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REGULAR ARTICLE

Exploring the sources of knowledge diversity in founding teams and its impact on new firms' innovation

Nicoletta Corrocher[1] · **Camilla Lenzi**[2]

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Abstract

This paper studies the relationship between founding team knowledge diversity and firms' innovative performance. We posit that knowledge diversity entails two dimensions: a team dimension and an individual dimension. In particular, we argue that founding team knowledge diversity can derive both from the presence of founders with different knowledge backgrounds, and from the presence of similar jack-of-all-trades (JOTs). We suggest that knowledge diversity is positively associated with innovation, especially when diversity comes from founders with different knowledge backgrounds, instead of coming from many JOTs. Furthermore, it matters more for firms whose knowledge base is oriented towards technical and scientific applications, as opposed to firms with a generalist, business-oriented knowledge base. We provide support to these propositions relying on a study of 1,800 newly established firms in Europe.

Keywords Knowledge diversity · Founding teams · Innovation · New firms

JEL Codes L26 · O31 · J24

✉ Nicoletta Corrocher
nicoletta.corrocher@unibocconi.it

Camilla Lenzi
camilla.lenzi@polimi.it

[1] Department of Management and Technology and ICRIOS, Bocconi University, Via Roentgen 1, 20136 Milan, Italy

[2] Department of Architecture, Built Environment and Construction Engineering, Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133 Milan, Italy

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1 Introduction

The impact of founding team diversity on firm innovation is an important issue for both scholars and the business community. The combination of individual characteristics, values and experiences determines whether a team is able to generate ideas and turn them into successful innovations (Lazear, 1999; Talke et al., 2010; Cooper et al., 2014; Hoogendoorn et al., 2013s et al., 2013; Kristinsson et al., 2016; Jin et al., 2017). The evidence on the relationship between team diversity and innovation is not entirely conclusive (Huber et al., 2014; Kristinsson et al., 2016; Lazar et al., 2020), both because different authors use different concepts of diversity, and because there are many, relatively unexplored factors mediating the relationship between team diversity and innovation.

Analysing the role of diversity for a team's innovative performance is particularly relevant in the context of new ventures, since most of new firms are founded by teams (Carland & Carland, 2012; Klotz et al., 2014; Åstebro & Serrano, 2015; Kristinsson et al., 2016; Jin et al., 2017). So far, the existing literature has looked either at the diversity of skills/knowledge of individual entrepreneurs (or solo founders), i.e. jack-of-all-trades (Lazear, 2005; henceforth JOTs), or at the diversity of founding team members in terms of age, gender, education, previous work/industry experience, personality and behavioural preferences (Coad & Timmermans, 2014; Visintin & Pittino, 2014; Kristinsson et al., 2016; Lazar et al., 2020). Here we consider both perspectives, since the endowment of individuals in terms of competences and knowledge background is a multi-faceted and composite concept. Individuals are themselves endowed with composite sets of skills and abilities (Lazear, 2005; Coad & Timmermans, 2014), so that, in principle, one might observe a high level of knowledge diversity even in a solo founder new venture. We therefore claim that diversity in founding teams may derive from two possible sources. On the one hand, it may originate from the combination of many individuals, each with a multifaceted human capital in terms of knowledge and skills (Lazear, 1999) and in terms of previous work experience and professional background (Shane & Stuart, 2002; Hsu, 2007). On the other hand, it may result from the combination of different individuals, each with a different knowledge background that is possibly complementary to the one of other team members. Since the impact of founding team diversity on innovation can be different according to the source of this diversity, studying this relationship requires an in depth analysis of the origins of diversity and of the conditions under which the interactions among diverse founders can lead to higher or lower levels of innovation (Huber et al., 2014; Kristinsson et al., 2016; Lazar et al., 2020).

This paper contributes to the literature in two ways. First, it provides a reappraisal of the relationship between founding team diversity and firms' innovative activity, based on a specific operationalization of team diversity that combines both the team-level diversity and the individual-level diversity. The numerous works that have investigated the diversity of founders within multi-founder teams so far have measured team members' diversity by assigning a single skill or knowledge field to each member. Instead, we argue that each member of a team is endowed with diverse knowledge, since she possesses a set of different skills that form her knowledge background and expertise, problem-solving attitudes and creativity (Huang et al., 2012;

Tidd, 2014; Kristinsson et al., 2016; Jin et al., 2017). Within multi-founder teams we therefore distinguish two types diversity: diversity due to the existence of many JOTs – i.e. "…*individuals who need not excel in any one skill but are competent in many*" (Lazear, 2005, p. 649) - and diversity due to the existence of different (possibly complementary) founders, who may excel in one specific knowledge field. We posit that it is the second type of diversity that is more conducive to a new venture's degree of innovation.

Second, we explore contextual moderators of the relationship between founding team diversity and innovation (Klotz et al., 2014; Kristinsson et al., 2016) and claim that the impact of diversity on innovation varies depending on the knowledge base embedded in the team. Innovation is a complex, non-routinary and uncertain task, especially in the context of new ventures that have a technical knowledge base that often results in technical innovations (Garnsey, 1995), whose commercialisation requires the transformation of scientific and technical knowledge into marketable products and services, which entails both scientific and market uncertainties. The greater the degree of complexity, the greater the uncertainty of the innovation process and the greater the diversity of the knowledge and expertise needed to improve decision-making and implementation as to achieve innovation (Kristinsson et al., 2016). Therefore, having a diverse founding team is particularly important for innovations when the new venture has a scientific and technical knowledge base (Zahra et al., 2007; Visintin & Pittino, 2014).

Empirically, we rely on a dataset collected within the framework of the AEGIS survey (Protogerou et al., 2017). This survey was administered in 2010 to more than 1,800 founders of new multi-founder firms established in the period 2001–2007 in the European Union, in the manufacturing and service sectors. In addition to firm-specific and market-specific information (e.g. dynamic capabilities and innovative strategies), and standard information on founders' demographic characteristics, educational background, and previous work experience, the survey collected detailed information on each founder's bundle of skills and abilities (i.e. knowledge background). We therefore exploit this information to measure diversity in a way that acknowledges the composite knowledge background of each founder, and the combination of those knowledge backgrounds within the founding team.

The remainder of the paper is organized as follows. Section 2 discusses the relevant literature and formulates the hypotheses to be tested. Section 3 describes the data and section 4 discusses the methodology, the empirical model, and the variables used. Section 5 presents the results of the empirical analysis and section 6 concludes by discussing some managerial implications.

2 Founders' knowledge diversity and firms' innovation: testable hypotheses

The potential impact of diversity on firm performance has receive a great deal of attention in the literature (for a review see Klotz et al., 2014; Jin et al., 2017; Lazar et al., 2020). The empirical research has examined different types of

teams such as top management teams (e.g. Bantel & Jackson, 1989; Amason et al., 2006; Hambrick, 2007; Talke et al., 2010; Boone & Hendriks, 2009), cross-functional teams within organizations (e.g. Mohrman et al., 1995; Finegold & Wagner, 1998; Mathieu et al., 2000; Cronin and Weingart, 2007), employee teams more generally (Hambrick et al.,1998; Ely et al., 2012; Youtie et al., 2012), and founding teams (e.g. Ucbasaran et al., 2003; Huang et al., 2012; Kaiser & Muller, 2013; Visintin & Pittino, 2014; Kristinsson et al., 2016; Protogerou et al., 2017). Overall, the literature has not found conclusive evidence on the relationship between team diversity and firm performance, even when measuring performance in terms of innovation (Huber et al., 2014; Zhan et al., 2015; Kristinsson et al., 2016; Protogerou et al., 2017). On the one hand, a narrow knowledge stock of a founding team may restrain the potential for knowledge creation because there is not much team members can learn from each other. On the other hand, members of a founding team with too diverse knowledge backgrounds might find it difficult to learn from each other because of a missing common frame and shared mental models of reference to build on (Mathieu et al., 2000). The same inconclusiveness characterizes the growing number of contributions investigating the role of team diversity in driving innovation (Van der Vegt & Janssen, 2003; Talke et al., 2010; Østergaard et al., 2011; Huang et al., 2012; Shin et al., 2012; Tidd, 2014; Zhan et al., 2015; Kristinsson et al., 2016). There are two prominent reasons for this inconclusiveness: first, different authors use different concepts of diversity; second, there are many, relatively unexplored factors mediating the relationship between team diversity and innovation (Shin et al., 2012). In what follows, we will tackle these two issues and develop our research hypotheses concerning the specific relationship between founding team diversity and innovation. Since we are considering relatively new ventures, it is reasonable to argue that the founding team is in many cases responsible for the innovation strategy of the firm and has therefore an important impact on the innovative performance (Huang et al., 2012; Kristinsson et al., 2016; Protogerou et al., 2017).

2.1. **Where does diversity come from?**In all the existing empirical works, diversity has been conceptualized and measured primarily by looking at the composition of teams in terms of demographic traits (gender, age, ethnicity); personality and behavioural preferences; education, field of expertise and industry experience (Ruef, 2000; Huang et al., 2012; Visintin & Pittino, 2014; Kristinsson et al., 2016; Lazar et al., 2020).

In diverse founding teams, each member can bring valuable human, social, and financial capital to the entrepreneurial project (Bowers et al., 2000; Colombo & Grilli, 2005; Eesley et al., 2013; Huang et al., 2012; Shin et al., 2012; Criaco et al., 2014; Protogerou et al., 2017). In particular, each member encompasses a varied set of knowledge, skills, and competencies, and the diversity arises from the combination of different individuals with multiple skills and various types of knowledge (Criaco et al., 2014; Klotz et al., 2014). In the case of new ventures, the professional background, previous experience and achievements of the founders are also crucial factors to develop a business network, to share

resources and capabilities with other firms in the sector, to promote cooperation and long-lasting relationships with suppliers and customers (Huang et al., 2012). The existence of diverse individuals within a founding team can contribute to the development of innovations, because it determines a wider range of opportunities and ideas that can be identified and explored, a larger set of capabilities to mobilise the resources for the concrete implementation of the ideas, and a more variegated external business network (Talke et al., 2010; Visintin & Pittino, 2014; Kristinsson et al., 2016; Protogerou et al., 2017). However, it is not just the mere presence of diverse members that is conducive to innovativeness in new firms, but it is the generative interaction among them, internally, and with business partners, externally, that make innovation more likely and more successful (Tidd, 2014). As often underlined in the literature, if the "mental models" are too distinct, team members may not share the same venture goals and may hold diverse views on how their business should develop in the future. These differences create a lack of common ground, resulting in problems of information exchange and interpretation, and eventually lead to further misunderstandings and distrust (Cronin and Weingart, 2007).

Traditionally, the literature has looked at (and operationalized) knowledge diversity in new ventures in two somewhat separate ways. On the one hand, starting from the works of Lazear (1999 and 2005), some scholars have investigated solo-founder firms, examining the extent to which individuals who possess a different set of skills – the so-called JOTs – are more successful entrepreneurs than individuals with a specialised background (Åstebro & Thompson, 2011; Huber et al., 2014). On the other hand, other scholars have studied the performance of multi-founder teams, assigning one single characteristic to each member of the team and looking at the result of the combinations of different characteristics (e.g. Colombo & Grilli, 2005; Kaiser & Muller, 2013; Østergaard et al., 2011; Huang et al., 2012; Zhan et al., 2015; Kristinsson et al., 2016; Jin et al., 2017).

In this paper, we focus on multi-founder teams and argue that team knowledge diversity encompasses two dimensions, therefore originating from two different sources. First, there is an individual dimension, which refers to the intrinsic knowledge diversity of each member of the founding team. Each individual is inherently endowed with a set of varied knowledge and skills that determine her cognitive structure, her perspective on opportunity/idea scouting and problem solving activities, her strategic choices on innovation fields (Talke et al., 2010). These characteristics have also important implications for the development of external business networks that are a crucial component of the success of new ventures (Ruef et al., 2003; Huang et al., 2012). The combination of different skills and knowledge in different (business and technical) areas is a distinctive entrepreneurial trait among individuals who are JOTs rather than specialists (Lazear, 1999 and 2005).

Second, there is a team dimension, which refers to the combination of individuals with different (possibly complementary) knowledge background and capabilities within a group. This dimension is the lens through which founding teams are usually analysed in the literature. However, when looking at team

diversity, scholars typically assign one single skill/ability or knowledge expertise to each member of the team, neglecting the intrinsic diversity of the knowledge background and capabilities of the individuals.

Starting from the existing literature on team diversity, here we argue that diversity in founding teams can be the outcome of either many JOTs or different (possibly, complementary) founders. If diversity is due to the presence of many JOTs, duplication of skills and knowledge may occur, with reduced benefits for the overall team innovative performance. Knowledge exchanges among actors with a similar knowledge background may lose value over time and opportunities of knowledge recombination, which lead to the development of innovation, may fade away (Ancona & Caldwell, 1992; Beckman, 2006; Beckman & Burton, 2008). Indeed, having many JOTs in a team does not mean having a highly diverse team, but rather having many individuals that are similar in their diversity.

On the contrary, when diversity is the result of the interaction of different team members with different (possibly, complementary) knowledge and skills, more advantages will take place. In line with most of the traditional literature on team diversity, we argue that, in this case diverse teams enable accessing to different types of competencies, skills, and knowledge embedded in human capital, and this variety of knowledge and competencies is likely to promote creative processes, by providing team members with different ideas, perspectives, and values (Shin et al., 2012). The interaction of multiple diverse founders involves a number of generative mechanisms that promote innovation, such as the development of complementary capabilities, the emergence of contrasting cognitive and creative styles, and the possibility to draw upon different external networks (Talke et al., 2010; Huang et al., 2012, Tidd, 2014). Since innovation requires a number of different activities that aim at integrating the technological domain and the business strategy, the combination of the scientific conception with the economic conception is a crucial component for the success of innovative activities (Visintin & Pittino, 2014).

Scholars have underlined that when diversity is the result of the combination of team members with different knowledge background, it benefits the development of innovations, since it is associated with increased levels of information, cognitive diversity and greater variance in decision-making alternatives and overall more constructive task conflicts that facilitate strategic decisions to focus on innovation fields (Dahlin et al., 2005; Talke et al., 2010; Kristinsson, 2016). Even if some scholars have underlined the risks of having too diverse knowledge backgrounds and experiences in a team, which might generate problems of information exchange, communication and eventually undermine the performance of the projects/businesses (Mathieu et al., 2000; Cronin and Weingart, 2007), most of the existing works agree that on the fact that teams that are more diverse tend to be more creative and to engage in explorative strategic behaviour as compared with teams with shared common experiences (Mohrman et al., 1995; Finegold and Wagner, 1998; Beckman, 2006). Knowledge diversity helps the recognition of opportunities, the identification of potential barriers to innovation and a more fruitful discussion of all the differ-

ent aspects related to the implementation of innovations – technology, market and firm-specific factors (Talke et al., 2010). Therefore, knowledge diversity can result in high-quality innovative decisions based on critical and investigative interaction processes (Van der Vegt & Janssen, 2003). Finally, teams made of individuals with different knowledge background can respond better to the challenges of commercialising technologies and turning ideas into successful innovations (Visintin & Pittino, 2014; Kristinsson et al., 2016).

On the basis of the above discussed literature, we aim at testing the following baseline hypothesis in the specific context of knowledge-intensive new ventures:

HP 1 – Founding team knowledge diversity is positively associated with innovation when diversity derives from the coexistence of diverse founders rather than from the presence of many JOTs.

2.1 Knowledge diversity, knowledge orientation and innovation

Many scholars have acknowledged that the relationship between founding team diversity and innovation is not straightforward, because research on the founding teams of new ventures frequently overlooks the impact of moderating factors (Talke et al., 2010; Klotz et al., 2014; Kristinsson et al., 2016; Jin et al., 2017). The interactions among founding team members and the role of diversity in driving innovation can vary along several dimensions (Lazear, 1999; Talke et al., 2010: Mäs et al., 2013; Cooper et al., 2014; Visintin & Pittino, 2014; Kristinsson et al., 2016; Lazar et al., 2020). Some scholars argue that the effect of team diversity on firm performance varies among sectors and may be mediated by the characteristics of the industrial environment – dynamic vs. stable, knowledge-intensive vs. non knowledge-intensive (Ensley & Hmieleski, 2005; Østergaard et al., 2011; Kaiser & Müller, 2013; Protogerou et al., 2017). Moreover, the relationship between team diversity and firm performance in the specific case of new ventures can be mediated by the distinctive characteristics of the team in terms of size and background (Visintin & Pittino, 2014), and in terms of team specific processes such as cohesion, interdependence of task and goals, the logic of decision-making and the strategic choice to focus on innovation fields (Ensley et al., 2006; Van der Vegt & Janssen 2003; Talke et al., 2010; Kristinsson et al., 2016). Additionally, diversity can have a varying impact on innovation according to the degree of uncertainty and complexity of the tasks to be performed and to the knowledge background of the group of founders. As a matter of fact, innovation is a complex activity due to the coexistence of both market and technological uncertainties in the implementation process. This is particularly true for innovations that originate from a scientific and technical orientation of the founding team (Visintin and Pittino, 2014). Importantly, Bowers et al. (2000) show that diverse teams achieve higher levels of performance as opposed to homogeneous teams in the case of very complex, uncertain and difficult tasks. Similarly, Page (2007) underlines that the extent to

which firms may harness the benefits of diversity for performance depends on the specificities of the problem to be addressed: if the problem is easy, diversity might not be key to success.

We extend this perspective by arguing that it is especially in science- and technology-based ventures that the combination of different knowledge backgrounds can enhance the likelihood of innovation. The joint presence of different members with an economic conception of science (Kassicieh et al., 2002; Ndonzauau et al., 2002) facilitates the transformation of scientific knowledge into commercial applications and is therefore particularly important when the knowledge base of the team has a scientific orientation. Scholars have indeed argued that the success of the technology-based ventures' (e.g. university spin-offs or new technology-based firms - NBTF) depends on the full exploitation of technology as a core resource, which needs the integration of scientific and business capabilities (Colombo & Grilli, 2005; Visintin & Pittino, 2014; Protogerou et al., 2017). Therefore, when the combination of different members' knowledge background results in a science and technology oriented firm knowledge base (e.g. engineering and technical knowledge), which is typically distant from market applications, the complementarity with other types of knowledge that is more oriented towards the development of marketing and business strategy becomes crucial to bring new ideas to the market, i.e. to innovate. In such contexts, knowledge diversity can be especially relevant for innovation. Therefore, we aim at adding an additional insight to the understanding of the relationship between knowledge diversity and innovation and formulate the following second hypothesis:

HP 2 - Knowledge diversity has a stronger positive association with innovation, the more the firm knowledge base has a technical and scientific orientation.

3 Data collection: the survey

The empirical investigation is based on original data and the results of the AEGIS survey, developed within the 7th Framework Program project AEGIS (see also Protogerou et al. 2017). The telephone survey was administered in 2010–2011 in native languages and aimed at understanding the determinants of knowledge-intensive entrepreneurship in different sectors and different European countries. It asked about firm-specific dimensions (e.g. business environment, strategies, knowledge sources) and firm founder-specific characteristics (e.g. age, working experience, knowledge background). The survey was conducted in ten European countries (Denmark, Croatia, Sweden, France, Italy, Netherlands, UK, Germany, Greece, Portugal), and included high-, medium-, and low-tech manufacturing sectors, and knowledge–intensive and traditional services. The interviewees were the firms' founders[1].

[1] The methodology involved an initial telephone call to each targeted company in order to identify the right respondent who had detailed information on the founders of the company. We do not have information on possible changes in the team structure during the period 2001–2007 and we acknowledge that there might

The firms selected for interviews were drawn from Amadeus database (Bureau Van Dijk) were new firms established in the period 2001–2007. The selection procedure excluded firms whose legal status had changed, and firms that had undergone other legal transformations, such as name changes, which are recorded as new firms in the business registries. The average response rate was 31.2% (with some differences across countries). More information on the survey methodology, selection of the database to identify target firms, target sample size, and the implementation strategy and method is available at: http://cordis.europa.eu/project/rcn/91092_en.html.

Across countries, 55% are manufacturing firms and 45% service firms. The country distribution of firms is as follows: 5.99% Croatia; 4.87% Czech Republic; 3.82% Denmark; 15.22 France; 13.31 Germany; 9.26% Greece; 15.85 Italy; 8.98 Portugal; 10.16 Sweden, and 12.54 UK. Manufacturing firms tend to predominate in Croatia, Czech Republic, Greece, Italy and Portugal (over 60% in these countries), while service firms prevail in Denmark, France, Germany, Sweden and the UK (over 50% in these countries). In relation to educational attainment, 57% of founders have a university degree and 35% have a post-graduate degree. The share of founders with higher education varies considerably across countries and sectors. In terms of work experience, 41% of the founders have previous work experience in the same industry, but only 15% have previous entrepreneurial experience (i.e. had founded a previous firm). Only 6% of founders were in their first job, which tends to match with the fact that 68% of founders are older than 39 years. The professional experience of founders is 12 years on average. Table 1 details the previous working experience of founders.

The founders' characteristics also show that, in 94% of firms, the founding team is made of up to four founders, and just 6% of founding teams include five to nine founders. Additionally, 37% of firms have just one founder. Table 2 shows the distribution of the number of founders per country. These descriptive statistics, then, support our choice of focusing only on firms with at least two and up to four founders, leaving us with more than 1800 firms.

be processes of entry and exit of members from the team that might affect innovation. This is a limitation of our study, but we believe that the main results of our analysis still provide important evidence in relation to the role of the founding team diversity.

Table 1 Previous working experience of founders

Last occupation	*% of founders*
Employee of a firm in the same industry	41
Employee of a firm in a different industry	19
Self-employed	11
Owner of a firm still in existence	10
None of the above - this is his/her first job	6
Owner of a firm that has ceased operations	5
Unemployed	3
University or research institute employee	2
Government employee	2
Total	100

Table 2 Number of founders by country (%)[a]

Number of founders	*HR*	*CZ*	*DK*	*FR*	*DE*	*EL*	*IT*	*PT*	*SE*	*UK*	*TOT*
1	52	35	56	45	37	27	21	24	56	35	*37*
2	33	41	26	34	30	36	35	49	26	40	*35*
3	11	12	10	13	13	19	23	12	12	11	*14*
4	3	8	5	4	10	11	12	9	3	8	*8*
5	1	3	2	2	6	3	4	4	2	2	*3*
6	1	1	1	1	1	2	2	1	0	2	*1*
7	0	0	0	1	1	1	1	0	0	1	*1*
8	0	0	0	1	1	0	1	1	0	0	*0*
9	1	1	1	1	1	0	1	1	1	1	*1*

[a]HR = Croatia; CZ=Czech Republic; DK=Denmark; FR=France; DE=Germany; EL=Greece; IT=Italy; PT=Portugal; SE=Sweden; UK=United Kingdom

To obtain information on founders' knowledge base and competencies, a question in the survey asked firm founders to indicate their areas of expertise out of five (not mutually exclusive) fields: technical and engineering knowledge, general management, product design, marketing, and finance. Each founder could select up to five fields of expertise. On average, technical and engineering knowledge accounts for 32% of competences in the founding team, followed by general management knowledge (27%). This percentage is 16% for finance, 14% for marketing, and 11% for product design knowledge.

Additionally, Table 3 reports the distribution of firms in the sample according to the share of JOTs in the founding team, i.e. founders that indicated expertise in all the five fields. Interestingly, the presence of a JOT in the founding team is more an exception rather than a rule. Less than 8% of firms have at least one JOT in the team and about 2% of firms have a team composed of JOTs only. Therefore, in most of the cases, the presence of a JOT in the founding team can coexist with the presence of other founders, which may have a different if not specialised knowledge background.

Table 3 Distribution of firms by share of JOT in the founding team (%)

Share of JOTs	*Frequence*	*Percentage*	*Cumulated percentage*
0	1,714	92.10	92.10
0.25	12	0.64	92.75
0.33	26	1.40	94.14
0.5	58	3.12	97.26
0.67	2	0.11	97.37
0.75	2	0.11	97.47
1	47	2.53	100.00

4 Drivers of innovation and estimation framework

4.1 The dependent variable

For the purposes of the present analysis, innovation is measured as a dummy variable that takes the value 1 if the firm introduced new or significantly improved goods or services in the three years prior to the survey. The majority of the surveyed firms (64%) appear to have introduced new or significantly improved goods or services during the previous three years; 36% did not report any kind of innovative activity related to specific products or services.

Innovation is estimated by means of a logit model as follows:

$\Pr(\text{INNOVATION}_j=1)=F(\text{diversity}_j; X_j; Z_j; \varepsilon_i)$ (Eq. 1).

where INNOVATION in each firm *j* depends on knowledge diversity, and a series of team- and firm- level variables (respectively, X_j and Z_j) plus a standard error term ε_i.

We acknowledge that, to some extent, this measure may overstate firms' innovative activities since an innovation that is new to the firm is not necessarily new to the market or to the world. However, here we understand innovation in relative terms, i.e. as a novelty with respect to the past rather than with respect to some best practice realized elsewhere. This is especially relevant in this study where the sample includes both more and less advanced countries, and more technology-intensive and less technology-intensive sectors.[2]

The selection of the set of firm- and founding team-specific variables is in line with the existing literature (Talke et al. 2010; Steffens et al. 2012; Klotz et al. 2014; Visintin and Pittino 2014; Lazar et al. 2020), as detailed in the subsequent sections. We explore, in particular, the role of team knowledge diversity and orientation, controlling for firm size, age, human capital, nature of competition, and strategy on the one hand, and founding team size, and average work experience of team members on the other. Given our interest in the different components of the team knowledge diversity we leave out from the analysis the "solo founders". In particular, since we aim at analysing jointly two types of knowledge diversity – the team-level knowledge diversity and the individual-level knowledge diversity – our unit of investigation (the team) needs to have at least 2 founders, otherwise we would have only one type of diversity (individual-based). Furthermore, we limit the analysis to the firms with 2 to 4 founders, because, even if a negligible percentage of firms has more than four founders, we only have information on four founders.

The description of the variables, their summary statistics and correlations are available in the appendix (Tables A1, A2 and A3).

[2] Results, available upon request, are robust to alternative coding of the dependent variable on four levels, namely: 0 if the firm did not introduce any innovation in the past three years, 1 if the innovation was new to the firm, 2 if the innovation was new to the market and 3 if the innovation was new to the world. Therefore, to ease the interpretation of the results, especially of interaction terms, we preferred to maintain the dichotomous coding of the innovation variable and to group the three different categories of innovation, thus emphasising the contrast between the innovation case (whatever type and degree of radicalness of innovation) and the no innovation case.

4.2 Measuring knowledge diversity

The AEGIS survey provides interesting information on the knowledge background of founders relevant to the operation of the new venture, which can be considered the main knowledge and competencies available to the firm at its foundation. Each of the founders was asked to indicate his/her main knowledge background out of five not mutually exclusive fields: technical and engineering knowledge, general management knowledge, product design knowledge, marketing knowledge, and finance knowledge.

Several indicators have been proposed in the literature to capture diversity in a given population, such as entropy-based measures of diversity, coefficient of variation, or standard deviation (for a review see Coad and Timmermans 2014). Given the categorical nature of the variable of interest (i.e., the knowledge background), we measure diversity as the opposite of the traditional Hirschman-Herfindahl index of concentration. It is computed as 1 minus the sum of the squared share of knowledge in field k, s_k, in the firm total knowledge base as summarized below:

Diversity $= 1 - \sum_{k=1}^{n} s_k^2$ (Eq. 2)

where *n* is the number of knowledge fields. The less heterogeneous the founders' knowledge backgrounds is, the closer the index is to 1/*n*; viceversa, the more diverse the team is the closer the index is to 1.

4.3 Founding team covariates

In relation to the team level covariates, we consider the following elements. First, a control for the number of founders is introduced, measured as the number of founders in the firm's founding team, ranging from 2 to 4; 66% of firms have 2 founders, 24% 3 founders and 10% 4 founders. The literature shows that smaller sized teams are less likely to experience problems of integration across members and free riding behaviours (van der Vegt and Janssen 2003; Steffens et al. 2012; Visintin and Pittino 2014).

Next, we introduce an indicator of the average working experience of founders, measured as the founders' average number of years of working experience. The distribution of this variable suggests that the firms in the sample are highly diverse in terms of founders working experience, with some founders being at the first job and others being in the job market for almost 50 years. The literature suggests that more experienced founders are more likely to launch more innovative and successful ventures (Shane and Stuart 2002; Klepper and Sleeper 2005). This control is necessary also because the founders' knowledge background is likely to expand with longer working experience, which will affect knowledge diversity.

Importantly, we account for the specific team composition, by introducing into the regression framework the variable accounting for the share of JOTs in the founding team (see Table 3 for its distribution). In particular, by interacting this variable with the diversity variable it is possible to test hypothesis 1. Indeed, when the share of JOTs is equal to 0, knowledge diversity can only arise from the presence of founders with different knowledge background; on the other hand, when the share of JOTs is equal to 1, knowledge diversity is the outcome of the presence of intrinsically diverse founders as JOTs are. Therefore, the marginal effect of diversity computed at differ-

ent values of the share of JOTs present in the founding team indicates whether diversity matters for innovation when it originates from the diversity across team members (i.e. share of JOTs equal to 0) or when its source lies in having individually diverse founders (i.e. share of JOTs equal to 1).

Accordingly, the estimated equation becomes as follows:

Pr (INNOVATION$_j$=1)=F(diversity$_j$; share of JOT$_j$; diversity$_j$ x share of JOT$_j$; X$_j$; Z$_j$; ε_i) (Eq. 3).

Finally, we take into consideration the knowledge orientation of the founding team, by computing the share of available knowledge in each of the five fields out of the total number of knowledge fields available in the founding team. Accordingly, we create five variables, one for each field of knowledge: technical and engineering, general management, marketing, finance, and product design. The distribution of these variables highlight the heterogeneity of knowledge background in founding teams: 32% of firms have founders with technical and engineering background, 25% have founders with general management background, 11% have founders with product design background, 14% firms have founders with marketing background and 14% have founders with finance background. In particular, we introduce four out of five variables, leaving the fifth as the reference case (in this specific context, the one accounting for general management knowledge). By interacting these four variables with the diversity variable, it is possible to test hypothesis 2, i.e. whether diversity matters for innovation especially when the firm has a technical and engineering knowledge orientation rather than when the firm has a general management knowledge. If the interaction of the variable accounting for technical and engineering knowledge with the variable of diversity shows a significant and positive coefficient, then, in relative terms, diversity is more important for innovation when the founders in the team have a scientific and technical knowledge orientation with respect to founders having a general management knowledge orientation[3].

The estimated equation therefore becomes as follows:

Pr (INNOVATION$_j$=1)=F(diversity$_j$; share of JOT$_j$; share of technical and engineering knowledge$_j$; share of product design knowledge$_j$; share of marketing knowledge$_j$; share of finance knowledge$_j$; diversity$_j$ x technical and engineering knowledge$_j$; diversity$_j$ x product design knowledge$_j$; diversity$_j$ x marketing knowledge$_j$; diversity$_j$ x finance knowledge$_j$; X$_j$; Z$_j$; ε_i) (Eq. 4).

4.4 Firm level covariates

The AEGIS survey also provides information on firm characteristics and the environment in which they operate. In particular, we follow innovation studies and introduce a set of variables that account for the effect of firm-specific and context-specific factors in the process of innovation development (Talke et al. 2010; Østergaard et al.

[3] When including the interactions, all the interaction terms, i.e., the interaction effects and simple effects, should be included unless there is a good (theory-based) reason not to do so (Brambor et al. 2006). Interpretation should be done in relative terms with respect to the reference case (in this case the general management knowledge) and not in absolute terms.

2011; Fontana et al. 2016; Kristinsson et al. 2016; Protogerou et al. 2017; Jin et al. 2017):

- firm size (class) and age;
- founders' educational level;
- main characteristics of the business environment;
- main strategy pursued;
- recognizing and seizing the opportunities for innovation;
- external sources of knowledge;
- relevance and use of networks.

The effects of age and size are discussed in the literature (see for example Santarelli et al. 2006; Coad 2007). In our study, the effect of age is captured by a variable indicating the firm's age at 2007; as result of the sample design, the surveyed firms are very young, aged 7 at maximum. The effect of size is captured by an ordinal variable measuring the number of full time employees based on six employee size classes: 1 employee; 2 to 5; 6 to 10; 11 to 20; 21 to 50; and over 50 employees. The majority (63.6%) of firms are micro firms, i.e. maximum of nine full-time employees with only a very small share (0.28%) of large or very large firms (>250 employees). The average number of employees in the surveyed firms is 11, which is as expected since 88.4% employ fewer than 50 people.

The educational level within the firm is an important determinant of innovation (Colombo & Grilli, 2010; Østergaard et al. 2011; Huang et al. 2012) and is measured as the share of employees with a bachelor or higher degree on total employees. Overall, the educational level of firms in our sample is high: two-thirds of all new companies have employees who have a university degree, and just over half (52%) have a post-graduate degree holder (including PhDs) among their employees.

The survey asked respondents to evaluate several statements characterizing their business environment. To synthesize this information, we used a factor analysis with principal component analysis extraction and oblimin rotation method[4]. We obtained two factors (results are available upon request), which we label "competition based on new products/technologies" and "competition based on price and/or quality".

The main strategy pursued by the firm is captured through a set of three dummy variables. The first takes the value 1 if the main strategy is based on cost leadership (i.e. offering standardized products and services at low prices) and zero otherwise; the second takes the value 1 if the main strategy is based on differentiation (i.e. offering unique products and services) and zero otherwise; the third takes the value 1 if the main strategy is based on the exploitation of opportunities in new niche markets and zero otherwise. This last is the reference category.

The survey also asked respondents to evaluate several statements about the recognition and exploitation of opportunities for innovation. Again, we synthesized this information using a factor analysis with principal component analysis extraction method and oblimin rotation method. We obtained three factors (results are avail-

[4] The oblimin rotation method is becoming very popular within the scientific community. For a discussion, see Fagerberg and Srholec (2008).

able upon request): "opportunities stemming from adaptation to change", "opportunities stemming from internal R&D", and "opportunities stemming from learning and training".

Some of the questions in the survey aim at evaluating the importance of several external sources of knowledge[5]. As in the previous cases, to synthesize this information, we a used factor analysis with the principal component analysis extraction method and oblimin rotation method. We obtained two factors: "science-based external knowledge sources" and "informal external knowledge sources" (results are available upon request).

Finally, to assess the relevance and use of networks, we used factor analysis to summarize information from the survey based on principal component analysis extraction method and the oblimin rotation method. We obtained one factor only (results are available upon request) for the extent to which the firm participated/contributed to the following operations: contacting customers/suppliers; selecting suppliers; training skilled labour; collecting information on competitors; accessing distribution channels; assistance with obtaining business loans/attracting funds; advertising and promotion; developing new products/services; managing production and operations; assistance in arranging taxation or other legal issues; and exploring export opportunities.

5 The impact of founding team knowledge diversity on innovation: results

Table 4 presents the results of the estimations of the innovation drivers in five main steps, with p-values in parentheses and the inclusion of country and sector dummies. Model 1 includes only the control variables and the variable for knowledge diversity. Model 2 includes the variables for the team composition (share of JOTs) and Model 3 includes the interaction effect between knowledge diversity and share of JOTs, as to test our first hypothesis. Model 4 includes the variables for knowledge orientation. Finally, Model 5 includes also the interaction effects between knowledge diversity and knowledge orientation and aims at testing our second hypothesis. We follow this order to comment on the results.

For the firm level covariates, we find that innovation is positively associated with size and the educational level of founders, which both display a positive and significant coefficient. These results are in line with the literature. As expected, the business environment of competition based on new products and technologies is more favourable to innovation, while the business environment of competition based on price does not have an effect on innovation. In terms of business strategy, both a cost leadership strategy and (to a lesser extent) a differentiation strategy seems less conducive to innovation with respect to a niche exploitation strategy (the reference category). This might be due to the young age of the surveyed firms since creation of a niche market could be a rather short-term effect of the initial launching of a

[5] We focus on external sources of knowledge because 65% of firms in the sample have no internal technical or R&D department; however, this does not mean that the firm does not create internal knowledge.

Table 4 Knowledge diversity and innovation

Dependent variable: Innovation = 1	1	2	3	4	5
Age	-0.012	-0.013	-0.013	-0.018	-0.021
	(0.661)	(0.636)	(0.619)	(0.512)	(0.433)
Size class	0.133**	0.133**	0.134**	0.149**	0.150**
	(0.008)	(0.008)	(0.008)	(0.004)	(0.003)
Education	0.846***	0.850***	0.849***	0.835***	0.852***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Competition based on new products/technologies	0.145*	0.143*	0.143*	0.137*	0.129*
	(0.022)	(0.024)	(0.024)	(0.032)	(0.043)
Competition based on price and/or quality	-0.102	-0.098	-0.096	-0.102	-0.096
	(0.117)	(0.130)	(0.138)	(0.118)	(0.143)
Cost leadership strategy	-0.617***	-0.612***	-0.612***	-0.606***	-0.616***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)
Differentiation strategy	-0.338*	-0.330*	-0.329*	-0.337*	-0.355**
	(0.011)	(0.013)	(0.014)	(0.012)	(0.008)
Opportunities - adaptation to change	0.290***	0.292***	0.292***	0.302***	0.305***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Opportunities - internal R&D	0.004	0.000	-0.000	0.009	0.010
	(0.948)	(0.998)	(0.999)	(0.895)	(0.881)
Opportunities - training and learning	0.317***	0.321***	0.321***	0.290***	0.284***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Science-based knowledge sources	0.047	0.049	0.047	0.065	0.072
	(0.480)	(0.459)	(0.473)	(0.325)	(0.280)
External knowledge sources	0.002	0.002	0.003	0.000	-0.008
	(0.981)	(0.977)	(0.960)	(0.998)	(0.903)
Networks intensity and usefulness	0.278***	0.277***	0.276***	0.267***	0.258***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of founders	-0.065	-0.067	-0.073	-0.080	-0.102
	(0.458)	(0.445)	(0.407)	(0.362)	(0.248)
Average working experience of founders	-0.003	-0.003	-0.003	-0.003	-0.004
	(0.694)	(0.712)	(0.699)	(0.647)	(0.602)
Team knowledge diversity	0.448*	0.515**	0.505**	0.602**	-0.105
	(0.015)	(0.007)	(0.008)	(0.003)	(0.737)
Share of JOT		-0.433	15.121	-0.552^	-0.678*
		(0.142)	(0.547)	(0.063)	(0.026)
Team knowledge diversity x Share of JOT			-19.551		
			(0.535)		
Technical and engineering knowledge				0.535*	0.120
				(0.021)	(0.659)

Table 4 (continued)

Dependent variable: Innovation = 1	1	2	3	4	5
Product design knowledge				0.918**	0.130
				(0.007)	(0.797)
Marketing knowledge				0.839**	0.549
				(0.004)	(0.176)
Finance knowledge				0.142	-0.266
				(0.635)	(0.554)
Team diversity x Technical and engineering knowledge					1.615*
					(0.012)
Team diversity x Product design knowledge					2.025^
					(0.053)
Team diversity x Marketing knowledge					0.504
					(0.577)
Team diversity x Finance knowledge					0.881
					(0.354)
Constant	1.064*	1.037^	1.048*	0.709	1.118^
	(0.046)	(0.052)	(0.049)	(0.204)	(0.054)
Pseudo-R-squared	0.139	0.140	0.140	0.146	0.150
Log likelihood.	-1025.513	-1024.502	-1024.203	-1017.430	-1012.733
Chi-squared	275.341	274.920	276.151	283.726	293.595

N = 1848. *p*-values in parentheses. Country and sector dummies included. $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

new firm. Once a new firm creates a market, competition will arise from established firms or from even newer firms. Training and learning are important for recognizing and exploiting opportunities for innovation. Finally, business networks are perceived as important and useful for the firm's operations and innovativeness. These results highlight a clear profile for innovative vs. non-innovative firms, with the latter being typically smaller, less educated, with a cost-cutting strategic focus, homogeneous in their knowledge base. We cannot exclude, then, that specific characteristics of new firms are systematically associated with innovation activity, leading to a potential risk of self-selection. Nonetheless, the robustness of our results to alternative coding of the dependent variable (see footnote 3) somewhat mitigates this concern.

Knowledge diversity is associated positively with innovation. This result confirm previous findings in the literature claiming that diversity is an important driver of firms' innovative activities (Dahlin et al. 2005; Talke et al. 2010; Tidd 2014; Kristinsson et al. 2016). This effect is strongly significant also when controlling for the number of founders and their average working experience.

When we introduce the variables accounting for the specific composition of the teams (Model 2 and Model 3), interesting results emerge. In particular, diversity is positively associated with innovation, even when controlling for the share of JOTs present in the founding team. Even if the interaction between knowledge diversity and the share of JOTs is, on average, not significant (the coefficient of the interaction

term is not significant in Model 3), the computation of the marginal effect of knowledge diversity at different values of the share of JOTs reveals important findings, in line with our expectations (Table 5).

In fact, we are interested in the effect of diversity computed at specific values of JOTs (i.e. when the share of JOTs is 0 and when the share of JOTs is 1) and not at the average values of share of JOTs. This approach is reasonable given the distribution and actual values of the variable accounting for the share of JOTs (see Table 3 and A2 in the Appendix). Importantly, when all founders are JOTs (share of JOTs is equal to 1), diversity is negatively and significantly associated with innovation. On the other hand, when there are no JOTs in the team and, thus, diversity arises because of the presence of founders with different knowledge background, diversity is positively and significantly associated to innovation. Finally, for intermediate values of the share of JOTs in the founding team, diversity is not significantly associated with innovation; in particular, the negative relationship between diversity and innovation arises when JOTs represent a considerable portion of founders in the team, i.e. more than 2/3 of founders. This finding fully supports our first hypothesis: diversity matters for innovation when it origins from the presence of founders with different knowledge background and not from the presence of founders, each having a diverse knowledge background. The interpretation of this finding lies in that the presence of many JOTs in a team creates redundancy of knowledge and possible duplications of skills, abilities and cognitive structures. In these conditions, knowledge exchanges among founders with a similar mix of competencies can lose value over time and the opportunities for recombination fade away. This in turn reduces the team's creativity, the opportunities for the emergence of generative mechanisms in the interaction across team members in terms of integration of complementary capabilities, contrasting cognitive and creative styles and adjacent networks, and the development of innovations.

Importantly, the relevance of diversity persists also after introducing the knowledge orientation variables measured (as discussed in Sect. 4.2) as the share of the firm's knowledge in each field, with general management knowledge as the reference category (Model 4). With the exception of finance, knowledge in any one of the other fields is more conducive to innovation with respect to orientation in general management knowledge.

Table 5 Marginal effect of knowledge diversity for different levels of the share of JOTs

Share of JOTs	*Marginal effect*	*Standard error*	*Z*	*p-value*
0	0.09	0.04	2.69	0.01
25%	-0.510	0.52	-0.99	0.32
33.33%	-0.61	0.53	-1.16	0.25
50%	-0.76	0.48	-1.59	0.11
66.67%	-0.86	0.42	-2.05	0.04
75%	-0.90	0.41	-2.20	0.03
100%	-1.02	0.46	-2.23	0.03

Model 5 specifically allows to discuss the role of knowledge orientation in the relationship between knowledge diversity and innovation, through the inclusion of the interactions between knowledge diversity and the variables accounting for the firm's knowledge orientation. Keeping orientation in general management knowledge as the reference case, the results indicate that knowledge diversity is more relevant for firms with a stronger technical and engineering knowledge than for firms with a more prominent knowledge in general management, as shown by the positive and significant coefficients of the interaction between knowledge diversity and technical and engineering knowledge. Interestingly enough, this effect is also found for the interaction between knowledge diversity and product design knowledge: knowledge diversity matters more for firms with a stronger product design knowledge than for firms with a more prominent knowledge in general management, as shown by the positive and significant coefficients of the interaction between knowledge diversity and product design knowledge. These results support our hypothesis 2, i.e., knowledge diversity is more important for firms whose knowledge base is more oriented towards technical applications (i.e. technical and engineering knowledge and product design knowledge), is more distant from market applications and requires complementarity with other types of knowledge to transform the scientific knowledge and technological output into new marketable products and services. These findings suggest that knowledge diversity is particularly beneficial if the new firm knowledge base is focused on science and technology fields. In this case, having a composite set of competencies and a variety of knowledge across founders stimulates the concrete development and commercialization of new ideas, as it allows to integrate a scientific and an economic conception of science and knowledge. A team of product designers greatly benefits from the complementary knowledge in finance or general management from other expert founders. On the contrary, a firm with a more general and less technical knowledge base across founders has, in relative terms, less benefits deriving from the presence of very diverse founders.

As a robustness check, we also controlled for the role of the founding team educational level[6]. In fact, as long as higher education is conducive to greater skills, and entrepreneurial and innovative attitude, one may expect that higher educational level in the founding team can help exploiting the advantages of knowledge diversity. To take this aspect into account, we extended the analysis by including a measure of the educational level of the founders, computed as the share of founders in the founding team with tertiary education or more. On average, the surveyed firms have only 14% founders with tertiary education. This percentage never exceeds the 50%, signalling that there are no firms in the sample in which all founders have tertiary educational attainment level.

Unfortunately, this variable is not significant per se nor in its interaction with team knowledge diversity. Neither are significant the interaction between the measure of the educational level of the founders and the variables accounting for the knowledge orientation of the founding team (i.e. the share of available knowledge in each of the knowledge fields available in the founding team). These results seem to exclude sub-

[6] We thank an anonymous referee for the suggestion to run a robustness check on the role of founding team education and on its possible moderating effect on the relationship between innovation and diversity.

Table 6 Knowledge diversity, team education and innovation

Dependent variable: Innovation = 1	1	2	3	4
Age	-0.014	-0.014	-0.019	-0.021
	(0.600)	(0.592)	(0.480)	(0.438)
Size class	0.131**	0.131**	0.147**	0.148**
	(0.009)	(0.009)	(0.004)	(0.004)
Education	0.796***	0.796***	0.785***	0.790***
	(0.000)	(0.000)	(0.000)	(0.000)
Competition based on new products/technologies	0.143*	0.143*	0.137*	0.137*
	(0.024)	(0.024)	(0.032)	(0.033)
Competition based on price and/or quality	-0.094	-0.094	-0.098	-0.101
	(0.146)	(0.147)	(0.131)	(0.122)
Cost leadership strategy	-0.608***	-0.613***	-0.602***	-0.600***
	(0.001)	(0.000)	(0.001)	(0.001)
Differentiation strategy	-0.332*	-0.334*	-0.339*	-0.340*
	(0.013)	(0.012)	(0.011)	(0.011)
Opportunities - adaptation to change	0.292***	0.291***	0.302***	0.301***
	(0.001)	(0.001)	(0.000)	(0.000)
Opportunities - internal R&D	0.001	0.001	0.010	0.009
	(0.985)	(0.983)	(0.880)	(0.891)
Opportunities - training and learning	0.318***	0.316***	0.287***	0.288***
	(0.000)	(0.000)	(0.000)	(0.000)
Science-based knowledge sources	0.047	0.047	0.064	0.062
	(0.474)	(0.475)	(0.336)	(0.351)
External knowledge sources	0.004	0.007	0.002	0.004
	(0.955)	(0.922)	(0.979)	(0.956)
Networks intensity and usefulness	0.281***	0.281***	0.270***	0.272***
	(0.000)	(0.000)	(0.000)	(0.000)
Number of founders	-0.061	-0.061	-0.074	-0.074
	(0.489)	(0.487)	(0.400)	(0.400)
Average working experience of founders	-0.002	-0.002	-0.003	-0.003
	(0.744)	(0.768)	(0.679)	(0.697)
Team knowledge diversity	0.511**	0.410^	0.594**	0.589**
	(0.007)	(0.071)	(0.004)	(0.004)
Share of JOT	-0.439	-0.448	-0.558^	-0.561^
	(0.138)	(0.133)	(0.062)	(0.061)
Team education	0.364	-0.017	0.346	0.510
	(0.223)	(0.974)	(0.249)	(0.461)
Team knowledge diversity xTeam education		0.765		
		(0.359)		
Technical and engineering knowledge			0.520*	0.605*
			(0.026)	(0.023)
Product design knowledge			0.915**	1.067**
			(0.007)	(0.008)
Marketing knowledge			0.837**	0.734*
			(0.004)	(0.031)
Finance knowledge			0.132	0.067
			(0.660)	(0.852)
Team education x Technical and engineering knowledge				-0.638

Table 6 (continued)

Dependent variable: Innovation = 1	1	2	3	4
				(0.507)
Team education x Product design knowledge				-1.284
				(0.415)
Team education x Marketing knowledge				0.797
				(0.579)
Team education x Finance knowledge				0.434
				(0.765)
Constant	1.008^	1.066*	0.689	0.684
	(0.060)	(0.047)	(0.218)	(0.229)
Pseudo-R-squared	0.141	0.141	0.147	0.148
Log lik.	-1023.780	-1023.393	-1016.781	-1015.762
Chi-squared	274.718	274.712	283.383	285.424

N = 1848. *p*-values in parentheses. Country and sector dummies included. $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$

stantial mediating effects of the education variable. Importantly, their inclusion does not alter our chief conclusions (see Table 6).

6 Conclusions

This paper contributes to fill a research gap in the literature on diversity and innovation, by providing an innovative perspective on diversity. It investigates the role of founders' knowledge diversity in determining firms' innovative performance across a sample of European newly established firms. An important strand of studies at the cross road between innovation and entrepreneurship has looked specifically at the impact of founders' diversity – mostly in terms of education and working experience – on firm performance. The present work builds on the existing literature on the topic, but extends it in three ways. First, from a theoretical perspective it examines diversity in teams' knowledge background by considering that diversity has two dimensions - an individual-related dimension and a team-related dimension – and that founding team knowledge diversity can be either the result of the presence of different members each with a different knowledge background within a team, or the outcome of the presence of many similar JOTs. Second, it explores in depth the extent to which the relationship between founding team diversity and innovation depends upon the source of the diversity, i.e. upon the composition of the team in terms of founders with different knowledge background vs. JOTs. Third, it explores the role of the knowledge orientation of founding team knowledge as a mediator in the relationship between diversity and innovation.

Overall, our results show that a founding team knowledge diversity is positively associated with firm innovative activity, when the team is composed by different members with different knowledge backgrounds, while it is negatively associated with innovation, when the team is composed only by JOTs. This result provides new evidence on the role of diversity for innovation, as it derives from the multi-dimensional understanding of knowledge diversity within a team and jointly considers the two levels of diversity (individual level and team level) that were previously exam-

ined separately by different strands of literature. This finding points at the importance of avoiding knowledge redundancy and duplication of sets of competences, and at promoting a combination of complementary skills and knowledge in entrepreneurial teams in order to achieve higher innovative performance.

The analysis also shows that knowledge diversity is less relevant for innovative activity, if the overall knowledge orientation of the team is predominantly in the area of general management, i.e. if the team has mostly business-related competences. On the contrary, knowledge diversity is positively associated with innovation if the overall knowledge base of the team is oriented towards technical and engineering or product design knowledge, i.e. if the team has a strong scientific and technical orientation. These findings are in line with the idea that having a founding team with diverse knowledge is particularly important for firms where the team's knowledge base is more technology-oriented. Indeed, in new ventures with a highly scientific profile, while technological orientation matters for the initial development of innovations, the process of commercialization of new products and services requires business-oriented skills (Visintin and Pittino 2014).

Our findings have important managerial implications for the innovative activity of new ventures. First, they confirm that founding team diversity is positively associated with innovation, which is in line with the recent emphasis on workforce diversity as an important driver of creative thinking and new ideas that translate into successful innovations (Dahlin et al. 2005; Talke et al. 2010; Tidd 2014; Kristinsson et al. 2016). The joint presence of different types of backgrounds is beneficial to stimulate innovation in new ventures, since it allows to face both technological and market uncertainties (Visintin and Pittino 2014) and to succeed both in the creative process of idea generation and in the more practical phase of idea implementation (Kristinsson et al. 2016). A composite rather than a specialized knowledge base allows companies to access a larger pool of knowledge, competences, business networks and experience, to exploit different perspectives on business problem solving and, and to achieve sustainable business growth over time through innovation (Østergaard et al. 2011; Huang et al. 2012). Second, and most importantly, our results clearly show that knowledge diversity in teams matters for innovation when it derives from the presence of different founders, while it is negatively associated with innovation, when it comes from the presence of many JOTs. It is the combination of diverse knowledge backgrounds more than the presence of similar JOTs that is more conducive to innovation.

Third, our findings show that since companies operate in different sectors and have different knowledge endowments, the extent to which founders' knowledge diversity matters for the firm's innovation activity depends on the specific context and business activity. By superseding a basic distinction between complex and simple activities, and between high and low-tech sectors, our findings suggest that companies should aim at diversity especially if their activities have a scientific and technological orientation and are therefore relatively distant form the market. In these cases, the integration of different knowledge backgrounds brings higher value added to the process of commercialisation of research outputs.

Our paper has some of limitations, which can open up avenues for future research. Given the cross-sectional nature of the data, it is impossible to control for firms' long-term capabilities, processes and dynamics, specifically with reference to the

development of innovation. Second, given that we deal with new ventures, we have considered all the founders in a team equally responsible for the innovation strategies. However, as time goes by, firm evolution goes hand in hand with the evolution decision-making processes related to innovation, so that different founders may have different roles in the innovative activity. Furthermore, there might be changes in the management team over time. Third, the survey is based on self-reported information from founders, which might be biased in terms of the evaluation of their knowledge backgrounds. Finally, we have considered only active firms between 2001 and 2007, which might introduce a survivor bias among the firms in the sample. This bias could be problematic, since the event of firm exit might have been correlated with the structure of the founding team (e.g., Roure and Maidique 1986) and since prior research has established a well-established link between innovativeness and survival rates (e.g. Hyytinen et al. 2015). Similarly, innovative and non-innovative firms seem characterised by significantly different profiles, opening to the risk of self-selection mechanisms and, thus, limiting somewhat the generalizability of the findings.

7 Appendix

Table A1 VARIABLES' DESCRIPTION

Innovation	Dummy variable = 1 if the firm has introduced new or significantly improved goods or services in the past 3 years and 0 otherwise
Age	Age of the firm
Size class	Ordinal variable measured by the number of full time employees grouped in six classes: 1 employee only; 2 to 5 employees; 6 to 10 employees; 11 to 20 employees; 21 to 50 employees; above 50 employees
Share of employees with university degree	Share of employees holding a bachelor degree on total employees
Competition based on new products/technologies	Factor referring to the statements describing the firm business environment: the lifecycle of products is typically short; customers regularly ask for new products and/or services; the speed of technological change is high; a company only succeeds if it is able to launch new products/services continuously
Competition based on price and/or quality	Factor referring to the statements describing the firm business environment: the activities of our major competitors are unpredictable and competition is very intense; price competition is prevalent; quality competition is prevailing
Cost leadership strategy	Firm strategy based on offering standardized products and services at low cost
Differentiation strategy	Firm strategy based on offering unique products and services

Table A1 VARIABLES' DESCRIPTION

Innovation	Dummy variable = 1 if the firm has introduced new or significantly improved goods or services in the past 3 years and 0 otherwise
Opportunities - adaptation to change	Factor referring to the statements regarding the sensing and seizing of opportunities within firm: our firm actively observes and adopts the best practices in our sector; our firm responds rapidly to competitive moves; we change our practice in response on customer feedbacks; our firm regularly considers the consequences of changing market demand in terms of new products and services; our firm is quick to recognize shifts in our market (e.g. competition, regulation, demography); we quickly understand new opportunities to better serve our customers
Opportunities - internal R&D	Factor referring to the statements regarding the sensing and seizing of opportunities within firm: there is a formal R&D department in our firm; there is a formal engineering and technical department in our firm; design activity is important in introducing new products/services to the market
Opportunities - training and learning	Factor referring to the statements regarding the sensing and seizing of opportunities within firm: we implement systematic internal and external personnel training; employees share practical experiences on a frequent basis
Science-based external knowledge sources	Factor referring to the external sources of knowledge: public research institutions; universities; external commercial labs/R&D firms/technical institutes; scientific journals and other trade or technical publications; participation in nationally funded research programs; participation in EU funded research programs (Framework Programs)
Informal external knowledge sources	Factor referring to the external sources of knowledge: clients or customers; suppliers; competitors; trade fairs, conferences, exhibitions
Business networks intensity and usefulness	Factor referring to the participation/contribution of firms to the following operations: contacting customers/suppliers; selecting suppliers; recreating skilled labour; collecting information about competitors; accessing distribution channels; assistance in obtaining business loans/attracting funds; advertising and promotion; developing new products/services; managing production and operations; assistance in arranging taxation or other legal issues; exploring export opportunities
Average working experience of founders	Average number of years of working experience of the founders
Number of founders	Number of founders in the firm's founding team
Team knowledge diversity	Opposite of the Herfindahl index computed on the squared share of knowledge in the founding team in the following five knowledge fields: technical and engineering knowledge, general management, product design, marketing, finance
Share of JOTs in the team	Number of JOTs out of the total number of founders in the team
Technical and engineering knowledge	Share of knowledge in the founding team in the field of technical and engineering
General management knowledge	Share of knowledge in the founding team in the field of general management

Table A1 VARIABLES' DESCRIPTION

Innovation	Dummy variable = 1 if the firm has introduced new or significantly improved goods or services in the past 3 years and 0 otherwise
Product design knowledge	Share of knowledge in the founding team in the field of product design
Marketing knowledge	Share of knowledge in the founding team in the field of marketing
Finance knowledge	Share of knowledge in the founding team in the field of finance

Table A2 SUMMARY STATISTICS

Variable	*Obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
Innovation	1861	0.65	0.48	0	1
Age	1861	4.05	2.14	0	7
Size class	1848	2.64	1.27	0	6
Share of employees with university degree	1861	0.36	0.40	0	1
Competition based on new products/technologies	1861	0.04	0.98	-2.47	2.22
Competition based on price and/or quality	1861	-0.005	1.01	-3.18	2.10
Cost leadership strategy	1861	0.17	0.37	0	1
Differentiation strategy	1861	0.58	0.49	0	1
Opportunities - adaptation to change	1861	-0.02	1.02	-3.11	1.55
Opportunities - internal R&D	1861	0.05	0.95	-3.10	1.95
Opportunities - training and learning	1861	0.07	1	-2.08	2.69
Science-based knowledge sources	1861	0.07	1.02	-1.31	3.11
External knowledge sources	1861	0.02	0.99	-3.65	1.99
Business networks intensity and usefulness	1861	0.04	0.99	-2.40	2.23
Average working experience of founders	1861	11.30	8.19	0	46
Number of founders	1861	2.44	0.67	2	4
Team knowledge diversity	1861	0.51	0.29	0	0.80
Share of JOTs	1861	0.05	0.18	0	1
Team education	1861	0.14	0.21	0	0.50
Technical and engineering knowledge	1861	0.32	0.31	0	1
General management knowledge	1861	0.25	0.26	0	1
Product design knowledge	1861	0.11	0.18	0	1
Marketing knowledge	1861	0.14	0.20	0	1
Finance knowledge	1861	0.14	0.20	0	1

Table A3 CORRELATION MATRIX

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Table A3 CORRELATION MATRIX

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Declarations

Conflict of interest **no conflict of interest**.

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