there is need for further research work so as to better understand the role of gender in firm innovation. The following hypothesis is hence generated:

Hypothesis 3b. Founding teams with at least one female founder are less likely to engage in radical innovation activities compared to all-male teams.

Even though the relationship between team size and new venture performance has been at best equivocal (Jin et al., 2016), in recent years, there has been an increasing body of evidence that firms founded by entrepreneurial teams are more likely to enjoy increased growth performance compared to those formed by a lone entrepreneur (Ben-Hafaïedh and Cooney, 2017).

As young firms are often associated with increased complexity and uncertainty, larger entrepreneurial teams are better able to cope with augmented information processing requirements and interpret the internal and external environment from different angles thus enhancing the successful completion of complex projects (Watson et al., 1993; Ensley et al., 2000). In addition, companies founded by multiple individuals have a broader network of contacts with customers, suppliers, potential employees and investors (Kor and Mahoney, 2000), they are flexible and team-based and give authority to those employees with the best knowledge of a particular area (Ben-Hafaïedh and Cooney, 2017). Therefore, it can be expected that firms formed by entrepreneurial teams will enjoy higher levels of innovative performance compared to those created by solo entrepreneurs. In addition, large teams composed of three or more persons are supposed to be qualitatively different from two-member teams (which frequently are spousal teams exhibiting very specific demographic characteristics and dynamics) and thus more favourable to innovation. Therefore it can be stated that:

Hypothesis 4. Founding team size is positively related to young firms' innovative performance such that the larger the team the greater the innovative performance.

2.1.2. Firm-specific factors

Among the internal factors conducive to firms' innovative activities, the literature highlights the knowledge, skills and expertise brought into the firm by its workforce obtained through earlier experience, education, training etc. (Al-Laham et al., 2011). While there has been extensive research on the influence of founders' human capital on firm performance there has been relatively less research on the impact of workforce skills and resources on firm performance outcomes. In particular, although founder's influence on a firm's performance and growth prospects sometimes overshadows the role of workforce human capital, recent empirical evidence indicates that workforce skills are important contributors to long-run growth and survival regardless of the human capital encapsulated in founder(s) (Siepel et al., 2017). Thus, there is a need to further research the contribution of workforce human capital to firm performance.

Formal education is considered as a critical source of general human capital because it enables a person to acquire the necessary skills to identify business opportunities and upsurges the firm's absorptive capacity (Goedhuys et al., 2013). Yet, the evidence regarding the influence of a firm's workforce education on innovation is inconclusive. An empirical study of Finnish manufacturing firms indicates that technical skills are essential to profitable innovations (Leiponen, 2005), however, a study in Germany shows that the number of highly-skilled employees was not necessarily positively related to the firm's innovative ability (Schneider et al., 2010). A recent study in Ireland also points out that workforce's third-level education had no effect on the firm's propensity to innovate (McGuirk et al., 2015). On the other hand, Romijn and Albaladejo's (2002) study in small electronics and software firms in England designates that the education profile of workforce, especially university trained engineers, can contribute to the firms' innovation capability. In the same line of argument, Love and Mansury (2007) in a study of service firms in the US found out that highly qualified workforce increases both the likelihood and extent of innovation.

Firms can further enhance their human capital stock over time by offering internal and external staff training. Formal schooling alone is usually not adequate as a means of labour force training. Graduation from schooling does not signify the completion of the training process but more or less indicates the end of a more general and preparatory phase (Mincer, 1962). Better-trained employees are generally more efficient and develop new skills effectively, thus, contributing to firm-level innovation (McGuirck et al., 2015).

Taking into consideration that workforce's skills and knowledge

[1] Although women are indeed involved in innovation in various ways they often may not fit the conventional ideas about innovation in one way or another. This practically means that they may be engaged in innovative activities in industries not considered to be the main locus of innovation, or in geographical and social contexts where innovation is rarely looked upon. However, even if women are involved in 'mainstream' innovation associated to manufacturing or technology, they still appear to be defined as different or the 'other' (Alsos et al., 2016).

obtained through formal education and training can be important contributors to firms' innovative activity, we hypothesize that:

Hypothesis 5. Better qualified workforce in terms of formal education and training is expected to be positively related to innovative performance

In addition to internal firm resources, external knowledge, networking and cooperation are also important determinants for firm innovation. Universities, in particular, are a recognized repository of public knowledge (Nelson, 1986) which is part of the total stock of externally available knowledge accessible to young firms, especially those that have not accumulated enough R & D assets through their own internal efforts. Boundary-spanning knowledge production with academic inventors raises the innovative performance of SMEs (Dornbusch and Neuhausler, 2015). Empirical research suggests that cooperation with universities increases the probability of young firms to innovate (Lynskey, 2004; Koch and Strotmann, 2008). Moreover, a recent empirical study in a large sample of manufacturing and services European firms showed that the greatest innovation benefits from interacting with universities are achieved by small and young research-intensive companies (Bellucci and Pennacchio, 2014).

Collaborations assist firms to use efficient and cost effective ways to access additional or complementary resources that can speed up progress and advance set targets. Especially technology cooperation agreements have become a strategically important part of business decision-making in many industries in recent years in both high and low-tech sectors and appear to be key capabilities explaining the growth and innovative performance of young firms. They include all sorts of cooperative R & D or technology arrangement such as joint ventures, technology partnerships and informal networking arrangements. Collaborations are important for startups in order to gain the knowledge necessary to develop or acquire the capabilities needed for new product development, R & D and innovation (Haeussler et al., 2012; Stam et al., 2007). Thus,

Hypothesis 6. External knowledge sources such as universities and targeted collaborative agreements are expected to have a positive effect on young firms' innovative performance.

Last but not least, the availability of risk capital is usually regarded as an important determinant to the innovation process and the fuel for emerging start-up firms (Lynskey, 2004). Young firms usually lack sufficient capital to finance innovation. Hence, they have to raise resources from external sources to acquire equipment and employ people for innovative activities. Venture capital funds come to bridge this funding gap and can boost young firms' innovation in several ways. They can assist them to obtain additional financing, identify customers and suppliers, help recruit a management team and engage in strategic and operational planning (Katila and Shane, 2005). Thus, it is expected that venture capital funding will be positively related to young firms' innovative performance.

Firm characteristics such as size and export orientation are likely to affect the innovative performance of young enterprises. Larger firms are generally expected to devote more resources to innovation projects than smaller ones. Competing on international markets requires competitive advantages. Thus, the export orientation of a firm is expected to be positively correlated with its innovative activity (Roper and Love, 2002).

2.1.3. Industry-specific factors

Market environment plays a significant role in determining when young firms innovate. Markets with intensive competition necessitate greater flexibility and would in general force firms to become more innovative. In such markets, those young firms that are good at deriving high-value from a given amount of resources, i.e. they are capable of using and managing their resources creatively, they are likely to be innovative (Katila and Shane, 2005). However, as the experience and resources of young firms are restricted, intensive price competition may also discourage innovation (Arvanitis and Stuchi, 2012). For example, because of their limited resources, new ventures face a great difficulty in competing on price against established firms and, hence, there is often the need to become somehow unique and differentiated from other firms in the marketplace (Ensley et al., 2002). Furthermore, market dynamism, usually interpreted as technological change or environmental volatility in general (Dess and Beard, 1984), can be conducive to innovation (Jansen et al., 2006; Yang and Li, 2011). Dynamic environments make existing products and services obsolete very quickly and call for the rapid development of new ones (Sorensen and Stuart, 2000). To avoid the threat of obsolescence, firms are required to introduce exploratory innovations by creating novel products and services or meeting the needs of emerging markets (Jansen et al., 2006). At the same time, firms active in highly dynamic environments need to devote resources to R & D so as to actively acquire new technologies, scrutinise evolving customer preferences and target promising market segments (Yang and Li, 2011).

3. Methods

3.1. Data

The data used in the quantitative analysis originate in a large-scale survey[2] carried out during late Fall 2010 and early Spring 2011, which purported to identify the motives, characteristics and patterns in the creation and growth of knowledge intensive young firms in high-tech manufacturing, low-tech manufacturing and knowledge intensive business services (KIBS). In this study, our point of departure for the selection of sectors was to include firms originating from both high and low-tech industries as well as the service sector. While the notion of innovation and technological change has been primarily applied to high-tech industries, the low-tech sector, although quite old and even mature in some cases, is reasonably innovative. In addition, low-tech industries not only innovate for their own benefit but, by being active users of products and ideas of newer industries, they contribute to the growth of high-tech industries as well (Hirsch-Kreinsen, 2014). Furthermore, despite the growing awareness of innovative activity in the service sector, much of the contemporary research work still focuses on the manufacturing industries. Within the service industries, the growing sector of KIBS is more and more acknowledged to play a significant role in the innovation process (e.g. Koch and Stahlecker, 2006).

Following the above reasoning, our sample included diverse industrial activities both in high and low-tech sectors as well as in KIBS[3] (Table 1).

For the purpose of this study we delineated young firms as those founded between 2001 and 2007, i.e. firms that had been established for 10 years or less at the time of the survey and also had managed to exceed the critical three-year survival threshold. At the time of the survey, then, the sample firms were between 3 and 10 years old (average firm age 6.81 years) and were established in ten European countries: Croatia, Czech Republic, Denmark, France, Germany, Greece, Italy, Portugal, Sweden, and UK. The countries were selected strategically in order to include the largest four economies and some of the medium and small economies in Europe belonging into different socioeconomic configurations (e.g. Nordic countries, southern European

[2] The survey was conducted in the context of the EU-funded research project "Advancing Knowledge-Intensive Entrepreneurship and Innovation for Economic Growth and Social Well-Being in Europe" (AEGIS), 7th Framework Programme for Research and Technological Development, European Commission, (contract number: 225134)

[3] The largest category of firms included in KIBS, i.e. *'selected business services activities'* (N = 1597) comprises firms from the following sectors (based on NACE 1.1 classification), 74.1: legal, accounting, market research and business and management consultancy activities, 74.2: architectural and engineering activities, 74.3: technical testing and analysis, 74.4: advertising 75.5: labour recruitment activities, and selected activities from 74.8, such as photographic activities, translation etc.

Table 1
Sectoral distribution of firm sample.

Sectoral group[a]	# of firms	% of firms
High and medium-high tech manufacturing	**414**	**10%**
High-tech manufacturing		
Aerospace	1	0%
Pharmaceuticals	3	1%
Manufacture of medical, precision and optical instruments	31	7%
Radio-television and communication equipment	83	20%
Medium-high tech manufacturing		
Chemicals and chemical products	49	12%
Manufacture of electrical machinery	50	12%
Manufacture of machinery and equipment	197	48%
Low and medium-low tech manufacturing	**1171**	**30%**
Medium-low tech manufacturing		
Basic metals	49	4%
Fabricated metal products	231	20%
Low-tech manufacturing		
Food and beverage	285	24%
Textile and clothing	204	18%
Paper and printing	168	14%
Wood and furniture	234	20%
Knowledge intensive business services	**2377**	**60%**
Telecommunications	29	1%
Computer and related activities	529	22%
Research and experimental development	60	3%
Publishing services activities	162	7%
Selected business service activities	1597	67%
Total	**3962**	**100%**

countries, eastern European countries). In order to capture newly-established firms the survey instrument included a set of screening questions to detect a) firms that were just legal reincarnations of already existing firms, b) subsidiaries of existing companies, and c) mergers, acquisitions, or joint ventures of existing firms. Such firms were characterized as non-eligible for the survey.

The survey questionnaire was developed in English and translated into the nine local languages. Then, each questionnaire version was back translated to English by a third party to ensure that it was an equivalent translation. During the pilot survey phase the questionnaire was pretested in eligible firms in all nine countries. The pretest further assured that there were no translation effects on the respondents' interpretation of the translated questionnaire versions.

All firms were contacted by telephone and the questionnaire was completed online by the firm founder or a member of the founding team (in case the firm was founded by two or more people) under the tutelage of expert interviewees. The questionnaire covered questions on basic information about the firm, its strategy, innovation and business models and the market environment. It also included detailed questions about the founder characteristics at the time of firm formation. In firms with multiple founders, the founder contacted gave information on up to 4 team members. Given that the average team size is small (2.8 people, median: 2 persons) we can assume that the responder was generally able to provide accurate information on the rest of the team members. In addition, considering that less than 5% of the companies in the sample have more than four founders, we are able to describe the characteristics of the whole founding team. In those cases where a founder was not able to provide complete or accurate details on other founders, another member of the founding team was contacted to obtain missing information.

The primary data source for the survey population was the Amadeus Database.[4] An initial sample of 23,405 firms was randomly drawn from the entire population of firms available. Among them, 10,581 were judged as not eligible for the survey by the screening part of the questionnaire. The final sample of eligible firms to be contacted was 12,824. Out of them approximately 4000 accepted to respond to the questionnaire, thus resulting in an average response rate of 31.2%, which varied across countries from Croatia at high end (63.9%) to Sweden at the low (19.5%) (Table 2). The response rate is within the range common in the SME literature and when surveys heavily involve young and small firms (Newby et al., 2003).

Two issues commonly raised concerning survey methodology are non-response bias and common method bias. To evaluate non-response bias, we tested for statistically significant differences between final and early responses (Armstrong and Overton, 1997).

The final responses were the proxy for non-respondents and early responses the proxy for respondents.[5] The *t*-tests performed to identify differences between the two groups on key demographic variables such as firm size, firm age, and sales volume indicated no statistically significant results. This suggests that non response would not likely bias our findings.

In order to minimize potential common method bias effects we used both procedural and statistical approaches (Chang et al., 2010). The procedural methods related to the way the questionnaire was designed and administered,[6] while the statistical method was Harman's one-factor test (Harman, 1976). If common method bias were a serious problem, we would expect a single factor to account for most of the covariance when all variables were entered together. We performed factor analysis and no general factor was apparent in the unrotated factor structure. The procedures and Harman's one-factor test suggested that common method bias was not a serious problem in this study.

The vast majority of the firms in the sample are small (Table 3). Micro firms (< 10 employees) account for 72% of the total, including a 8.5% share of non-employers (no employees besides the owner). Firms with 10–49 employees (small) account for an additional 25% of the sample while the next size category (50–249 employees) (medium) accounted for just 3% of the total. This structure conforms to earlier findings whereby most firms remain 'micro', a relatively small portion grow to become 'small', a very small portion become 'medium', and only very few grow to 'large' (Landström and Johannisson, 2001).

[4] As our research frame targeted young firms, we were concerned whether by using Amadeus we would actually limit our analysis to only large or medium-sized firms (in terms of employment size). However, data drawn from Amadeus for 2009 pertaining to the 10 countries included in the survey showed that, in general, the representation of small firms was indeed satisfactory −36% of the total population of firms available in Amadeus for the ten selected countries were micro firms, i.e. firms with up to 10 employees. Such a population was by all means desirable and eligible for the needs of our research and that's why we finally decided to proceed with the use of the specific database as the primary population source for our survey design. The only exception was UK (17%), suggesting a potential underrepresentation of smaller UK firms in the Amadeus database, however, we should point out that ultimately the UK sample did not appear to behave differently than those of the other countries.

[5] We define as 'early' responders those firms that have participated in the survey within one month after the initial contact (N = 2527), as 'intermediate' responders those that were interviewed up to 2 months (N = 880) after initial telephone contact and as late responders those that have completed the questionnaire more than 2 months (N = 555) after initial contact.

[6] The procedural methods we used to decrease common method bias included: a. Reducing survey item ambiguity by pretesting the survey instrument in the ten countries to validate the questionnaire's readability, clarity and appropriateness to the sample frame. Feedback and suggested improvements were incorporated before the final questionnaire version was launched; b. Improving the scale items. The survey instrument was accompanied by a manual/guide for the interviewers which provided definitions on unfamiliar terms and specific examples to respondents when needed; c. Protecting the respondents' anonymity and reassuring them for confidentiality of the study so as to decrease their tendency to provide socially desirable answers; d. Separating scale items to reduce the possibility that the respondents guess the relationship between variables and then consciously match their responses to those relationships. We accomplished this by placing predictor and criterion variables far apart; e. Targeting the founder or one of the founders as respondents. When firms are small, (in our study the majority of companies are micro firms) single-respondent bias is less of a problem. By interviewing a firm founder we obtained the greatest information from that single responder.

Table 2
Country distribution of firms.

Country	Number of firms	Response rate
Czech Republic	199	63.9%
Croatia	196	38.0%
Denmark	329	30.4%
France	568	33.5%
Germany	548	23.9%
Greece	326	38.8%
Italy	573	50.9%
Portugal	327	50.5%
Sweden	326	19.5%
United Kingdom	570	22.7%
Total	3962	31.2%

Table 3
Age and size class distribution of sample firms.

Age class	No of firms	%	Size class	No of firms	%
3–5 years	1421	36	Micro	2865	72
6–8 years	1475	37	Small	986	25
9–10 years	1066	27	Medium sized	111	3
Total	3962	100	Total	3962	100

3.2. Measures

3.2.1. Dependent variables

In empirical studies of firm innovation it is common to proxy innovation by using either input or output indicators even though there are some well-articulated problems (Tether, 2003; Rogers, 2004). In view of the complexity of the innovation process characterized by several stages before market introduction, an approach relying on a single measure may leave out important relationships and produce results that are not robust (see e.g. Kleinknecht et al., 2002; Rogers, 1998). In this study we use two innovation indicators covering both the input and output side of the innovation process. As an input measure we utilize the share of R & D expenditure in firm turnover. This is a continuous variable provided by the responded for the last available year. Innovation output is measured as the degree of radicalness or novelty of product innovation. It refers to the last three year period and is also provided by the respondent. Initially, the interviewee was asked to designate whether the firm has introduced new or significantly improved goods or services during the past three years. Then, he/she also specified the degree of novelty of innovations by stating whether they are *new to the firm* (the minimum entry level for an innovation), *new to the market* (the firm is the first to introduce the innovation on its market) or *new to the world* (the firm is the first to introduce the innovation for all markets and industries, domestic and international). New to the world, therefore, suggests a qualitatively higher degree of novelty than new to the market. Thus, we constructed an ordinal variable that can take four possible values depending on the novelty of the product innovation developed and introduced into the market: 0 (=no innovation); 1 (=new to the firm); 2 (=new to the market); and 3 (=new to the world).

3.2.2. Independent variables

The explanatory variables can be subdivided in three groups. The first group encompasses indicators to describe the human capital of the entrepreneurs focusing both on generic and specific human capital as well as on the founding team's diversity. The second and third groups include variables corresponding to firm and industry-specific determinants of innovation respectively.

To examine the effect of founders' human capital on the innovative performance of young firms, we consider several key attributes as described below:

3.2.2.1. Educational attainment. For each founding team member we measure educational attainment using an ordinal variable taking the values: 1- elementary education; 2-secondary education; 3-Bachelor degree; 4-Postgraduate degree; 5-PhD degree. We average across team members to derive an overall measure of founders' education.

3.2.3. Professional experience

The years of work experience before establishing the new firm is proxied by the age of founders at the time of the firm's founding. Each founder's age is measured using four different age groups, namely below 30 years, 30–39, 40–49, and over 50 years of age. We average across age group of team members to obtain an overall measure of founders' age.

3.2.3.1. Prior industry specific experience. The average years of work experience of founders in the same industry of the firm in question before its foundation.

3.2.3.2. Prior working experience in university or research institute/lab. A binary variable taking the value of 1 when at least one of the founders had previously been exposed to academic research.

3.2.3.3. Team diversity in terms of expertise. For each founder we could distinguish between five main areas of expertise (i.e. technical/engineering; general management; product design; marketing; finance). More than one answer was possible for each individual. The *diversity* of experiences among team members is calculated with Blau's index (1977) ($1-\sum_{i=1}^{p} p_i^2$), where p_i is the fraction of team members with experience i. This index takes values between 0 and 1. A higher index indicates more mixed teams in terms of expertise.

Moreover, the synergistic gains that may arise from certain combinations of heterogeneous and complementary expertise within the entrepreneurial team were measured as three dummy variables. If *technical and general management expertise*, *technical and marketing expertise* or *technical and financial expertise* are present in the same team the variable takes the value of 1.

3.2.3.4. Team diversity in terms of occupational background. For each founder we measured his/her last occupation before founding the firm in question choosing among different options such as firm owner, firm employee, self-employed, university or research institute employee, government employee or unemployed. We measure occupational diversity within founding teams using Blau's index.

3.2.3.5. Female representation. While, in principal, women could account for any percentage of the founding team of a given firm, a) the share of firms with at least one woman in the founding team is substantially lower (30%) compared to the share of firms with all-male teams (70%), and b) the number of firms with more than one women among a founders is 9.0%. Therefore, we operationalized female representation using a dichotomous variable. It takes the value of 1 when at least one female is present in the founding team and the value of 0 when only male founders are present.

3.2.3.6. Team foundation. A binary variable which takes the value of 1 when the firm was founded by large teams of more than two persons and the value of 0 when formed by a lone entrepreneur or a two-member team.

Turning to firm-specific factors, we use a large set of variables to

describe characteristics of the firm.

Firm size is measured by the natural logarithm of full-time employees.

Sales in international markets is a continuous variable measuring the percentage of sales obtained in international markets in the last three years. It reflects the degree to which a firm pursues opportunities beyond domestic markets.

In order to capture workforce skills, we use two variables to measure the quality of the firm's human capital as expressed by educational qualifications and employee training. *University degree* is a continuous variable measuring the number of employees with a university degree as a percentage of full time employees. *Employee training* is a binary variable taking the value of 1 when the firm puts emphasis on systematic, internal and external, personnel training and 0 when no emphasis is put on training.

Venture capital funding is a binary variable taking the value of 1 when the firm has received venture capital funding and 0 when no such funding has been received.

External knowledge sources depicting the firm's absorptive capacity are gauged with two variables. N*etworking with universities* is a single Likert-type variable asking respondents to evaluate the importance of universities as knowledge sources for exploring new opportunities (1: not important; 5: extremely important). *Technology collaboration* is a multi-item Likert-type scale variable where respondents were asked to evaluate the extent of their firm's participation (1: not at all; 5: very often) in six different types of formal agreements, namely, strategic alliances, R & D agreements, technical cooperation agreements, licensing agreements, subcontracting and research contract-outs.

Finally, industry-specific factors relate to the type and strength of competition in the market as perceived by the company. The market environment is approximated by two dimensions: market dynamism and market competition again *Market dynamism* measures the extent to which the market environment changes rapidly due to technological advancement and the need to continuously introduce new products. *Market competition* is a single item measure of competitive intensity as reflected in price competition. To capture industry specific effects, we also include two dummies to identify firms from high and medium-high tech manufacturing and low and medium-low tech manufacturing, (we set KIBS, which is the largest sectoral group, as a reference group). Country dummies are also included in all calculations. The descriptive statistics of model variables are summarized in Table 4, while the correlation matrix of independent variables is provided in the Appendix A.

Table 4
Descriptive statistics.

Variable	Mean	S.D.	Min.	Max.
Product innovation	1.20	1.08	0.00	3.00
R & D intensity	12.46	19.36	0.00	100.00
Founder's characteristics				
Educational attainment	2.90	0.99	1.00	5.00
Professional experience	2.99	0.79	1.00	4.00
Prior industry experience	12.57	9.19	0.00	55.00
Prior experience in R & D	0.03	0.16	0.00	1.00
Team diversity in functional expertise	0.46	0.30	0.00	0.80
Team diversity in occupational background	0.14	0.23	0.00	0.75
Technical and marketing expertise	0.28	0.45	0.00	1.00
Technical and general management expertise	0.39	0.49	0.00	1.00
Technical and finance expertise	0.29	0.45	0.00	1.00
Gender	0.31	0.46	0.00	1.00
Team foundation	0.28	0.45	0.00	1.00
Firm specific characteristics				
International sales	14.45	26.49	0.00	100.00
Size	1.74	1.07	0.00	7.24
Employees with university degree	0.52	0.87	0.00	28.00
Employees training	0.42	0.49	0.00	1.00
Venture capital funding	0.02	0.14	0.00	1.00
Networking with universities	2.09	1.07	1.00	5.00
Formal technology collaborations	1.87	0.84	1.00	5.00
Industry specific variables				
Price competition	3.44	1.32	1.00	5.00
Market dynamism	3.24	1.01	1.00	5.00
Low & medium-low tech manufacturing	0.30	0.46	0.00	1.00
High & medium-high tech manufacturing	0.10	0.31	0.00	1.00
Valid No of observations 3340				

4. Empirical results

To capture different aspects of innovative activity we estimate two models for both innovation input and output. Since innovation output is proxied by a categorical ordinal variable, two ordered logit models (1 and 2) are employed to estimate the effects of the predictor variables on the probability to introduce product innovation of different degrees of radicalness. For innovation input (R & D intensity) we apply tobit regression models (3 and 4). Tobit regression refers to regression models in which the range of the dependent variable is censored in some way, meaning that values tend to be concentrated either at the higher or the lower limit of the data. The R & D intensity data are left censored with a clustering at zero, reflecting that a considerable number of firms in our sample do not report R & D expenditures. In models 2 and 4, for ordered logit and tobit regressions respectively, team diversity in functional expertise has been replaced by three variables representing certain combinations of functional expertise so as to examine their interactive effect on innovation performance.

Table 5 presents the results of the econometric analysis for both innovation output and innovation input models. The OLM results reported are the ordered log-odds (logit) regression coefficients. Such a coefficient assigned to an independent variable can be interpreted as the expected change in the dependent variable (in the ordered log-odds scale), for a one unit increase in the independent variable, while the other independent variables in the model are held constant. For example in model 1, if a firm were to increase its technology collaboration score by one point, its ordered log-odds of being in a more radical innovation category would increase by 0.346 while the other variables in the model are held constant. Tobit regression coefficients are interpreted in a similar manner to OLS regression coefficients. For example, in model 3, for a one unit increase in founders' prior R & D experience, there is an 6.855 unit increase in the predicted value of a firm's R & D intensity.

Agreeing with prior literature (Arvanitis and Stuchi, 2012; Lynskey, 2004; Marvel and Lumpkin, 2007; Kato et al., 2015), the education level of firm founders appears to be positively and significantly associated with both the R & D intensity and the radicalness of product innovation. On the contrary, the extend of prior work experience as approximated by the average age of the founding team members is found to be negatively related to R & D output and to have an insignificant effect on product innovation radicalness This practically means that the general human capital hypothesis is partially supported.

Of the specific human capital variables, prior industry working experience appears to have a negligible effect on product innovation radicalness but to be positively related to R & D intensity. Moreover, there is a statistically significant and positive association between founder previous R & D exposure and both innovation measures. Thus, the specific human capital hypothesis is partially confirmed by our analysis.

Regarding the variables reflecting founding team's heterogeneity, team diversity in terms of expertise appears to be significantly related to product innovation radicalness as well as R & D intensity. In addition, the coexistence of technical/engineering and marketing expertise seems to be positively associated with innovative performance (models 2 and 4), while the combinations of technical and general management or finance expertise appear to have a non-significant effect. This suggests that the blending of technical with marketing expertise in an entrepreneurial team matters the most for the innovation of young firms as it can enhance the ability of the firm to successfully recognise opportunities and the actual commercial value of a technologically advanced product/service. Our analysis also indicates founders' diverse occupational background is

Table 5
Determinants of innovation in young firms.

Variable	Radicalness of innovation		R & D intensity	
	ordered logit regression coefficients		tobit regression coefficients	
	model 1	model 2	model 3	model 4
Founder's characteristics				
Educational attainment	0.085**	0.098***	2.286***	2.471***
Professional experience	−0.068	−0.001	−1.764***	−1.493**
Prior industry experience	0.001	−0.049	0.090*	0.085*
Prior experience in R & D	0.499**	0.495**	6.855***	7.915***
Team diversity in functional expertise	0.550***		4.271***	
Technical and marketing expertise		0.294***		3.424***
Technical and managerial expertise		0.059		1.252
Technical and finance expertise		−0.097		−0.928
Team diversity in occupational background	0.062	0.090	3.640*	3.300*
Gender	−0.150**	−0.126*	−2.376**	−1.867**
Team	0.077	0.066	1.781*	1.686*
Firm specific characteristics				
International sales	0.008***	0.008***	0.109***	0.106***
Size	0.099***	0.115***	0.294	0.438
Employees with university degree	0.015***	0.015***	−0.035	−0.033
Employees training	0.117*	0.108*	0.059	−0.184
Venture capital funding	0.307	0.322	16.694***	16.218***
Networking with universities	0.100***	0.098***	3.212***	2.998***
Formal technology collaborations	0.346***	0.357***	6.256***	6.370***
Industry specific variables				
Price competition	−0.154***	−0.155***	−1.086***	−1.142***
Market dynamism	0.347***	0.354***	4.855***	4.782***
Low & medium-low tech	0.119	0.182**	−0.937	−0.896
High & medium-high tech	0.404***	0.405***	3.922***	3.799***
Constant			−28.800***	−29.651***
Log likelihood: −4174.735		−4396.944	−11084.27	−11533.289
LR(χ^2):580.92***		624.03***	811.89***	866.37***
McFadden's R^2 = 0.065		0.066	0.035	0.036
Number of obs.	3340	3340	3340	3340

Notes: Country dummies are included in all models. Regression coefficients in models 1 and 2 are ordered log-odds. Three, two and one asterisk correspond to $p < 0.01$, $p < 0.05$ and $p < 0.10$ respectively.

positively associated with R & D expenditure while there is no relationship with product innovation radicalness. Hence, hypothesis 3 is partially confirmed. On the whole, estimation results, as suggested by relative coefficients in Table 5, indicate that certain founder's characteristics have a significant influence on the innovative activities of young firms. Specifically, both product innovation and R & D expenditure are determined by previous exposure to R & D, team functional diversity and the education level of founders.

Finally, in line with our expectations, our findings indicate that entrepreneurial teams with at least one female founder are less likely to engage in radical innovation activities than all-male ones.[7] Thus, hypothesis 3b is supported. Most interestingly, our robustness check results (see Table 6 below) illustrate that the gender variable violates the proportional odds assumption, suggesting that there is no significant difference between teams with female representation and all-male teams in the proportion who innovate versus those who do not, but that there is a difference between those who don't innovate or innovate at the firm level and those who innovate at the market or the world level (i.e. radically innovate). This finding clearly demonstrates that although teams with women might be just as likely to be involved in innovation activities, they are less likely to engage in high risk activities such as radical innovation and intense R & D in comparison to all-male teams. In this vein, a recent study in Germany showed that women's entrepreneurship does not essentially fit with the dominant ideas on innovation as technological and product-based. However, the authors come to the conclusion that women are not less innovative than men, but that a combination of institutional factors and traditional role models contributes to self-selection into female-typed professions and working structures (Bijedić et al., 2016).

Large founding teams are positively associated with R & D intensity, yet they also appear to have a negligible influence on radical product innovation. Hence, hypothesis 4 is only partially supported. This finding suggests that although a larger team may have a more rich and diverse knowledge base that is crucial to enlarge the stock of information applied to the innovation process, perhaps it is not the team that matters (neither the size of it) to innovation radicalness because a team does not necessarily equate with the quality of human capital accumulated (Ucbasaran et al., 2003).

In unreported regressions we also examined whether founding team size and team diversity interacted with each other to affect the innovative performance of young firms, or whether founding team size interacted with the networking variables. In this way we aimed at testing for synergistic effects of team size with team diversity and networking capabilities. For example, one would expect that larger teams may also have increased functional or occupational diversity (and presumably more options for actions) or may have developed more advantageous networking ties than smaller teams and in consequence they are likely to have a significant positive interactive effect on innovation. We did not find any significant effects for either these types of interaction.

The results of the firm-specific and industry-specific variables are in line with expectations. Firms with more qualified employees (both in terms of formal education and training) appear to be more prone to product innovation, while their effect appears to be negligible on R & D

[7] In our base case analysis, we measure female representation using a dummy variable. Given that a small number of our sample firms have more than one woman among founders, we redefine female representation as the percentage of a firm's founding team accounted for by women, and perform again the OLM and tobit regression analyses. The results remain qualitatively unchanged further supporting our initial findings.

Table 6
GOLM estimates explaining the impact of diverse factors on product innovation radicalness.

Variable	(1) Firms with no innovation contrasted with more innovative firms	(2) Firms with no or "new to the firm" innovation compared to firms with more radical innovation	(3) Firms with no or less radical innovation compared to firms with "new to the world" innovation
Founder's characteristics			
Educational attainment	0.080**	0.080**	0.080**
Professional experience	−0.072	−0.072	−0.072
Prior industry experience	0.001	0.001	0.001
Prior experience in R & D	0.457**	0.457**	0.457**
Team diversity in functional expertise	0.562***	0.562***	0.562***
Team diversity in occupational background	0.058	0.058	0.058
Gender	−0.062	−0.256***	−0.086
Team	−0.067	−0.067	−0.067
Firm specific characteristics			
International sales	0.004**	0.008***	0.013***
Size	0.176***	0.049	0.001
Employees with university degree	0.017***	0.017***	0.017***
Employees training	0.226***	0.081	−0.062
Venture capital funding	0.291	0.291	0.291
Networking with universities	0.104***	0.104***	0.104***
Formal technology collaborations	0.346***	0.346***	0.346***
Industry specific variables			
Price competition	−0.155***	−0.155***	−0.155***
Market dynamism	0.346***	0.346***	0.346***
Low & medium-low tech	0.114	0.114	0.114
High & medium-high tech	0.250**	0.342***	0.635***
Constant	−1.629***	−2.146***	−4.018***
	Log likelihood:-4143.85 LR(X^2):642.68*** McFadden's R^2 = 0.072		
Number of obs.	3340		

Notes: Country dummies are included in all models. Three, two and one asterisk correspond to $p < 0.01$, $p < 0.05$ and $p < 0.10$ respectively.

expenses. Hence, hypothesis 5 is partially confirmed by our estimates. Firms with technology collaborations and networking activities with universities tend to have a higher propensity for innovation activity than firms without such characteristics. Most interestingly, the effect of technology collaborations on innovative performance as estimated by the respective coefficients is found to be much stronger than that of university networking. Thus, hypothesis 6 is clearly confirmed. Furthermore, export orientation is significantly related to both innovation performance measures, whereas, availability of venture capital appears to positively associated only with the R & D expenses of young firms.

Price competition appears to be negatively related to innovation output while market dynamism is found to stimulate both product innovation radicalness and R & D expenditures. Last but not least, high and medium-high tech manufacturing appear to have greater innovation activity compared to KIBS, while there is no significant difference between the innovation performance of low and medium-low manufacturing firms and KIBS firms in the sample. Country dummies were also included in the OLM and tobit models, however, they had no statistically significant effect on a firm's innovative performance suggesting that the country context does not matter in our analysis.

4.1. Robustness check for the OLM estimates

In this section, the robustness of the OLM estimates is tested. This check relates to parallel lines assumption that underlines the estimation procedures for OLM, i.e. the hypothesis that coefficients of the independent variables do not vary across each category of the dependent variable. This view neglects the possible heterogeneous effects of some explaining factors (Long and Freese, 2006).

The OLM is equivalent to j-1 binary regressions, where j refers to the categories of the dependent variable. In order to test whether the parallel lines assumption is violated by our OLM models we use a Wald test by Brant (1990) to determine whether the coefficients of some independent variables differ across the binary equations by whether the outcome y is equal to j or not. The Brant test statistics, not shown here for parsimony reasons, indicate that the assumption is violated for the following variables: gender, sales in international markets, firm size, employee training and high & medium-tech manufacturing.

Then, we provide a robustness check for our basic ordered logit model (model 1 in Table 5)[8] providing additional estimates with a generalized ordered logit model (GOLM) which allows for different estimates of coefficients across categories of the dependent variable for the independent variables that violate the parallel lines assumption (Williams, 2006).

Table 6 presents the estimates for each of the binary models. The first column contrasts firms with dependent variable equal to 0, i.e. firms with no innovation, with firms having dependent variable more than 0. The second column contrasts firms with dependent variable equal to 0 or 1, with firms having dependent variable equal to 2 or 3. The last column contrasts firms with dependent variable less than 3, with firms that have a dependent variable equal to 3, i.e. firms that exhibit the highest degree of novelty in product innovation. Hence, positive coefficients indicate that higher values on the explanatory variable make it more likely that responding firm belongs to a higher category of Y (dependent variable) than the current one, whilst

[8] A robustness test was also run for model 2 of Table 5, all results obtained by OLM were confirmed.

negative coefficients suggest that higher values on the explanatory variable increase the likelihood of being in the current or lower category.

All of the results obtained by the OLM seem to be confirmed. In particular, effects of the constrained variables can be interpreted much the same as they were previously (see Table 6). Focusing on the variables that violate the parallel lines assumption, the differences from before are more or less a matter of degree. For example, the coefficients for sales in international markets are consistently positive but increase across cut-off points. This finding suggests as a firm's export activity increases it is more likely that the firm's innovation output will be of higher novelty.

In the same vein, the control variable for firms belonging to high-tech industries is positive and coefficients increase across columns. This practically means that high-tech firms are more likely to launch innovations of higher degree compared to firms active in other sectors, with the greatest differences being that high-tech firms are more likely to introduce new-to-market or new-to-world product innovations. The coefficients of employees training are positive in the first two columns and become negative in the last one (and insignificant in columns 2 and 3) implying that workforce training becomes less significant to innovation output as the degree of innovation output increases.

5. Discussion and implications

The purpose of this study has been to investigate the impact of diverse firm resources and competences such as founders' human capital, workforce human capital and acquisition of knowledge from external sources, namely, universities and technology collaborations, on the innovation performance of young firms. In doing so, we also take into account other determinants of innovation suggested by the literature such as characteristics of a firm's market environment. The empirical analysis was based on rich survey data that examined young firms between 3 and 10 years of age, across a wide industrial spectrum of industrial activities in ten European countries. The current study provides evidence that aspects of both internal and external firm factors are critical for explaining innovative activity.

Regarding founder's general human capital, our results indicate that educational attainment is positively related to both measures of innovation activity, while general professional experience exerts a significant negative effect on innovation input. This finding suggests that founders' educational level might be more important to young firms' innovation compared to their general professional experience since higher education attainment can be a source of substantial value especially in contexts where the continuous absorption of complex specialized knowledge is required as a basis of competitive advantage and innovative activity. As far as founder's specific human capital is concerned, our results highlight the vitality of previous R & D experience to both radical innovation and R & D intensity while they also suggest that industry experience has a positive influence only on R & D expenditure. This finding implies that innovative activities primarily necessitate a certain level of innovation-specific know-how in order to manage effectively available research resources, to devise R & D strategies and to organize and coordinate relative projects (Arvanitis and Stuchi, 2012; Lynskey, 2004). Finally, prior industry experience appears to impact positively R & D intensity in contrast with general professional experience which exerts a significantly negative effect on innovation input. The fact that work experience in the same sector of the new firm has a positive impact on innovation highlights the key role of industry-specific capabilities of founders in providing young firms with a competitive advantage.

We also checked for the existence of synergistic effects arising from the presence of complementary skills within a founding team. Our findings highlight that increased diversity in terms of functional expertise, and especially the coexistence of specific types of functional expertise i.e. technological and marketing skills, enhances the ability of firms to pursue radical innovation and at the same time boosts R & D intensity. This finding suggests that given the human and financial constraints that many young firms face in achieving the final marketing stage (Gimmon and Levie, 2010), policy makers should try to encourage, for example, single technical entrepreneurs or technically oriented founding teams to embrace business and management training or they should create mechanisms through which adequate support could be offered to such firms. In addition, policy makers that are responsible for allocating financial aid to firms which undertake projects of high innovative potential should not only look for technical efficiency in a team but they should also ensure the existence of adequate managerial and business skills that will enhance firm performance

In terms of gender effect, our results point out that although teams with female representation might be just as likely to engage in innovative activities they are less likely to engage in high risk taking, i.e. develop and launch radically new products or services, compared to all-male founding teams. Our findings might designate that a specific gender composition of the founding team (i.e. more diverse) may make the team better in performing one task (incremental innovation) than the other (radical innovation), since the two tasks may necessitate different skills for their effective performance. Moreover, these findings may be related to the way we measure innovation focusing on product innovation and R & D expenditure, i.e. measures which are primarily related to high-tech industries and technology. In our sample founding teams with female representation are also present in low-tech and services sector, hence, it can be argued that the innovation measures employed may not fully capture equally important innovation types such as process-oriented and organizational innovation, "soft'; innovations etc. that are taking place at the grassroots level in organizations and are also very important for value creation in low-tech or service sectors (Alsos et al., 2013).

Our findings partially support the hypothesis that the knowledge and skills brought into the firm by the workforce positively contribute to a young firm's innovative activity. This may be related to the fact that at this stage of the firm's life cycle, the human capital of founders is much more decisive in shaping its innovative capability. Moreover, resources devoted to training may not always translate in higher innovative performance, as its purpose would also be to improve managerial or secretarial functions. What's more, the value of employees' individual education level as a competitive advantage may be diminishing in the years to come, as the proportion of people with higher education levels constantly increases, especially across developed countries (OECD, 2015). Therefore, our findings suggest that beyond supporting education and training programmes, policy makers should also consider incorporating initiatives that encourage the development of an 'innovative human capital' by developing more 'soft' skills for innovation "intertwined with methods to incentivize and inspire managers to innovate and encourage innovation within the firm'(McGuirk et al., 2015).

Last but not least, our findings support the hypothesis that the ability of a young firm to interact and access external knowledge sources has a significant effect on its innovative activity. In particular, estimation results indicate that formal technology collaborations have a stronger effect on innovation than networking with universities and research institutes suggesting that collaborations with commercial/market related partners may be more important than those with academic partners. The initial relationships that new companies have are important it the very early phase but their importance tends to diminish over time and there is a need to develop collaborative relationships with a broad range of actors such as users/customers, suppliers and

competitors (Laage-Hellman and McKelvey, 2016) Therefore, innovation-supporting policy efforts should facilitate young ventures build collaborative interfirm relationships by providing information linkages about the key variables impacting young ventures in their industry or contacts to facilitate finding new collaboration partners. For instance, a main place for policy may be in supporting a diverse range of intermediary actors such as industry associations or chambers of commerce that can facilitate access to market partners. Programmes facilitating networking with universities may help young companies complement and expand their limited technological resource and knowledge bases. However, there is a need of more targeted policy instruments to differentiate the types of alliances according to the specific needs of young firms. For instance, for small ventures in science based industries, university networking may be critical for strengthening credibility and reputation while interfirm collaborations are critical for product development and commercialization which are conducive to innovative activity.

An interesting point from our analysis is that human capital resources, especially those of founders, and external knowledge linkages have a positive parallel role in the innovative performance of young firms. This indicates the necessity of the development of internal firm capabilities and human capital in conjunction with networking capabilities and the use of external sources of knowledge in order to create value-added innovative activities. Therefore, efforts for establishing interaction mechanisms and openness to knowledge sharing should complement internal efforts for a balanced and more efficient approach to innovation.

Of course our research comes with limitations. First, human capital should be task related and directly related to knowledge and skills as previous studies have shown that the effect sizes increase when human capital is measured at a higher level of specificity (Unger at al., 2011). A data limitation in our study is that we do not have measures capturing the specific educational background of the founders (e.g. technical/engineering education, business education), in this way we cannot assess whether there are synergistic effects arising from complementary formal educational backgrounds in the founding team, or from diverse educational backgrounds and functional expertise (e.g. coexistence of technical education and managerial or commercial experience). Moreover, it would also be interesting to gauge synergistic effects among founders and personnel, either in terms of formal education or expertise. Using more detailed measures for founders and employees' human capital would allow us to better understand the magnitude of their effect on the innovative performance of young firms.

Our study as it is cross-sectional in nature gives only a snapshot of the impact of several factors on the innovation performance of young firms. Future research based on panel data could complement such an analysis by applying structural modeling in a more dynamic setting, thus allowing for safer causal conclusions. Other innovation determinants may also be important, however, in the context of one and only study it would be impossible to identify and measure all of them. In any case, further research could certainly identify and test additional processes/variables that would more broadly capture both firm-specific and external drivers of innovation for young firms. For instance, innovation performance is largely based on strategic decisions that are determined simultaneously and are jointly depended on third factors, which we do not know or do not observe and for which we have very few environmental variables that can serve as relevant and valid instruments (Mairesse and Mohnen, 2010).

A future research direction would be to measure changes in the human capital over time, especially in terms of founding teams as members enter or exit the team. In this way we will be able to determine whether the specific and general human capital of founders can have long-lasting effect on the innovation of young firms or can be reversed by changing the composition of the founding team over time. In addition, taking into consideration that founders' human capital is considered as a strategic asset for the young firm it would be interesting to examine whether the overall impact of founders' human and social capital diminishes as the venture ages. For example, in the face of rapidly changing environments, any specific knowledge is likely to decrease as time goes by. In addition some skills and knowledge will even have to be unlearned, while other human capital aspects may become more relevant e.g. the construct of adaptive expertise in contrast to the stock of experience. Such a learning process approach would perhaps call for additional empirical methods such as case-study research which could complement econometric models and provide rich insights and information which often are the source for more rigorous approaches (Cohen, 2010).

In our models we have included sector dummy variables to account for industry specific effects. However, future research should look into more detail into the impact of certain factors and especially human capital on the innovation performance of young firms in diverse industries. For example, a high degree of required specialization in high-tech industries may lead to higher effects of specific functional expertise in high compared to low-tech industries.

A better understanding of the relationship between gender and innovation calls for future research toward two different directions. First, understanding women's innovative activity necessitates a critical investigation of the normative frames and structural factors underpinning theory development and/or empirical investigations (Alsos et al., 2013). Second, there are also methodological challenges that need to be overcome related to the gendered concept of innovation itself. Therefore, we need to look for more gender neutral concepts when we empirically examine innovation with survey or interview questions and at the same time develop methods to examine what people do, rather than how they talk about it. A fruitful future research direction should then focus on research that would both involve the actors and their interaction (Alsos et al., 2013 Nählinger et al., 2012).

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Appendix A. Pearson correlation matrix of independent variables and VIF values

Variable	VIF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1 ind_exper.	1.360	1.000																					
2 edu_attain	1.300	**−0.072**	1.000																				
3 prof_exper.	1.330	**0.482**	*0.022*	1.000																			
4 R & D_exp	1.090	−0.017	**0.199**	0.012	1.000																		
5funct_div	1.050	−0.022	0.024	−0.017	−0.008	1.000																	
6 occup_div	1.220	**−0.130**	**−0.048**	**−0.071**	**0.096**	**0.151**	1.000																
7 tech_mark	1.630	−0.040	0.028	−0,037	0.008	n.a.	0.098	1.000															
8 tech_gen.man	1.660	0.023	*0.020*	−0,010	−0.005	n.a.	0.140	**0.503**	1.000														
9 tech_fin	1.780	−0.011	0.003	−0.003	−0.017	n.a	**0.148**	**0.558**	**0.557**	1.000													
10 gender	1.120	**−0.148**	**−0.073**	**−0.051**	*−0.048*	**0.069**	**0.258**	0.001	−0.018	0.036	1.000												
11 team_size	1.170	**−0.047**	**0.047**	**−0.050**	**0.075**	**0.110**	**0.295**	**0.113**	**0.165**	**0.163**	**0.085**	1.000											
12 intern_sales	1.090	*0.023*	**0.094**	**0.070**	**0.073**	0.003	0.019	0.007	0.012	−0.007	*−0.047*	*0.042*	1.000										
13firm_size	1.510	0.035	**−0.070**	0.005	−0.003	**0.063**	**0.067**	*0.041*	**0.086**	**0.070**	**−0.061**	**0.194**	**0.157**	1.000									
14uni_empl	1.390	−0.023	**0.193**	0.014	**0.053**	0.008	0.011	0.008	0.007	0.011	**−0.065**	**0.139**	**0.121**	**0.439**	1.000								
15 training	1.080	0.010	*0.050*	0.001	0.025	0.005	−0.009	*0.026*	**0.050**	0.000	0.025	0.043	−0.020	**0.129**	**0.102**	1.000							
16 vent_cap	1.040	−0.009	**0.088**	0.012	**0.141**	0.026	**0.004**	0.020	−0.003	−0.002	*−0.033*	*0.052*	**0.058**	**0.078**	**0.104**	**−0.020**	1.000						
17tech_collab	1.320	−0.019	**0.148**	−0.031	**0.119**	**0.059**	*0.032*	**0.089**	**0.078**	*0.030*	**−0.053**	**0.104**	**0.144**	**0.107**	**0.139**	**0.156**	**0.058**	1.000					
18know_scien	1.270	*0.028*	*0.024*	*0.030*	**0.112**	0.010	**0.079**	0.019	0.047	*0.030*	0.018	**0.062**	**0.062**	**0.115**	**0.067**	**0.165**	−0.001	**0.405**	1.000				
19price_comp	1.090	0.026	**−0.171**	−0.012	**−0.054**	*0.024*	−0.021	**0.045**	0.040	0.012	*0.024*	*−0.039*	**0.064**	**−0.063**	**−0.044**	*0.040*	**0.018**	*−0.033*	−0.051	1.000			
20mark_dyn	1.140	**−0.048**	*−0.043*	**−0.096**	0.012	*0.033*	*0.021*	**0.060**	**0.040**	−0.012	−0.012	0.012	**0.084**	**0.047**	**0.042**	**0.148**	0.196	**0.189**	**0.025**	**0.196**	1.000		
21 low-tech	1.400	0.001	**−0.353**	−0.034	**−0.075**	**0.065**	**0.056**	*0.027*	*0.032*	**0.040**	**0.085**	**−0.056**	0.192	**0.006**	**−0.131**	**−0.071**	0.024	**−0.150**	−0.024	**0.089**	−0.034	1.000	
22 high-tech	1.150	**0.074**	*−0.030*	**0.075**	0.031	−0.005	0.016	*0.031*	**0.056**	*0.029*	**−0.085**	**0.046**	**0.121**	**0.149**	0.004	0.028	0.038	**0.049**	**0.028**	−0.014	**0.045**	**−0.227**	1.000

Notes: values in bold: correlation is significant at 0.01 level; values in italics: correlation is significant at 0.05 level. n.a.: not applicable.

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