The importance of team diversity for academic spinoff performance

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Abstract: This study examines how team diversity affects the performance of academic spinoffs. Building on the upper-echelon theory, we argue that different forms of diversity, namely profile diversity, cognitive distance, CEO non-duality, and the presence of a non-academic CEO may positively affect the early performance of academic spinoffs. Our hypotheses are tested on a sample of 307 Italian academic spinoffs founded between 2010 and 2014. Our results support the positive role of diversity in enhancing growth, but only for innovative academic spinoffs. The presence of a non-academic CEO is the only diversity measure that plays a direct positive role, regardless of company technological features.

Keywords: academic spinoffs; team diversity; disciplinary diversity; institutional diversity; upper echelon theory.

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1 Introduction

Academic spinoffs (ASOs) are high-tech start-ups founded by academics who aim to bridge the gap between scientific research and its commercialisation by exploiting technological innovations in the form of marketable products or services (Roberts and Malone, 1996; Steffensen et al., 2000). For years, the public policy debate has acknowledged ASOs as fundamental for their potential role in boosting economic activity (Di Gregorio and Shane, 2003), in creating employment in science-based sectors (Clarysse et al., 2005; O'Shea et al., 2008) and in transferring knowledge from research institutions to the private sector (Audretsch et al., 2020; Belitski et al., 2019; Cunningham and Menter, 2020).

Nonetheless, empirical observations show that the majority of these companies remain very small with disappointing performance (e.g., Clarysse et al., 2011; Mathisen and Rasmussen, 2019), especially in comparison with their non-academic counterparts (Hmieleski and Ensley, 2005; Wennberg et al., 2011). One of the obstacles to their growth is traced to their technology (Clarysse et al., 2011; Knockaert et al., 2011), which is very often created out of a scientific idea – as ASOs operate in an environment of basic or applied research – and by the time the firm is founded it does not necessarily meet customer needs (Colombo et al., 2014). As a result, ASOs are potentially able to develop groundbreaking innovations and generate technologies so radical in nature to be disruptive yet, struggling to find a market application for their innovations (Gruber et al., 2013). Accordingly, radical innovations are characterised by a high degree of technological uncertainty in the commercialisation phase (Unger et al., 2011).

For such technology-based sectors, the founding team is considered extremely relevant for a successful technology transfer (Bock et al., 2018; Colombo and Grilli, 2010; Colombo and Piva, 2012; Knockaert et al., 2011). Nonetheless, relatively few studies on ASOs focus on the performance of new ventures by considering the features of the founding teams (Mustar et al., 2006; Visintin and Pittino, 2014). ASOs represent an interesting phenomenon to analyse, as they need a proper balance between scientific

orientation and business orientation. Specifically, scientific orientation is necessary for the process of discovery and early technology development, whereas business orientation is required for the effective commercialisation of the products and services which incorporate the technology (Walter et al., 2006). The consequence of such a dual dimension for the company performance can be fully understood by investigating the structure and composition of ASO funding teams (Knockaert et al., 2011; Visintin and Pittino, 2014). Thus, according to the Upper Echelons theory, company behaviour and performance depend on the cognitive attributes of the top managers (Carpenter et al., 2004; Hambrick and Mason, 1984).

We apply this framework to the funding teams of ASOs by assessing the appropriate configuration in terms of combinations of scientific and business-related skills to generate a positive impact on ASO performance, displayed as economic growth. In this area, there is still no consensus among scientists (Knockaert et al., 2011; Markman et al., 2008; Nikiforou et al., 2018). Our results highlight the positive role played by diversity in founding teams in terms of profile diversity, cognitive distance, and CEO non-duality, exclusively when the innovativeness of the technology adopted is high. The only diversity measure that directly influences the growth of ASOs, regardless of the degree of technological innovativeness, is the presence of a non-academic CEO. Thus, according to the Upper Echelon theory, the CEO is relevant to the functioning of a company, and they are the sole individual who can introduce valuable complementary skills, knowledge and competence.

This paper proceeds along the following lines. In the next section we describe the context of analysis, namely the ASOs, by briefly reviewing the literature on Upper Echelon theory and formulating the hypotheses which can be derived thereof. Section 3 describes the sample and the empirical method. In the fourth section we present the results, while in Section 4 results are discussed further and compared with the previous literature. Finally, in the last section we highlight the current limitations of the study and suggest future developments for research.

2 Theoretical background and hypotheses development

In line with the Upper Echelons theory, organisational outcomes are a function of the characteristics of the founding team (Hambrick, 2018; Hambrick and Mason, 1984). Entrepreneurship scholars in particular have suggested that the composition of the founding team is one of the main factors that influences the performance of new entrepreneurial ventures (Birley and Stockley, 2017; Mustar et al., 2006). The direct influence of the founding team is greater in small, new companies, where coordination through direct supervision is facilitated by the reduced size, the flexibility of processes are enhanced and information and communication processes are not mediated or distorted by bureaucratic structures and hierarchies (Daily et al., 2002; Finkelstein and Hambrick, 1996).

Technology-based ventures are more frequently founded by entrepreneurial teams rather than single entrepreneurs (Visintin and Pittino, 2014), because the success of start-ups in high tech industries depends on the integration of the technology with business strategy and, compared to single founders, entrepreneurial teams are more likely

to possess the capabilities needed to achieve a fit between technology and strategy (Colombo and Grilli, 2010; Colombo and Piva, 2012). In addition, teams seem to handle the high levels of environmental uncertainty characterising the science-based sectors better than single entrepreneurs (Unger et al., 2011).

ASOs are small, science-based companies (Colombo and Piva, 2012; Knockaert et al., 2011), operating in high-tech industries (Bock et al., 2018; Visintin and Pittino, 2014) and are founded by small entrepreneurial teams (Aspelund et al., 2005). In recent years, a large number of studies have focused on the impact of TMT composition on the performance of start-ups. These studies usually included ASOs (Amason et al., 2006; Bock et al., 2018; Kollmann et al., 2017). Hmieleski and Ensley (2005) explained the underperformance of spinoff companies compared to independent start-ups with the fact that ASOs' entrepreneurial teams are significantly more homogeneous in terms of education, industry experience, functional expertise and skills than those of a sample of independent start-ups. Similarly, in line with the meta-analysis from Unger et al. (2011), some studies found a large positive influence of team heterogeneity on performance in multiple contextual settings (Knockaert et al., 2011; Visintin and Pittino, 2014). Heterogeneous teams are considered more capable of facing changes in a venture's environment because they are better equipped when compared to homogeneous teams, which lack adequate experience in areas not specifically related to the technology invented (Knockaert et al., 2011).

The heterogeneity of the founding team within ASOs can be studied from different points of view. First, one can observe the profile differentiation, or the presence of both academic and non-academic members within the team (Visintin and Pittino, 2014). Academic members are university-affiliated researchers who work as academic personnel, while non-academic members are those in the team who have no university affiliation and therefore work strictly in the industry. As the fundamental goal of ASOs is the transformation of scientific knowledge and research outputs into marketable products or services (Civera et al., 2020), in the pursuit of this goal it is convenient to create differentiated team structures where members have either research or business profiles. Whereas academic members of the teams have in-depth technological knowledge and operate according to the Mertonian norms of science, they lack experience in business tasks which needs to be integrated by individuals who have worked in the industry and are likely to have accumulated entrepreneurial, managerial and commercial experience – if they want to spin out a successful business (Bock et al., 2018; Visintin and Pittino, 2014). Based on this theoretical assertion, we derive the following hypothesis.

> *Hypothesis*: *The profile differentiation of the founding team is beneficial for ASO's performance.*

Though it is clear that ASOs often lack commercial experience, it may be insufficient to add one or more people to fill the 'commercial gap' within the team. As argued by Knockaert et al. (2011) a simple focus on the number and dispersion of the functions covered by the founding team may thus fail to capture important interactions between team members that are necessary for knowledge to be transferred. Rather, there is a need to consider the degree to which knowledge, experience, skills, frames of reference and cognition across team members is different or overlapping. In other words, there may need to be some degree of 'cognitive distance' between team members (Wuyts et al., 2005). The cognitive distance between academics measures the heterogeneity of

scientific disciplines the academic members belong to. By contrast, the cognitive distance between academic and non-academic members shows the heterogeneity of their cognitive fields (Beckman and Burton, 2008; Bock et al., 2018; Visintin and Pittino, 2014). Similar experience and educational background may promote the development of shared norms and facilitate communication, since members have common cognitive frames of reference (Beckman et al., 2007), or 'mindsets' (Knockaert et al., 2011). For example, in ASOs this happens when both academic and non-academic members have had prior entrepreneurial or managerial experiences, or have the same disciplinary background (Visintin and Pittino, 2014). Consider an example of a team composed of two academics, one affiliated to the mechanical engineering department and one to the law department of the same university, along with a third, non-academic member with a prior experience in a start-up specialised in mechanical solutions for renewable energy production. The cognitive distance between the two academics as well as between the law-affiliated academic and the non-academic is relevant as they do not overlap in their knowledge basis, while the distance between the engineer-affiliated and the non-academic is modest.

Hypothesis 2: The cognitive distance of the founding team is beneficial for the ASO's performance.

Although attention to the entire team often provides enhanced predictions of organisational outcomes, in line with the Upper Echelons theory, a focus on the top executive role (i.e., CEO) can also be illuminating (Hambrick, 2018). In particular, CEO-duality (namely the same person playing the role of CEO and chairman of a company) represents a fundamental element in the structural arrangement of a board that can affect performance of high tech firms (Knockaert et al., 2015) and specifically ASOs (Sciarelli et al., 2020). In the context of small firms, to which ASOs belong, scholars in support of the CEO-duality argue that the leadership of a single individual leads to higher firm performance due to simpler decision-making processes and greater flexibility (Rashid and Lodh, 2011). By contrast, those advocating CEO-nonduality argue that the separation of the roles enables greater scrutiny of managerial behaviour and lead to higher performance (Pugliese and Wenstøp, 2007). With specific regard to ASOs, the position of chairman and chief executive officer is usually held by a single person (Di Berardino, 2016; Sciarelli et al., 2020). Whereas CEO-duality may potentially stimulate the interests of the close members of firms, it may limit the benefits from hiring the best existing professional managers, which can be particularly large for innovative activities in university spinoffs (Prencipe, 2016). The need for extensive knowledge and expertise, according to the arguments of hypothesis 1, come from hiring non-academic members (Ambos et al., 2008; Visintin and Pittino, 2014). Due to the relevance of the CEO position in affecting firm performance and team functioning and processes, one may suppose that the beneficial effect is even higher when the CEO is a non-academic individual. Henceforth, we postulate:

Hypothesis 3: CEO non-duality in the founding team is beneficial for ASO's performance.

Hypothesis 4: The presence of a non-academic CEO is beneficial for ASO's performance.

Entrepreneurial firms such as ASOs are usually formed around a technology that is radically new, disruptive and often early-stage and general purpose (Knockaert et al.,

2011). A high degree of innovation in technology may be positive for firm growth because it offers a great competitive advantage, since it is more difficult to imitate and prevents the entrance of new competitors, leaving more time to the ASOs to commercialise the product or service (Aspelund et al., 2005; Bock et al., 2018). On the other hand, the newness of the technology can be negatively associated with growth (Clarysse et al., 2011), because a novel technology requires time and effort to satisfy customers, enough that generating first revenues is deferred into the future. Moreover, the benefits of a (radically) new technology may be hard to be understood at the beginning, and the ASOs' founders need to convince potential users through a set of commercial and business skills (Bock et al., 2018). Hence, the technology is rarely market-ready because it is embodied in the academic scientist entrepreneurs (Clarysse et al., 2007; Markman et al., 2008), who possess in-depth technological skills and knowledge about their field of expertise, but their experience and networks from industrial and entrepreneurial activities are very limited or missing at all (Bock et al., 2018; Clarysse et al., 2005; Colombo et al., 2014). The lack of networks to business professionals outside the research organisation and the radicality of the new technologies may negatively affect the possibilities to transfer ASOs' technologies and knowledge into commercial products and services (Clarysse et al., 2011; Colombo and Piva, 2012). The team composition and characteristics, in particular by its heterogeneity in terms of accumulated skills and knowledge (Bock et al., 2018; Unger et al., 2011), result to be even more beneficial in a condition of uncertainty due to an endowed innovative technology. The knowledge gaps in the skills of academic entrepreneurs (Mosey and Wright, 2007), when filled by complementary competencies, allow for reconfiguration of the nature of ASOs' capabilities, which in turn enhance their performance (Lockett et al., 2003). Therefore, we formulate:

Hypothesis 5: The TMT diversity in terms of (i) profile differentiation, (ii) cognitive distance, (iii) CEO non-duality, and (iv) a non-academic CEO is beneficial for innovative ASO's performance.

3 Research design

3.1 Data and sources

The database chosen for studying the impact of diversity includes 307 spinoffs established between 2010 and 2014 provided by Spinoff Italia, a database created by the collaboration between the Center for Innovation and Entrepreneurship of the Polytechnic University of Marche, Netval and the Institute of Management at the Sant'Anna School. We matched this information with balance sheet data from the Bureau Van Dijk AIDA database to get financial information about each spinoff. The dataset was then expanded with information concerning the founding team of each spinoff. By processing LinkedIn pages, spinoff websites and parent university websites, some basic information of the founding team of each spinoff was found. By sourcing individual CVs, we defined four diversity measures for each spinoff. Contextual and university control variables are instead derived from the National Institute of Statistics (Istat) and the Ministry of Education (MIUR) databases.

3.2 Model and variable definition

The model used to test the hypotheses is an ordinary least square (OLS) regression, where the dependent variable is the three-year growth rate (in terms of income). Growth has been commonly accepted as the most relevant indicator of performance among new ventures for many years (Brush and Vanderwerf, 1992). Growth in total income has been used in several studies on spinoffs (Parhankangas and Arenius, 2003; Sapienza et al., 2004). It is considered a good measure of economic and financial performance as it considers revenues and expenses of the firm, it provides incentive for firms to increase production and it allows for greater capacity to finance tangible and intangible investments, in particular investment in research and development (Shepherd and Wiklund, 2009). Furthermore, Walter et al. (2006) consider income as an indicator of the management ability to exploit its entrepreneurial autonomy. A fast rise in the income proves that the market accepts the products or services offered by the firm and consequently testifies the success of technology transfer. Fast growing spinoffs are more likely to become profitable and get listed. Total income is only one of the companies' key performance indicators, but also a fundamental indicator of their contribution to the economy. Nonetheless, according to Clarysse et al. (2011), growth may be delayed in companies that use a novel technology and initial growth not necessarily indicates a reliable measure of firm success. We chose a three year time span since it is the one that is most frequently adopted in studies on early growth performance of new ventures (Dobbs and Hamilton, 2007; Hansen and Hamilton, 2011; Visintin and Pittino, 2014). Therefore, we calculate the income growth as the compound growth rate between the year of establishment and the end of the third year of activity.

In order to test the hypotheses, it is necessary to calculate for each spinoff the levels of diversity, which are our independent variables. A level of diversity equal to or greater than 50% is assigned to high heterogeneity. The *Profile differentiation* (D1) refers to the heterogeneity of the founding team resulting from the presence of any non-academic members. To measure it, each spinoff is associated with a number between 0 and 1 based on the number of academic and non-academic members in the founding team. The results are presented in Table 1.

Table 1 Definition of the Profile differentiation (D1)

Classification	*Description*	*Level diversity*	*Percentage*
Pure Homogeneous Spinoff	All members are academics	D1 = 0	145/307 = 47.2%
Low Heterogeneous Spinoff	Most of the members academics	$0 < D1 < 0.5$	89/307 = 29%
High heterogeneous Spinoff	Most of the members are non-academics	$0.5 \leq D1 < 1$	60/307 = 20%
Pure heterogeneous Spinoff	All members are non-academics	D1 = 1	12/307 = 3.8%

The *Cognitive distance* (D2) refers to the heterogeneity of the founding team resulting from members belonging to different cognitive fields. More specifically, in relation to academics it indicates the disciplinary field they belong to, which represents their field of research. In relation to non-academics, it represents the disciplinary background. Each

spinoff is associated with a number between 0 and 1 based on either the number of academic members which belong to different scientific disciplines or the number of both academic and non-academic members who are characterised by different cognitive fields (e.g., the research field of academics is different from the industrial sector of non-academics). The results are presented in Table 2.

Table 2 Definition of the cognitive distance (D2)

Classification	*Description*	*Level of diversity*	*Percentage*
Pure homogeneous spinoff	All members are from the same disciplinary area	D2 = 0	154/307 = 50.2%
Low heterogeneous spinoff	Most of the members are from the same disciplinary area	$0 < D2 < 0.5$	84/307 = 27.4%
High heterogeneous Spinoff	Most of the members are from different disciplinary area	$0.5 \leq D2 < 1$	67/307 = 21%
Pure heterogeneous Spinoff	All members are from different disciplinary area	D2 = 1	4/307 = 1.4%

The third measure of diversity (D3) refers to the *CEO non-duality* in the governance structure of the ASO. Whereas a D3 equal to 0 indicates that the CEO and Chairman are the same person, a D3 equal to 1 specifies that CEO and Chairman are two different individuals. The statistics are presented in Table 3.

Table 3 Definition of the CEO/Chairman duality (D3)

Classification	*Description*	*Level of diversity*	*Percentage*
Homogeneous spinoff	Spinoff with Dualism: CEO and chairman are the same person	D3 = 0	270/307 = 88%
Heterogeneous spinoff	Spinoff without Dualism: CEO and chairman are two different persons	D3 = 1	37/307 = 12%

Finally, D4 measures if an ASO is associated to a *Non-academic CEO*/*Chairman*. When both CEO and Chairman are academics, D4 is equal to 0, and when either CEO or Chairman are non-academics, D4 is equal to 1. Table 4 shows the statistics.

Table 4 Definition of non-academic CEO/Chairman (D4)

Classification	*Description*	*Level diversity*	*Percentage*
Homogeneous spinoff	Both CEO and Chairman are academics	D4 = 0	90/307 = 29%
Heterogeneous spinoff	Either CEO or Chairman are non-academics	D4 = 1	217/307 = 71%

Regarding the founding team, we have included the number of people in the founding team as a control at firm level. A high number of team members can in fact introduce a greater extent of diversity (Visintin and Pittino, 2014).

The dummy variable *Innovative spinoff* is the last independent variable. It is built on the Italian Registry of Innovative Firms (Registro delle imprese innovative). Companies that are included in this register benefit from the flexible employment contracts of start-ups and receive fiscal incentives to employ highly qualified personnel (among other regulatory features). To be considered an innovative start-up (in our analysis an innovative spinoff), according to the Decree Law 179/12, companies must be independent, based in Italy and also comply with additional criteria. Companies other than ASOs (which are automatically included) must be less than 5 years old, have a turnover of less than 5 million euros, be at least 51% directly owned by physical subjects, aim to develop innovative products or services and have a high degree of technological content. Moreover, the firm must meet (at least) one of the following further requirements: R&D expenses/return ratio must be greater than 15%, at least one-third of the total workforce must possess a Ph. D. or have worked for at least 3 years at a research institute and the firm must be the holder or licensee of at least one patent.

The selection of control variables is based on the existent literature that demonstrates that context conditions impact on the growth of spinoffs (Bekkers et al., 2006; Gilsing et al., 2010). Focusing on the Italian context, three sets of control variables are considered: regional-level, university-level and firm-level.

The first category is composed of firm-level control variables measured at the year of establishment of the ASOs. *Firm size* measured by the total sales at the year of establishment per firm, *Team size* as number of people in founding team at founding date; Return on investment (*ROI*); *Leverage* calculated as the ratio between company's total liabilities and stockholders' equity; *LLC Spinoffs*, a dummy variable equal to 1 for Limited Liability Companies (Civera et al., 2019, 2020; Fini et al., 2011).

The second category involves university-level control variables calculated at the year of establishment of the ASOs for parent universities. *TTO size,* displayed as the number of employees in the Technology Transfer Office and *Spinoff experience* calculated by the spinoffs accumulated by a university, identifying its commitment toward entrepreneurship. The total number of *Students* indicates the university size; *Medical studies* and *Technical university* inform the university orientation toward specific disciplines. Finally, the university presence in the ARWU ranking controls for research eminence (Civera et al., 2019, 2020; Fini et al., 2011).

The last category, regional-level control variables, considers regions where ASOs are settled at the year of establishment. This includes *Regional GDP per capita* to account for the favourable economic environment of the regions and the percentage of *STEM* G*raduates* (Science, Technology Engineering and Mathematics) to measure the quality of the human capital to be employed (Civera et al., 2019, 2020; Fini et al., 2011). Table 5 summarises the variable definition and data sources.

Table 5 Variable definitions and relative data sources

Variable	*Description*	*Source*
	Panel A: Dependent variables	
Spinoff Growth	Compound annual growth rate of income per firm three year after the establishment	AIDA
	Panel B: Independent variables	
	Diversity measures	
Profile differentiation	Diversity derived from the presence of non-academic members	Own elaboration of the CV
Cognitive distance	Diversity derived from the presence of members belonging to different disciplinary fields	Own elaboration of the CV
CEO non-duality	Diversity derived from the absence of CEO duality	Own elaboration of the CV
Non-academic CEO	Diversity derived from the presence of non-academic members as CEO	Own elaboration of the CV
	Technological level	
Innovative spinoff	Dummy equal to 1 if the academic spinoff adopts technologies and applications such as the Internet of Things, Industry 4.0, artificial intelligence, block chain, automation, remote monitoring, predictive maintenance, smart contracts, big data, cloud computing	(Parida et al., 2019)
	Panel C: Control variables	
	Firm Level Control variable	
Firm size	Total Sales at the year of establishment per firm (ln 1 + Total Sales in regression analyses)	AIDA
Team size	Number of people in the founding team	Own elaboration
ROI	Return on investment at the year of establishment per firm	AIDA
Leverage	Debt-to-equity ratio calculated by dividing company's total liabilities by its stockholders' equity at the year of establishment per firm	AIDA
LLC Spinoff	Dummy variable equal to 1 for Limited Liability Companies	AIDA
	University level control variable	
TTO size	Number of people employed in Technology Transfer Office of the parent university at the year of establishment	CRUI
Spinoff Experience	Cumulative number of spinoffs from the parent university until the year of establishment	MIUR
Students	Total number of students of the parent university at the year of establishment	MIUR
Medical Studies	Dummy variable equal to 1 for parent universities comprising medical studies	MIUR
Technical University	Dummy variable equal to 1 for parent universities comprising technical studies	MIUR

Table 5 Variable definitions and relative data sources (continued)

Variable	*Description*	*Source*
	University level control variable	
ARWU	Dummy variable equal to 1 if the parent university is ranked in the Academic Ranking of World Universities, zero otherwise.	Shanghai ranking website
	Regional level control variable	
Regional GDP per capita	Ratio of gross domestic product and population at regional level, in thousand euros. This variable is per region at the year of establishment	Istat
STEM Graduates	Number of graduates in science, technology, engineering, and mathematics between 20 and 29 years old (per thousand people) per region at the year of establishment	Own elaboration of the MIUR database

4 Results

There are 1257 total members of founding teams in our sample, which averages out to four members per founding team. Table 6 exhibits some characteristics of the founding teams. Only 23% of members are female. Three out of four members belong to academia. Among the academic members, 54% are tenure academic staff (39% are professors and 15% are researchers[1]) whereas 43% are research fellows,[2] of which 18% are post-doc research fellows. The remaining 3% consists of students. Regarding the field of study of the academic members, five disciplinary areas are identified based on the SSD (Settore Scientifico Disciplinare) of each member. 44% of the founding members belong to the field of Engineering and Technology, followed by the fields of study in Medicine and Biology (20%) and Natural Science (26%), while only 4% are involved in Humanities and social sciences. By focusing on non-academic members, four areas are identified. The largest percentage is represented by members working in the fields of Information Technology and Engineering (43%), yet there are members from the economic-legal sector (24%) and research in private organisations (20%). The smallest percentage is represented by the medical-biological sector (13%). When considering the CEOs and Chairmen, only one-fifth are female, and one-third are non-academic members.

Table 7 exhibits the descriptive statistics of the sample. On average the Italian spinoffs grows by 4.31% during the first three years. Referring to the independent variables of our analysis, around 24% of the ASOs are established by teams with non-academic members, 21% with members belonging to different disciplinary fields, 13% by teams where the CEO and the Chairman are two distinctive individuals, and 9% by teams with a non-academic CEO/Chairman. Our descriptive statistics on founding team composition are mostly in line with previous studies grounded in the Italian context. Visintin and Pittino (2014) in the period December 2009–February 2010 conducted interviews on 103 companies, out of the total 558 spinoff companies founded in the period 2000–2006, which is earlier than our timespan. Their study indicates that around 44% of members are characterised by common disciplinary background (vs. 50% of our study, in Table 2). The academic members' status is mainly homogenous, as 60% of the

members have the same academic rank (similar to our descriptive statistics in Table 6). Similarly, the profile differentiation is around 35% while in our study it is close to 24% (see Table 1).

Table 6 Descriptive statistics of the founding team members

Variable	*Percentage* (%)	*Variable*	*Percentage* (%)
Founding team members		*CEOs and Chairmen*	
Academic members	75	Academic members	71
Non-academic members	25	Non-academic members	29
Male	69	Male	80
Female	23	Female	20
Internal members positions			
Professors	39		
Researchers	15		
Research fellows	43		
Of which Postdoc research fellows	18		
Students	3		
Academic members' profile		*Non-academic members' profile*	
Engineering	44	Information Technology and Engineering	43
Medicine and Biology	20	Economic-legal sector	24
Natural Science	26	Research in private organisations	20
Humanities and social sciences	4	Medical-biological sector	13

Not surprisingly, less than 1 out of 7 ASOs (14%) is characterised by innovative technology. Compared with northern EU countries, Italy is a moderate innovator (Galati et al., 2017), characterised by low venture capital levels (Iacobucci and Micozzi, 2015), weaker innovation systems (Colombo and Delmastro, 2002), poor support to the growth of high-tech start-ups (Fini et al., 2017; Iacobucci and Micozzi, 2015) and low levels of doctorates or graduates (Rizzo, 2015).

The firm-, university-, and regional-level characteristics are consistent with those from Civera et al. (2020), who analyse a sample of 613 Italian ASOs established over the period 2006–2012. At firm level, 98% of the companies are limited liability companies. The firm size is small and the total assets are around 24.4 thousand euros on average. The financial leverage is lower than 30%, meaning that Italian ASOs do not rely on debt but rather on equity. The return on investment is slightly negative. Concerning the university level controls, employees of the TTOs are on average 4, and the previous spinoff experience includes 4 spinoffs per university. Around 76% offer medical studies, only 8% are technical universities and more than half are ranked in the Shanghai ranking. In considering regional control variables, the average GDP per capita is equal to 29 thousand euros and the ratio of graduates in the STEM disciplines is 14%. [3]

Table 7 Descriptive statistics of the sample

Variable	*Obs*	*Mean*	*Std. dev*	*Min*	*Max*
Dependent variable					
Spinoff growth (%, over 3 years)	307	4.31	64.61	–76.67	277.72
Independent variables					
Diversity measures					
Profile differentiation (D1) (%)	307	23.54	28.28	0.00	100.00
Cognitive distance (D2) (%)	307	20.57	24.26	0.00	100.00
CEO non-duality (D3) (%)	307	12.87	33.54	0.00	100.00
Non-academic CEO (D4) (%)	307	8.98	28.64	0.00	100.00
Technological level					
Innovative spinoff (dummy)	307	0.14	0.35	0.00	1.00
Firm-level controls					
Firm size (k€)	307	24.41	61.62	0.00	580.38
Team size (No.)	307	3.83	1.58	1.00	10.00
ROI (%)	307	–0.47	14.19	–29.71	29.39
Leverage (%)	307	27.04	37.28	0.00	71.42
LLC Spinoff (dummy)	307	0.98	0.11	0.00	1.00
University-level controls					
TTO size (No.)	307	4.53	3.43	0.00	13.00
Spinoff Experience (No.)	307	3.88	4.10	0.00	20.00
Students (k)	307	33.67	24.16	0.00	135.08
Medical Studies (%)	307	75.75	42.92	0.00	100.00
Technical University (%)	307	8.00	27.00	0.00	100.00
ARWU (%)	307	54.49	49.87	0.00	100.00
Regional-level controls					
Regional GDP per capita (k€)	307	28.53	2.23	15.98	39.68
STEM Graduates	307	14.10	3.90	0.75	18.94

Empirical results are reported in Tables 8 and 9 respectively. Table 8 shows the relationship between diversity measures and growth. Model 1–4 includes the individual measures of diversity, while Model 5 includes all the measures together. Hypotheses 1, 3 and 4 are verified as the coefficients for D1, D3, and D4 are positive and statistically significant ($p < 0.05$). The statistical significance becomes weak when the diversity measures are all taken into consideration. Our results confirm the idea that the presence of both academic and non-academic members allows the integration between scientific and economic competencies, which leads to better performance (Visintin and Pittino, 2014). This result is in line with extant literature underlying the relevance of non-academics in providing complementary competencies to the ASO's founding team (Wennberg et al., 2011). By contrast, if we assess the effect of different disciplinary backgrounds, or cognitive distance, the hypothesis is not supported. Visintin and Pittino (2014) found the same evidence by analysing a sample of 103 Italian ASOs. This might

suggest that, in contrast with Knockaert et al. (2011), the degree to which knowledge, experience, skills, and cognition differ is less important than the mere inclusion of a non-academic member. Referring to the role of the CEO, our results verify the past research stating that performance is higher when CEO non-duality is in place as it ensures greater scrutiny of managerial behaviour and leads to higher performance (Pugliese and Wenstøp, 2007), especially in the case of ASOs (Prencipe, 2016). Moreover, as the CEO position is extremely relevant and affects the organisation, according to the Upper Echelon theory (Knockaert et al., 2011), a non-academic CEO is beneficial for the growth of the company in virtue of their competence and experience in business aspects.

Table 8 Diversity and growth

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Growth (3 years)	*Growth (3 years)*	*Growth (3 years)*	*Growth (3 years)*	*Growth (3 years)*
Profile differentiation – D1	0.379**				0.372**
	(0.163)				(0.501)
Cognitive distance – D2		0.115			0.076
		(0.070)			(0.125)
CEO non-duality – D3			0.112**		0.092*
			(0.058)		(0.057)
Non-academic CEO – D4				0.186**	0.179*
				(0.082)	(0.105)
Innovative Spinoffs	0.318*	0.331*	0.331*	0.336*	0.319*
	(0.170)	(0.186)	(0.188)	(0.186)	(0.172)
Firm size	–0.001	–0.001	–0.001	–0.001	–0.001
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
Team size	0.042	0.043	0.041	0.043	0.048
	(0.029)	(0.032)	(0.030)	(0.029)	(0.033)
ROI	0.003	0.004	0.004	0.004	0.003
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Leverage	0.177**	0.206**	0.208**	0.182**	0.169***
	(0.083)	(0.099)	(0.102)	(0.092)	(0.039)
LLC Spinoff	0.258*	0.201	0.225	0.246	0.288
	(0.155)	(0.134)	(0.151)	(0.165)	(0.180)
TTO size	0.742	0.727	0.705	0.698	0.806
	(0.783)	(0.808)	(0.755)	(0.880)	(0.870)
Spinoff Experience	0.129	0.124	0.144	0.165	0.180
	(0.117)	(0.118)	(0.115)	(0.117)	(0.099)
Students	0.780	0.760	0.760	0.710	0.801
	(0.500)	(0.520)	(0.470)	(0.590)	(0.614)
Medical Studies	–0.079	–0.081	–0.085	–0.081	–0.060
	(0.054)	(0.055)	(0.066)	(0.084)	(0.085)

Table 8 Diversity and growth (continued)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Growth (3 years)	*Growth (3 years)*	*Growth (3 years)*	*Growth (3 years)*	*Growth (3 years)*
Technical University	0.425	0.417	0.418	0.446	0.209
	(0.569)	(0.554)	(0.508)	(0.608)	(0.439)
ARWU	–0.306	–0.277	–0.278	–0.286	–0.311
	(0.245)	(0.290)	(0.294)	(0.292)	(0.309)
Regional GDP per capita	0.146	0.124	0.170	0.110	0.085
	(0.180)	(0.120)	(0.192)	(0.110)	(0.102)
STEM Graduates	0.906	0.864	0.880	0.852	0.799
	(0.804)	(0.800)	(0.699)	(0.972)	(0.871)
Constant	–1.958	–1.903	–1.911	–1.943	–2.066
	(1.767)	(1.904)	(1.902)	(1.871)	(1.981)
Observations	307	307	307	307	307
R-squared	0.071	0.060	0.060	0.062	0.072

Heteroskedasticity robust standard errors are reported in brackets. ***, ** and * represent, respectively, significance at less than 1%, 5% and 10%.

The independent variable *Innovative spinoffs* is also positive and statistically significant, but only at 10%. This was also the case for the 98 German research-based spinoffs founded between 1997 and 2012 that were studied by Bock et al. (2018). Likewise, Clarysse et al. (2011) analysed 48 corporate and 73 university spinoffs, comprising the population of spinoffs in Flanders from 1991–2002, and found that technology is positively associated with growth. Again, based on 80 Norwegian and Swedish technology-based start-ups, Aspelund et al. (2005) highlighted that a greater degree of innovativeness leads to a higher probability of survival. Thus, radical innovations are less subject to being imitated and guarantee greater competitive advantages, giving the companies more time to commercialise the product or service (Bock et al., 2018).

Among the controls, only the leverage is positively and statistically significant. According to Cassar (2004), start-up growth intentions significantly influence the leverage and long-term leverage of firm start-ups, and in particular start-up growth intentions are positively related to outside and bank financing.

Table 9 displays the interaction between the founding team diversity and the technological innovativeness of the ASOs, and the results are intriguing. The positive role of founding team diversity is verified only in the case of innovative companies. Thus, only the interaction coefficient is statistically significant and positive in its sign, whereas the direct effect is no longer significant (see Model 1–3 and Model 5). The only exception is for the non-academic CEO, which exerts a direct influence on growth. This is coherent with the systematic literature review by Unger et al. (2011), who found that the contextual conditions under which human capital characteristics are employed are particularly important. Specifically, when sophisticated and complex technologies are

adopted, extensive knowledge and research are required because companies operate in dynamic and uncertain environments (Khandwalla, 1976). Diverse human capital should help because knowledge and valid experience reduce uncertainty associated with innovation and dynamic environments (McMullen and Shepherd, 2006). Extant literature demonstrates that the lack of networks to business professionals outside the research organisation and the radicality of the new technologies negatively affect performance of companies such as the ASOs (Clarysse et al., 2011; Colombo and Piva, 2012).[4]

Table 9 Moderating effect of innovative spinoffs

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Growth (3 years)	*Growth (3 years)*	*Growth (3 years)*	*Growth (3 years)*	*Growth (3 years)*
Profile differentiation – D1	0.049				0.039
	(0.173)				(0.172)
D1×Innovative Spinoffs	0.640**				0.838**
	(0.285)				(0.325)
Cognitive distance – D2A		0.059			–0.004
		(0.214)			(0.201)
D2×Innovative Spinoffs		0.283**			0.214*
		(0.099)			(0.127)
CEO non–duality – D2B			0.028		0.128
			(0.161)		(0.149)
D3×Innovative Spinoffs			0.229**		0.186*
			(0.107)		(0.109)
Non–academic CEO – D4				0.228**	0.215**
				(0.098)	(0.102)
D4×Innovative Spinoffs				–0.029	–0.624
				(0.182)	(0.836)
Innovative Spinoffs	–0.087	0.268	0.263	0.355*	–0.080
	(0.280)	(0.196)	(0.214)	(0.204)	(0.254)
Firm size	–0.001	–0.001	–0.001	–0.001	–0.000
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Team size	0.060*	0.044	0.039	0.043	0.063*
	(0.033)	(0.032)	(0.030)	(0.029)	(0.038)
ROI	0.003	0.004	0.004	0.004	0.003
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Leverage	0.206**	0.207**	0.208**	0.177**	0.189***
	(0.088)	(0.089)	(0.091)	(0.084)	(0.046)

Table 9 Moderating effect of innovative spinoffs (continued)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Growth (3 years)	*Growth (3 years)*	*Growth (3 years)*	*Growth (3 years)*	*Growth (3 years)*
LLC Spinoff	0.213	0.207	0.232	0.255	0.265
	(0.142)	(0.137)	(0.158)	(0.173)	(0.185)
	(0.804)	(0.800)	(0.699)	(0.921)	(0.876)
TTO size	0.711	0.710	0.710	0.710	0.690
	(0.718)	(0.719)	(0.719)	(0.698)	(0.618)
Spinoff Experience	0.122	0.123	0.120	0.122	0.157
	(0.110)	(0.112)	(0.113)	(0.121)	(0.145)
Students	0.762	0.754	0.754	0.756	0.652
	(0.571)	(0.581)	(0.584)	(0.579)	(0.564)
Medical Studies	–0.077	–0.109	–0.103	–0.142	–0.103
	(0.284)	(0.297)	(0.292)	(0.278)	(0.287)
Technical University	0.494	0.471	0.488	0.414	0.327
	(0.546)	(0.547)	(0.549)	(0.546)	(0.356)
ARWU	–0.260	–0.276	–0.284	–0.290	–0.269
	(0.205)	(0.249)	(0.254)	(0.246)	(0.248)
Regional GDP per capita	0.141	0.130	0.152	0.098	0.060
	(0.168)	(0.118)	(0.189)	(0.110)	(0.092)
STEM Graduates	0.896	0.904	0.801	0.848	0.716
Constant	–1.955	–1.925	–1.917	–1.922	–1.877
	(1.776)	(1.951)	(1.921)	(1.898)	(1.707)
Observations	307	307	307	307	307
R-squared	0.108	0.060	0.061	0.063	0.116

Heteroskedasticity robust standard errors are reported in brackets. ***, ** and * represent, respectively, significance at less than 1%, 5% and 10%.

5 Conclusions

Academic spinoffs are companies founded by academic inventors aiming to exploit technological knowledge that originated within a university to develop products or services. These companies contribute to technology transfer in two stages. First, they transfer technology from their parent organisation to themselves and, second, they transfer the technology to customers. Such companies have received increasing attention in the last two decades from both researchers and practitioners, mainly due to their ability to advance industrial application of scientific knowledge. Recently, however, the focus

has shifted to ASO performance and the determinants of their growth. The existing empirical evidence shows that there is either a positive or negative link between heterogeneity of competences and performance (Bock et al., 2018; Hmieleski and Ensley, 2005; Knockaert et al., 2011; Visintin and Pittino, 2014).

This paper sheds light on the role of several dimensions of diversity for the growth of a sample of 307 Italian ASOs. The results provide support to the fact that profile differentiation, CEO non-duality and the presence of a non-academic CEO enhance the initial growth of ASOs. Yet, this is the case only when the ASOs are characterised by a high level of technological novelty. Thus, profile differentiation, cognitive distance and CEO non-duality are drivers of company growth exclusively when mediated by the adoption of an innovative technology, thereby confirming the extreme relevance of context (Unger et al., 2011).

6 Contribution to scholarship

We contribute to the stream of literature dealing with founding team diversity and firm performance by applying the upper-echelon theory to ASO companies. These spinoff teams have been shown to be largely homogeneous in terms of education, industry experience, functional expertise and the skill sets of their members (Hmieleski and Ensley, 2005; Lockett et al., 2005), and therefore likely to possess a 'knowledge gap' in relation to their multidisciplinary task. Including non-academic members, members with different background in terms of disciplinary field and cognitive frames and maintaining CEO non-duality are beneficial, but only when the ASO is technologically innovative. Thus, a highly-innovative technology helps ASOs to scale up during the early stage of development, as it is positively related to the growth rate in the first three years after the establishment. Moreover, we demonstrate that ASOs grow when innovative technology is adopted by a highly-diverse founding team. Therefore, innovative contexts require a greater extent of diversification in terms of roles, disciplines and ranks within founding teams. By contrast, picking a non-academic member as CEO is always beneficial for ASOs to improve their initial performance, regardless the technology adopted. This is because, according to the Upper Echelon theory, the leading role is able to influence the whole organisation, and non-academic CEOs provide complementary skills and competences valuable for firm performance, regardless of the technologies adopted.

7 Contribution to practice

This study is relevant during the spinoff formation process, especially for the definition of the initial team. The findings may provide the most proper configuration for founding teams in ASOs aiming to grow. It can be useful for Technology Transfer Offices, which have the aim to spur business innovation, foster competitiveness, generate new job opportunities and facilitate economic and social development of the academic activity. The specific policies of technology transfer set out by TTOs mainly address the creation

of spinoffs considered as a driving force in enhancing economic and social development. Moreover, these results can be considered relevant to universities managers, to design policies intended to enhance team diversity. For example, they might create some incentives, either economic or non-economic, in favour of ASOs generated by diverse teams. An individual CV shows for the academics their rank and scientific field in which they are an expert; similarly, for non-academics, a CV indicates in which industry they accumulate their experience, their job position and function. By receiving this document, it is possible for university management to assess the degree of diversity of the founding teams and therefore to distribute the planned rewards accordingly.

Basing on our empirical findings, supporting differentiation of founding teams is even more important for innovative companies. Therefore, the level of innovativeness in the technology adopted should be at centre of the policies designed by both TTOs and university managers in general.

8 Limitations and future research

Nevertheless, the study is not free from limitations. First, the robustness of the causal relations among the dimensions investigated may be limited by the short period of investigation. Second, the generalisation of the results and the theoretical background on the matter of the role of team diversity would benefit from a comparison among ASO activities from other European countries. Third, a number of additional diversity measures could be calculated and tested. Fourth, the analysis is cross sectional, as the ASOs are observed at the year of foundation. For these reasons, the next steps of the research might consist of widening the sample, including spinoffs from other countries and analysing different types of diversity. For example, we have studied the profile differentiation (academic vs non-academic) of team members and in particular of CEOs. This dichotomy supposes that non-academic members, compared to academics, have experienced business activities, and developed business-related competences to complement the scientific one. Yet, we do not directly take into account the previous entrepreneurial experience of team members, which is a more precise detail about their managerial skills and competences. Although we may deduce that, even when the non-academic members have no prior entrepreneurial experience they enhance the company performance, controlling for it may present worthwhile insights and better disentangle the concept of diversity. Moreover, it would be interesting to observe yearly changes in the founding team composition to better understand the existing dynamics and potential conflicts. Finally, as suggested by Civera et al. (2020), not all ASOs are generated to grow. There are several motivations to establish ASOs, and these can lead to different types of performance. Investigating whether the diversity of the founding team and the innovativeness of the technologies adopted play a different role according to the motivations at the base of the academic entrepreneurial activity constitutes an interesting future venue of research. Furthermore, the success of a company can be measured also in terms of external capital, such as the ability of the ASOs to attract VCs and/or Business Angels. Collecting ad hoc data by matching the sample of companies with those

registered on online platforms such as Crunchbase would make this avenue of investigation possible.

Finally, we call for additional studies on the technology adoption process both in innovative and non-innovative companies in order to detect specific mechanisms and channels. Lastly, it would be interesting to investigate how new market opportunities are detected and whether ASOs need to develop new ad hoc technologies to take advantage of them.

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Notes

[1]Until a few years ago in Italian universities, researcher was a permanent position, with a probationary period of three years, which included passing a written and oral examination. The position of researcher is being phased out and being replaced by two new positions, non-tenure researchers (Ricercatori a tempo determinato di tipo A – RTDA) and tenure-track researchers (Ricercatore a tempo determinato di tipo B – RTDB).

[2]Research fellows (in Italian assegnisti di ricerca) are non-tenure researchers who work as research assistants for a specific project.

[3]The correlation matrix is available in Appendix.

[4]Results yield similar evidence, in terms of sign, at lower level of significance when the dependent variable is the growth of the number of employees.

Appendix. Correlation matrix

		(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*	*(16)*	*(17)*
(1)	Spinoff Growth	1.000																
(2)	Profile differentiation	0.105	1.000															
(3)	Cognitive differentiation	0.039	**0.391**	1.000														
(4)	CEO non-duality	0.036	0.114	0.065	1.000													
(5)	Non-academic CEO	0.059	**0.324**	0.181	**0.216**	1.000												
(6)	Innovative spinoff	0.144	0.061	0.044	0.044	-0.009	1.000											
(7)	Firm size	0.044	–0.084	–0.098	–0.033	–0.054	0.011	1.000										
(8)	Team size	0.075	0.048	**0.286**	**0.287**	0.025	0.013	0.037	1.000									
(9)	ROI	0.069	–0.039	–0.091	–0.032	–0.044	–0.015	**0.479**	0.000	1.000								
(10)	Leverage	0.101	0.123	0.009	–0.021	0.191	–0.021	–0.022	0.010	0.010	1.000							
(11)	LLC Spinoff	0.034	–0.054	0.010	–0.053	–0.070	0.057	0.005	–0.013	0.020	0.003	1.000						
(12)	TTO size	–0.010	0.037	0.025	–0.011	0.023	–0.046	0.118	0.092	0.095	–0.007	–0.129	1.000					
(13)	Spinoff Experience	–0.060	**0.176**	0.087	0.009	0.046	0.056	**–0.151**	0.033	–0.101	–0.039	0.045	0.019	1.000				
(14)	Medical Studies	0.091	0.006	0.040	0.047	0.024	0.035	0.136	0.047	0.117	0.057	–0.010	0.303	–0.186	1.000			
(15)	Technical University	0.033	–0.079	0.047	–0.134	–0.006	0.011	–0.070	–0.032	–0.051	–0.010	0.056	0.075	–0.086	0.047	1.000		
(16)	ARWU	–0.032	0.060	–0.107	0.123	0.028	0.023	0.092	–0.048	0.070	0.011	0.014	–0.095	0.064	–0.033	–0.909	1.000	
(17)	Regional GDP pc	–0.001	0.067	0.017	0.066	0.071	0.018	0.058	0.047	0.021	0.062	0.013	0.160	–0.155	**0.434**	0.048	–0.055	1.000
(18)	STEM Graduates	–0.033	0.042	–0.125	0.073	0.028	0.058	0.091	0.054	0.039	–0.083	0.023	0.233	0.055	0.125	-0.053	0.046	**0.326**

Coefficients significant at less than 1% are in bold.