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Does team diversity really matter? The connection between networks, access to financial resources, and performance in the context of university spin-offs

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Abstract University spin-offs (USOs) are an important driver for innovation, along with economic and social development. Hence, understanding which factors help them perform successfully is crucial, especially regarding their peculiarities in a scientific environment. This study focuses on essential factors such as team composition and diversity in USOs in the biotech sector in 64 founding teams in Switzerland and Germany. By identifying the team composition, and going beyond the usual team characteristics, along with checking in parallel for network and financing effects, the paper adds empirical evidence to the ongoing debate if and how team diversity in USOs affects the performance of this special group of newly founded firms. We test our hypotheses with the partial least squares method (PLS). Our results from the mediation model show how the diversity of teams is related to networks and financial resources and affects the performance. In addition, our study reveals the direct and indirect effects of team diversity on success in USOs. This way we contribute to the ongoing discussion on performance investigating the sources of team effects more in detail.

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1 Introduction

In the last two decades, research on team composition and the effectiveness of university spin-offs (USOs) in the entrepreneurship and management literature has increased (e.g., Cohen and Bailey (1997), Mathieu et al. (2008), Klotz et al. (2014), Hahn et al. (2019), Civera et al. (2020), Civera et al. (2019b)), due to the fact that USOs in knowledge- and technology-based industries have become an important wealth-creating factor as vehicles of technology transfer (Shane (2004)): they are often considered the cornerstone of innovation, growth, and social welfare by commercializing research results (Vohora et al. (2004), Hogan and Zhou (2010), Bolzani et al. (2014)) and by altering existing sectors or establishing new ones (Breznitz et al. (2008)). Pushed by policy support measures, a growing venture capital (VC) industry, and an increasing interest of researchers themselves (Mustar et al. (2008), Lam (2010), Venkataraman (2004), Horta et al. (2016) from a push perspective), there has been a substantial rise in the creation of USOs in the USA, Europe, and other industrialized countries, representing the majority of new ventures, as is characteristic in biotechnology (Bonardo et al. (2011)).

To understand better the drivers of performance of USOs, we have to define them: Compared to regular start-ups, USOs are founded by academics and researchers who transfer technology or technology-based ideas and inventions developed within a university to the private sector with the aim of transforming scientific findings into marketable processes and products (Helm and Mauroner (2007), Steffensen et al. (2000), Walter et al. (2011)).

However, does team diversity really matter in this context? The question if team diversity, namely team hetero- or homogeneity, affects performance in USOs is still unanswered and a clear effect cannot be found (Mathisen and Rasmussen (2019); Nikiforou et al. (2018), Chowdhury (2005)). Thus, an ongoing and still unresolved debate on whether heterogeneous teams are more successful and better than their homogeneous counterparts, or vice versa exists (e.g., Klotz et al. (2014)). Even observing some fruitful empirical insights concerning team diversity in general (Clarysse et al. (2007a), Grandi and Grimaldi (2003)) and especially in USOs (Ben-Hafaïedh et al. (2018)), the question about the most effective and promising team composition in USOs remains unanswered due to a paucity of research regarding team composition (Markman et al. (2008), Ferretti et al. 2018) and performance (Czarnitzki et al. (2014)), (Meoli et al. (2018)). Current research confirms that USOs often do not outperform innovative start-ups (Visintin and Pittino (2014), Civera et al. (2019a, b), Siegel and Wright (2007), Wright et al. (2007)). To get a better understanding of performance, a growing number of studies do analyze either organizational issues (institutional aspects like incubators) or environmental settings (e.g., financing and social capital) (Audretsch et al. (2016), Ferretti et al. (2019)) or the characteristics of the founders (Ben-Hafaïedh et al. (2018)), such as human or social capital, team size, and team composition (Ferretti et al. (2018), Huynh et al. (2017), Huynh (2016)), but could not find consistent results (see the overview of Mathisen and Rasmussen (2019)).

With this study, we want to link our research questions with the gaps of the current research and follow the advice of Mathisen and Rasmussen (2019: 1909), explaining that: "The USO context is also well suited to study how new venture teams are able to connect with other actors that can provide access to the resources necessary to start, develop and grow a new venture. Promising theoretical perspectives include identity processes (Powell and Baker 2017) and social networks (Leyden et al. 2014), because these can go beyond the surface characteristics and structures of teams and investigate the sources of team dynamics. Because USOs typically relay on many different actors in their development, research that shed light on the relationship between USO teams and their support networks or ecosystem, would be of high practical relevance." Thus, finding an answer to this open research gap in the performance factors of USOs, especially the team composition, appears to be fairly challenging. Therefore, it could be important to work with data restrictions to analyze specific context factors in different kinds of start-ups, to get closer and more thoughtful insights in this unique empirical context, and to explore also questions of broader theoretical interest (i.e., in regard to general team composition and management (Fini et al. (2019)). This paper follows this approach by focusing on USOs as a very peculiar kind of newly started businesses, because they are located between a scientific and commercial context and have to deal with specific challenges (Visintin and Pittino (2014), Knockaert et al. (2009), Hahn et al. (2019)). To do so, "…will also improve the understanding of USOs performance by bringing in a broader set of theoretical perspectives…" (Mathisen and Rasmussen (2019: 1917). Thus, we work with data from USOs in the life science industry, namely, the biotechnology sector, in Germany and Switzerland. This endeavor might help develop reasonable measures for team diversity variable(s) and find other models, such as the rarely used mediation models, that might lead to more satisfactory results (e.g., Ensley and Hmieleski (2005)) in this specific, highly innovative, and challenging context (i.e., Meoli et al. (2018)).

Until now, performance factors are often tested separately and in different ways, but rarely in interactions with one another (Ilgen et al. (2005)). Moreover, the team composition is commonly focused only on single aspects concerning diversity (either human or social capital tested with one variable or by age (Mathisen and Rasmussen (2019)); hence, a high probability for measurement errors and biased results exists (Carpenter et al. (2004)). These studies have asserted that a heterogeneous team is mostly conducive to the performance of young and developing USOs (Ben-Hafaïedh et al. (2018), Huynh et al. (2017), Huynh (2016)) and that the specific type of diversity matters, such as the proportion of academics and non-academics in a spin-off. Therefore, less or controlled diversity might enhance performance (Ferretti et al. (2019), Ferretti et al. (2018), in parts also Knockaert

et al. (2011), Visintin and Pittino (2014), Hahn et al. (2019)). Team composition is rarely tested in combination with other typical success factors of USOs embedded in the theory approach of the resource-based view, for example, by either the characteristics of the firm (resources including founders, strategies, capabilities, characteristics, initial competence endowments, sufficient or diverse human, social, and technological knowledge) (Clarysse et al. (2011), Colombo and Piva (2012), Cho and Sohn (2017), Hayter et al. (2017)) or other external factors (relationship with parent organizations, external supports) (Hossinger et al. (2019), Shane (2004)).

Therefore, this paper focuses on the effects of team diversity on performance in USOs, going beyond the general literature on team composition by combining this important factor of the involvement of multiple founders (e.g., Hahn et al. (2019)) with other imprinting factors, such as the founding team's network (Florin et al. (2003)) and access to financial resources (Hayter (2013)) trying to contribute new insights into the debate on USO performance (a more general overview offer Hossinger et al. (2019)), following the advice of Nikiforou et al. (2018) that "…also financing networks are very relevant largely discussed topics in the literature on USO teams…"

Wrapping this up, with this paper, the following aspects are stressed: (1) team composition as a determinant of USO performance; (2) the puzzling relationship between team diversity and performance in USOs both from a theoretical and empirical perspective (why diversity is good and why is it bad for USOs?); (3) contrasting the findings and discussing biased measures of diversity; and finally (4) the need to introduce an overall measure of diversity and to consider mediators to explain the mechanisms through which diversity leads to performance in order to reconcile the puzzles of the diversity-performance relationship. To do so, this paper aims to capture a broad approach on diversity issues in teams and to understand the direct and indirect effects of this diversity on USO performance. Moreover, this study generates new insights in the interrelation of USO team composition and other success factors, such as social capital, networks, and access to finance on performance. Moreover, we enlarge this research by focusing on the biotech USOs, thereby delivering a specific context insight regarding a field in two different national environments (Switzerland, Germany). This idea that team diversity matters in USOs because it helps to access a variety of resources is another contribution to the literature with some important managerial and practical implications (Diánez-González and Camelo-Ordaz (2019)). One typical problem of USOs, in fact, is the inability to transition from the university to the business world; this feature makes them relevant for questions related to mainstream management (transfer) research (Fini et al. 2019).

Our data allows us to shed light on the interrelation among team diversity, success factors as social capital and access to finance, and performance for USOs using a suitable research method (PLS). The results show that team diversity is essential for firms' network and could enhance the possibility to procure finance and generate an indirect, significantly positive influence on performance. Additionally, team diversity has a positive direct impact on the access to financial resources that in turn lead to a higher performance of firms. Therefore, our results regarding USOs in biotechnology emphasize to choose a more heterogeneous team composition either from the founders themselves or from universities and other public supporters which help to set up diverse teams over time and to consider other success factors in parallel. Based on the results of this study, team diversity seems to overcome the typical difficulty to access resources and gain credibility which inherently characterizes USOs and hampers their success (Rasmussen et al. 2011).

The rest of this paper is organized as follows: In the next section, the theoretical background and effects of team diversity on firm outcomes, especially performance in USOs, are discussed. Then, we outline and develop our hypotheses along with the prior discussion thoroughly, followed by presenting our sample, data, and the chosen empirical method. Finally, we discuss our results and reflect them in relation to the current literature and offer some implications for future research, policy makers, and managers of universities.

2 Theoretical background and hypothesis development

2.1 Upper echelon theory and team effectiveness frameworks

We follow Roberts (1991) or Hossinger et al. (2019) and Hahn et al. (2019) who suggest that the team of founders plays a critical role in shaping USO performance (Ferretti et al. (2018), Hesse and Sternberg

(2017)) due to their specific organizational conditions, such as combining science and commercialization (Knockaert et al. (2011), Mathisen and Rasmussen (2019)). Most team diversity research is based upon upper echelon theory (Hambrick and Mason (1984), Hambrick (2007)), theorizing that the management strategy and firm success or performance primarily depend on the composition, characteristics, and demographic of the top management team and that this effect is even stronger for smaller new companies compared with big ones (Greiner (1998), Ensley et al. (2006)). This is due to a primary lack of organizational structures in new venture firms that allow a greater latitude of the entrepreneurial team and therefore a higher influence on firm performance.

The analysis of direct effects and critical mediating mechanisms (indirect effects) with the other potential success factors of USO performance is needed to discover the relationship between team diversity and team outcomes. The upper echelon research on team diversity puts an emphasis on the direct effects of team composition on performance instead of indirect effects (Ilgen et al. (2005)). The analysis of direct effects is not satisfactory enough to open the black box between team inputs and performance (Klotz et al. (2014), Carpenter et al. (2004)). Meanwhile, in organizational behavior research, the relationship between team diversity and team outcomes is explained by the input-process-outcome (IPO) framework (McGrath (1964)) and the input-mediator-outcome (IMO) framework (Ilgen et al. (2005)). These team effectiveness frameworks provide the foundation for entrepreneurship researchers to develop their studies about the relationship between teams and outcomes and are more capable of explaining this relationship. It must be clarified that these frameworks exclusively use mediation models to analyze the effects of team composition. The IMO framework that constitutes the advanced IPO framework provides that outcomes (O) are the result of inputs (I) and mediators (M) (for a detailed explanation, see Ilgen et al. (2005)). Following Klotz et al. (2014), these inputs consist of prior experience, social capital, personality, and general ability. The mediators are team processes (transition processes, interpersonal processes, action processes) and emergent states (collective cognition, cohesion, team confidence, psychological safety, and affective tone), while the outcomes could be sales growth, profitability, number of employees, innovativeness, satisfaction, and well-being. Our approach in this paper is to follow the requirement of a mediation model to explore the relationship between team diversity and performance in USOs, whereby the mediators used are the most common critical success factors instead of emergent states and team processes as highlighted in the IMO and IPO models. Therefore, the upper echelon approach and the IPO and IMO frameworks represent the theoretical fundament in two ways: to identify prior research results regarding team diversity effects in general and for USOs in particular and to develop our hypotheses and empirical testing (see the following section).

2.2 Teams, team diversity, and outcome

When dealing with USOs, a common finding in the literature is that they are mostly founded by teams (Roberts (1991), Knockaert et al. (2011), D'Este et al. (2012), Hayter (2013), Visintin and Pittino (2014), Ciuchta et al. (2016), Huynh et al. (2017), Ferretti et al. (2018)). Before diving into the discussion and analysis of prior studies analyzing the impact of team composition on USO performance, we provide a definition of a team in an organizational context. According to Mathieu et al. (2008) and Kozlowski and Bell 2003: Teams are "collectives who exist to perform organizationally relevant tasks, share one or more common goals, interact socially, exhibit task interdependencies, maintain and manage boundaries, and are embedded in an organizational context that set boundaries, constrains the team, and influences exchanges with other units in the broader entity." (Kozlowski and Bell (2003), p. 6). Additionally Ensley et al. (1998) stated that entrepreneurial team members must have (1) established the firm, (2) a financial interest, and (3) an influence on strategic choices. Ucbasaran et al. (2003) corroborated these aspects of founding teams. In our analysis, we follow Kozlowski and Bell (2003) and Ensley et al. (1998) and concentrate on teams and team members fulfilling these requirements.

To start, the effects of team diversity on firm performance in general are the topic of a controversial debate (Webber and Donahue (2001)). This is not surprising, regarding the two diametrically opposed theories of Byrne (1971) and Horwitz (2005). The latter emphasized the superiority of heterogeneous teams, while

Byrne (1971) showed that homogeneous teams perform better because the similarity-attraction paradigm states that homogeneity pushes team cohesion, motivation, and interaction among team members. On the contrary, on the basis of the theory of cognitive resource diversity, Cox and Blake (1991) and Horwitz (2005) demonstrated that heterogeneous teams are more powerful than homogeneous ones because they are more innovative and creative and able to solve problems much easier due the strength of their diversity. However, in the end, most studies have claimed that USOs with a founding team do outperform companies started by a single founder (Roberts (1991), Ensley and Hmieleski (2005)). Some articles have confirmed these findings, emphasizing the importance of homogeneous and balanced composition and structure of a team, and others have focused on the diverse expertise of heterogeneous teams in USOs as the best way to achieve success in start-ups in general and USOs in particular, because of their specific challenges (Mathisen and Rasmussen (2019), Knockaert et al. (2011)).

2.2.1 University spin-offs and diversity of teams—positive and negative effects

A growing body of literature focusing on the effects of team diversity on the performance for USOs (e.g., Hahn et al. (2019)) has three main directions—the founder or inventor, the team, as well as the skills and networks (Mathisen and Rasmussen (2019), Diánez-González and Camelo-Ordaz (2019)). In this paper, we focus on the effects of team composition, because this literature is still a bit scarce and "one-dimensional." Earlier studies have focused more strongly on this one or two dimensions of diversity or measured only by team size and the effects on USO performance. Team diversity is commonly measured by human capital in terms of team members' previous industrial or management experience, with industrial experience serving as a key predictor for firm performance (Diánez-González and Camelo-Ordaz (2016), Delmar and Shane (2006)). Several studies have confirmed that the composition of a team significantly improves the USO performance when complementary human and social capital, such as business management expertise or market and technological knowledge, is important in the founding team, explaining that team heterogeneity is important for success without controlling for other factors, such as team size or deepness of diversity (Toole and Czarnitzki (2009), Gimmon and Levie (2010), Wennberg et al. (2011), D'Este et al. (2012), Borges and Jacques Filion 2013), Criaco et al. (2014), Fernández-Pérez et al. (2014), Nielsen (2015), Ciuchta et al. (2016), Helm et al. (2018)). For instance, Diánez-González and Camelo-Ordaz (2016) validated that the recruiting of non-academic individuals in the management team of USOs could outweigh the missing experience of the academics; hence, they are in favor of the heterogeneous combination of these skills and manager types to enhance USO performance. The same holds true for the study of Huynh et al. (2017) showing that the capabilities of the founding team have a positive influence on USO performance. Kilduff et al. (2000) similarly find that, in the case of demographic diversity, heterogeneity in the age of founder team members has a positive influence on performance (units sold, market share, other performance indicators) as well as differences in tenure (Jehn and Bezrukova (2004)). Furthermore, Eisenhardt and Schoonhoven (1990) affirmed that a growing team size leads to higher sales growth or productivity (Campion et al. (1993), Magjuka and Baldwin 1991). McGee et al. (1995) and Eisenhardt and Schoonhoven (1990) show that functional diversity (industry and work experience) affects performance positively, as well as heterogeneity in the proportion of different job categories (Magjuka and Baldwin (1991)). Regarding personality traits, Mohammad and Angell (2003) and Neuman et al. (1999) showed that diversity in team extraversion and emotional stability affects performance positively.

Conversely, studies like Shane and Stuart (2002) have delivered the insight that the industry experience of a USO founding team has no effect on the survival of the USO as a success measure. Instead, they show when some team members have different and higher levels of industry experience the time to market is shortened if the USOs survive the seed stage. Furthermore, entrepreneurial experience has no additional impact on the new venture success of USOs (e.g., Nerkar and Shane (2003)). For other measures, too, such as team diversity of age, religion, and family background, the results are not robust in delivering positive or negative performance effects (Roberts (1991)), but are rather inconsistent. Therefore, when considering even more the specific USO context, it has to be emphasized that the business idea is mostly created around a technological idea or very specific knowledge, often embedded or tacit in the head of one scientist or a team doing research on this

issue (Markman et al. (2008), Clarysse et al. (2007b)). Thus, when starting a business, these team members are commonly needed to transfer the invention into an innovation and a market-ready prototype or product (e.g., Knockaert et al. 2011, Di Gregorio and Shane (2003), Zucker and Darby (1998)). Therefore, this literature typically finds that a homogeneous team might be more promising due to the overlap of knowledge and (technological) understanding (Knockaert et al. (2011)). Amason et al. (2006) found that overall the increase of team heterogeneity leads to a decrease in new venture performance, processes, and effectiveness, as well as functional diversity (Carpenter (2002), Jehn and Bezrukova (2004), Pitcher and Smith (2001), (Knight et al. (1999), (Pelled et al. (1999), Ancona and Caldwell (1992), (Hambrick et al. (1996)). Diversity in extraversion as a personality trait (Mohammad and Angell (2004)) inhibits processes and diversity in neuroticism to performance (Halfhill et al. (2005)). Specifically, with regard to demographic aspects, such as race/ethnicity, gender, age, tenure, and even education, Jackson et al. 2003, Kirkman et al. (2001), Leonard et al. (2004), Li and Hambrick (2005), Mohammad and Angell (2004), Simons et al. (1999), Timmerman (2000), Townsend and Scott (2001), and Watson et al. (1998) verified that these diversity measures diminish performance as well and make processes more complicated. Webber and Donahue (2001) as well as Campion et al. (1993) found no effect of demographic diversity or skill heterogeneity on performance Thus, we can observe fairly inconsistent results (see again Mathisen and Rasmussen 2019).

Other research has verified that, in this case, the practical expertise is missing to commercialize the invention successfully. Therefore, a mix of both types of expertise would be better in a more heterogeneous team (Hahn et al. (2019), Knockaert et al. (2011), Visintin and Pittino 2014). Some of these studies show that the balance or rate of diversity has to be controlled for to minimize the problems in heterogeneous teams (Hahn et al. (2019), Knockaert et al. (2011), Visintin and Pittino (2014)). A further solution can be a specific mix of characteristics (Ben-Hafaïedh et al. (2018)). If not, the already discussed negative effects of team heterogeneity will exceed and lead to problems and negative performance in the case of USOs (Ferretti et al. (2018)).

Hence, Knockaert et al. (2011) found in their in-depth qualitative analysis of nine cases of USOs that these spin-offs were mostly founded around the research team and thus very homogeneous from the technological background and somehow the science fields but at the same time heterogeneous in terms of the age of the members along the hierarchies in the team (experienced researchers and PhDs or PostDocs). This is crucial for the initial success to develop the idea to a marketable level. At the same time, they can show that, for further development, bringing in other individuals with more commercial experiences is crucial; that is, a heterogeneous team is necessary but in a balanced way so as not to cause misunderstandings. They emphasized that tacit knowledge among the team members is the most important aspect; thus, the homogeneity and understanding of these team members appear to be more crucial. Visintin and Pittino (2014), who analyzed 103 Italian USOs, similarly observed that a team with both academic and non-academic backgrounds fosters the performance of USOs positively (sales and employment growth) but only when the duality of experiences is tempered by other characteristics such as sharing a common background (same university or field) and a smaller team size (Visintin and Pittino (2014)).

Ferretti et al. (2018) also showed quite distinctive and differentiating results in their panel study on 138 Italian USOs from 1999 until 2009. They found some positive effects of the academic and non-academic heterogeneity in teams on performance (sales). The ratio of academic to non-academic team members in a USO is an important success factor. Furthermore, Ben-Hafaïedh et al. (2018) showed with their analysis of 165 USOs in Italy from 2000 to 2007 that, for the subgroups of the academic and non-academic founders of USOs, the mix or the homogeneity is substantial for the different performance measures (innovation or sales growth). Thus, for innovation, having a pure academic team appears to make more sense, while for sales growth, the balanced mix and size of the subgroups have a positive impact. The authors moderate this effect by implementing the stakeholder effects of either university or commercial stakeholders. Summing up, prior research results indicate that the relation of team composition on outcomes is unclear. The effects of team composition depend on the input variables, the embedding context (Jackson et al. (2003)), time (how long team members stay together) (Harrison et al. (1998)), and organizational culture (Brickson (2000), Ely and Thomas (2001)). The

diverse research results lead to the conclusion that the effect of team diversity on performance is difficult to grasp, and the question rises whether uncovering the relationship of team diversity and performance on a direct level is possible at all either for general start-ups or for the context of USOs (for an in-depth overview, see Mathisen and Rasmussen (2019)). Moreover, most of these studies take place in an Italian context, are focusing USOs from all types of disciplines, and rarely combine team composition and other potential success factors as recommended for further research (see again Mathisen and Rasmussen (2019) or Nikiforou et al. (2018)). On the basis of this controversial debate about the effectiveness of homogeneous or heterogeneous teams in USOs and their inconsistent results on performance, we hypothesize the following, measuring performance as growth in sales and employees following standard measurement processes in USO research (McKelvie and Wiklund (2010), Mathisen and Rasmussen (2019):

Hypothesis 1. *Team diversity in USOs has no direct impact on firm performance.*

2.2.2 Team diversity, networks, and performance

We observe a research gap for the analysis of team diversity and the interrelated effects with critical success factors for USOs (Mathisen and Rasmussen (2019)). Some studies on USO performance control for the university or commercial stakeholders, or they control for the size of the team or check for technology transfer offices or other institutional settings (e.g., Ben-Hafaïedh et al. (2018)). On the basis of the mentioned literature and the following data, we address that the access to financial resources and specifically team members' network are the most critical success factors. As we will explain in the following, we assume that these success factors are interrelated with the team composition, specifically the diversity of USO teams. Due to the network success hypothesis and social capital theory (Granovetter (1973), Brüderl and Preisendörfer (1998)) and the fact that informal and formal networks serve to embrace entrepreneurial opportunities (Baron and Tang (2009), Baron (2006), Ozgen and Baron (2007), Florin et al. (2003)), we posit that firm and specifically team member networks are among the most important success factors for new venture firms and USOs. Shane and Stuart (2002) postulated that the direct and indirect contacts of the founding team with venture capitalists in their social network reduce the likelihood of failure. Furthermore, Grandi and Grimaldi (2003) confirmed that the frequency of interaction with externals before founding the firm has an impact on the new venture's network and interaction frequency that boosts firm performance. Another reason why firm networks serve as a major success factor is that the effect of social capital could be more important than teamwork capabilities (Brinckmann and Hoegl (2011)) and could enhance performance (Vissa and Chacar (2009), Balkundi and Harrison (2006), Walter et al. (2006)). Mosey and Wright 2007 addressed the notion that differences in the existing social capital and networks of academic entrepreneurs help overcome barriers to new venture development. Academics who have business ownership experience are more adept at building relationships with experienced managers and potential equity investors (Mosey and Wright (2007)), which might be helpful and supportive to gain better performance. Other studies have confirmed that USO innovativeness and performance are also positively associated with the networks of academic founders in a team with different backgrounds (Rasmussen et al. (2015), Rasmussen et al. (2011), Walter et al. (2011), Scholten et al. (2015)). Thus, team diversity leads to a more diversified and greater network (e.g., Hossinger et al. (2019), Reagan et al. (2004), Burt (1992), Granovetter (1973)). Additionally, networks to other individuals may also enhance the entrepreneurial orientation and performance of USOs (Knockaert et al. (2011), Hayter (2013), Diánez-González and Camelo-Ordaz (2016), Prencipe (2016)). A higher degree of different external networks of team members who are less overlapping should provide more unique information inflows (e.g., Granovetter (1973), Reagan et al. (2004)) and lead to a larger pool of external advisers and more innovation (e.g., Hambrick (1994), Hansen (1999), Alexiev et al. (2010)), which in turn is conducive to a stronger performance of USOs. Vissa and Chacar (2009), Balkundi and Harrison (2006), and Walter et al. (2006) argued that a greater and more diversified network should permit more business activities and therefore enhance USO performance. Moreover, Huynh et al. (2017) and Huynh (2016)found only the indirect (positive) effects of USOs' network on

performance. Regarding the relevance of network and social capital, we posit that team diversity has a strong impact on firm networks, and in turn the firm's network has an impact on the access to resources and firm performance (see Hypotheses 2 and 3):

Hypothesis 2. *A heterogeneous team composition has a positive impact on the USOs' network.*

Hypothesis 3. *USOs' diverse team network has a positive impact on performance.*

2.2.3 Team diversity, access to finance, and performance

A positive impact of network on the access to financial resources was found by Jarillo (1989), Birley (1986), and Starr and MacMillan (1990). In a more recent critical review of networks in the entrepreneurship literature, Hoang and Antoncic (2003) showed that a developed network could be an advantage for spin-offs or new venture firms to obtain access to financial resources. Furthermore, Brüderl and Preisendörfer (1998) and Zhao and Aram (1995) confirmed that network ties could enhance the access to financial resources. Lindstrom and Olofsson 2001 also validated that USOs are suffering due to greater difficulties in obtaining finance than start-ups from other origins. Therefore, several researchers have, especially for USOs, searched for supportive factors for obtaining finance and found that the team founders' human capital (commercial experience, technical knowledge, and academic status) (e.g., Huynh (2016) focusing on the impact of industrial, managerial, and entrepreneurial experiences of founding teams to enhance the financing of USOs) and social capital, such as number and density or broadness of networks (Nahapiet and Ghoshal (1998), Huynh (2016)), could increase the chances of getting externally financed (e.g., Gimmon and Levie (2010)). Similarly, Shane (2004) and Vohora et al. (2004) explained the quality of a USO team's network as an external resource, having a strong impact on the financing process (seed, starting, and growth) (Lindstrom and Olofsson (2001)). Effective financing supports USO founders in bringing the idea to market, and thus, this financing has a positive effect on performance (Powers and McDougall (2005)) and growth (Rosman and O'Neill (1993)), such as Wright et al. 2006 and Shane (2004) also show for USOs. With regard to the resource-based view (Wernerfelt (1984)), the financial resources of new venture firms or USOs constitute a critical success factor. This leads to the next two hypotheses that the access to financial resources can be enhanced by the diverse networks of USO teams and that having an effective financial resource enhances the performance of USOs:

Hypothesis 4. *The extent of diversity in a team's network has a positive impact on the financial resources of USOs.*

Hypothesis 5. *Financial resources have a positive impact on USO performance.*

According to pecking-order theory (Myers and Majluf (1984)), venture capitalists tend to invest in USOs after the seed stage whereas business angels or universities during the seed stage of USOs. Hence, the financing of USOs with venture capital is considered to be the most important funding source (Wright et al. (2006)). Thus, several studies have analyzed how USOs are evaluated by investors and financing institutions and whose evaluation criteria must be fulfilled to obtain financing. One of the most important evaluation criteria concerns the entrepreneurial team (e.g., Silva (2004)). The most frequently mentioned team characteristics are industry experience, leadership experience, managerial skills, and engineering/technological skills that attract venture capital (Franke et al. (2008)). Human capital can serve as a signaling effect; therefore, heterogeneous teams are preferred because of their functional diversity (Franke et al. (2008)). This again is found in other studies such as Huynh (2016), where the capabilities of the USO founding team lead to financing in different stages. The same holds true for the studies of Clark (2008) or Muzyka et al. (1996) where investors require sufficient business skills as the main aspect to finance a USO. Thus, the stage of a USO's diverse team skills is highly valued by financing institutions (Shane (2004)). These findings lead to the following hypothesis:

Hypothesis 6. *A heterogeneous USO team composition has a positive impact on the access to financial resources.*

2.2.4 Interrelation of team diversity, networks, access to finance, and performance

The previous hypotheses have focused on the direct effects of team diversity, networks, and access to finance as important success factors for the performance of USOs. The indirect paths of our research approach must also be analyzed to understand how USO teams can exploit networks and access to finance to enhance the impact of team diversity on performance. Hence, the mediating effects of networks and access to finance on team diversity are included in the analysis. This has been rarely undertaken in the USO research. Exceptions include, e.g., Huynh (2016) and Huynh et al. (2017) for networks and team capability. It is important not to ignore possible mediating mechanisms that could explain the impact of team diversity on performance more in-depth and shed light as to why the direct diversity impact generates inconsistent results. We build a mediation model that is able to investigate direct and indirect effects. We suppose that the direct effect of team composition on firm performance is mediated by the firms' network and financial resources. Why should there exist indirect effects of networks and access to finance that serves to clarify the nature of relationship between team diversity and performance? We posit that a combined analysis of success factors and their interrelated (indirect) effects can clarify the relationship between team diversity and performance better than the analysis of single direct effects. This can be explained through the fact that USO performance depends on a huge amount of factors so that entrepreneurial resources and personal characteristics in a diverse team could be of secondary importance (Stringfellow and Shaw (2009)) if we measure them as direct effects (Huynh (2016), Huynh et al. (2017)).

We therefore focus on the indirect effects of the success factors as well, but the selection of these variables must be carefully considered. Shane (2004)and Knockaert et al. (2011) verified that USOs are very specific in terms of their business idea, background, and development, because they are created around research inventions, new solutions, and ideas solving a problem. Thus, at the beginning, having a team of founders with scientific and technological knowledge is crucial to drive this idea into a marketable innovation. At this point of development of a USO, the common understanding of the involved team members as a kind of homogeneity is important (Knockaert et al. (2011)). At the same time, researchers in this field have found that it is important to identify how founding teams in USOs co-evolve with the stages of firm development and that this kind of change might have an impact on USO performance or survival (Clarysse and Moray (2004)), often driven by context or other success factors like financing (e.g., Huynh (2016), Huynh et al. (2017)), Vohora et al. (2004), Wright et al. (2006)).

The same holds true regarding the network of USOs as Ferretti et al. (2019), Ben-Hafaïedh et al. (2018), Huynh (2016), and Huynh et al. (2017) found. Their studies highlighted how social capital and networks of a USO team develop and change over time due to more market contacts and different kinds of the involvement of university institutions (e.g., TTOs) and governmental support programs. The composition and diversity of a USO team and thus the direct effect might influence these contacts and network relations, bringing in non-academics or academics with commercial and market experiences (Clarysse and Moray (2004), Vohora et al. (2004), Vanaelst et al. (2006)). This leads to our Hypotheses 7 (a*b) and 8 (c*d).

Hypothesis 7. *The direct effect of team diversity on firm performance is mediated by the firm's network.*

Hypothesis 8. *The direct effect of team diversity on firm performance is mediated by the firm's financial resources.*

Summarizing the discussion and bringing together the hypotheses, the mediation model is developed (Fig. 1). Following the former results, discussion, and analysis, we create a model including four latent variables: Team Diversity, Network, Finance, and Performance, which are measured with 31 items (for a detailed explanation, see the next section). The paths between the four latent variables represent the hypotheses in our model. We assume that the variables Network and (access to) Finance are mediators for the effect of Team Diversity on Performance. These hypothesized causal chains, in which team diversity affects financial resources and networks that, in turn, affect performance, are derived from theoretical considerations explained above.

Figure 1 shows the model. The paths in the figure are labeled to distinguish easily between direct and indirect effects.

3 Research method

3.1 Sample

We obtained the addresses of all USOs in Switzerland and Germany from the address pools of the agencies of biotech companies in both countries. We controlled for these addresses online and then sent out an online survey in German/Swiss-German and English to contact all existing biotech companies at that time without any sampling or selecting. A standardized questionnaire was used and sent to 900 USOs in 2008 (return rate 15%) and subsequently in 2012 and 2013 to keep in touch with the respondents online/via the web. The respondent was always one of the founders or top management team members of the USOs. The survey includes 60 questions. Our empirical study consists of 131 USOs in the German and Swiss biotechnology sector, whereby 64 are founded by teams that are used for the analysis. Our pure focus on biotech USOs specializing in this field has the advantage of avoiding or diminishing the effects of field differences in the USO team composition, networks, financing, and performance (e.g., Knockaert et al. (2011)). A total of 78% of the companies are from Germany and 22% from Switzerland. Although a clear distinction of the business activities of the companies in the biotech business is not always possible, we categorized them according to the main business content. A total of 30% of the respondents produce pharmaceuticals; 25% work in genetic engineering, 22% in laboratory testing/innovation, and 14% in medical technology; and 4% produce chemicals and 3% biotech-related software.

The information from 31 items is used to estimate the path coefficients. Each latent variable in the structural model (Fig. 1) is measured by a block of items (measurement models) that are asked for in our questionnaire. To measure *Team Diversity*, we use typical items discussed in the theoretical background section. These 10 items explain functional and demographic diversities and personal traits, such as study programs and degrees, doctorates/PhDs, other titles, soft skills (e.g., leadership experience), industry experience, character aspects, contacts, age, nationality, and size of the team, because Visintin and Pittino 2014, Knockaert et al. (2011), Scholten et al. (2015), Criaco et al. (2014), and Gimeno et al. (1997) have already used these measures. The latent variable *Finance* is measured by asking for the usual financing issues for new ventures and USOs in particular taking into account the different kinds of financial support USOs can obtain (Shane (2004), Beckman et al. (2007), Zimmerman (2008), Franke et al. (2008), Huynh (2016), Clarysse and Moray (2004)). To measure the firm's network and social capital of the team members adequately, the latent variable network is measured by 12 items that consider formal and informal contacts whereby we focused strong ties. To reflect the special USO context with new ventures from the biotechnology sector, we design the items correspondingly, which means using network contacts USOs have in common (Shane (2004), Vohora et al. (2004), Ferretti et al. (2019)). On the basis of the assumption from the upper echelon theory that firm performance is directly influenced by team effectiveness (e.g., Amason et al. (2006), Brinckmann and Hoegl (2011), Sine et al. (2006)), the performance variable is measured by usual items from the management and USO performance literature (Unger et al. (2011), Klotz et al. (2014), Visintin and Pittino (2014), Ben-Hafaïedh et al. (2018)). Our study uses the common measures of growth rates for sales or employment (McKelvie and Wiklund (2010), Mathisen and Rasmussen (2019)). Except for the items for measuring the performance variable, we use 5-point Likert-type scales for all items, ranging from totally agree to totally disagree or for the team diversity construct ranging from totally homogeneous to totally heterogeneous. Table 1 lists the items, and the Appendix shows the descriptive statistics of the items.

3.2 Partial least squares model

Following Carpenter et al. 2004, Ferrier (2001), and Kor (2003), we use structural equation modeling, especially the partial least squares method (PLS) (Wold (1966) and Wold (1974)) to test our hypotheses. Carpenter et al. (2004) argued that, if the theoretical construct is top management team diversity, more sophisticated methodologies, such as structural equation modeling, should be used.

> "The advantage of such an approach is that measurement error becomes less of a factor and the odds of generating spurious results from single item demographic variables is significantly reduced." (Carpenter et al. (2004), p. 772)

Furthermore, we use the PLS method because it has proven capable of handling small- and medium-sized samples (Chin and Newsted (1999), Chin (1998)) where

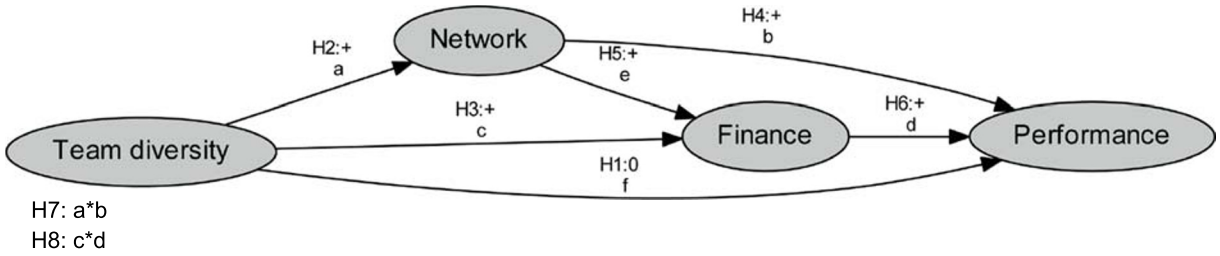

Fig. 1 Structural model and hypotheses: The paths are labeled with small letters (a, b, c, d, e, and f) representing the direct effects captured by Hypotheses 1 to 6. The indirect effects can be analyzed by Hypotheses 7 and 8 or a*b and c*d representing the mediation effects

a sample size of 20 observations could be appropriate (Henseler et al. (2009)). As a heuristic rule, Chin (1998) recommended multiplying the highest number of the measured items of one of the constructs in the model with five to obtain the minimum observation requirement for the data. Following this rule, we need at least 10*5 = 50 observations in the data; hence, our analysis with 64 teams can be confirmed as satisfactory concerning sample size. Other reasons why we choose PLS is the absence of distribution assumptions for the data (e.g., Lohmöller (1989)), and testing mediation directly in the model is possible.

Our model in general shows the interaction among the *Team Diversity*, *Finance*, *Network*, and *Performance* of USOs. These are the latent variables (see Fig. 1) representing the structural model. *Network*, *Finance*, and *Performance* are endogenous variables; *Team Diversity* is exogenous because this construct is based of team variables that consist of sociodemographic variables (age, doctorates, industrial experience, nationality, other titles, study programs, and degrees) that are given by the socialization and education processes of team members. These sociodemographic variables are given and cannot be influenced by the other model variables. We also include soft factors (character, contacts, and soft skills) and the number of team members. The team composition takes place before the team searches for the financing (finance construct) or firm contacts and partners (network construct) so that the soft factors and the number of team members are also exogenous. The operationalization of these latent variables can be made by reflective and formative measurement models. Given that Petter et al. (2007) showed that 30% of the measurement models in information system research are faulty, the use of formative or/and reflective measurement models should be evaluated carefully (for a detailed analysis, see Bollen and Lennox (1991), MacCallum and Browne (1993), Edwards and Bagozzi (2000), Jarvis et al. (2003)). We decide to measure *Team Diversity* and *Finance* formatively and *Network* and *Performance* reflectively.

As an example, we consider the variable *Team Diversity* in detail. This variable is operationalized by 10 items that measure the diversity of the observed teams in the data. Instead of an indexing approach that often leads to biased results, the *Team Diversity* construct in our PLS model shows how the team diversity items influence the team diversity, specifically a homogeneous or a heterogeneous team composition. We based our questions in the survey (a) on a thorough literature analysis on already used different diversity variables (Visintin and Pittino (2014), Knockaert et al. (2011), Scholten et al. (2015), Criaco et al. (2014), and Gimeno et al. (1997)) and (b) on testing the meaning of the questions beforehand by interviews and pretests. In contrast to reflective measurement models, the formative indicators cause variance in the construct and can be individually evaluated on the basis of their contribution to the construct (latent variable) analyzing their path weights and their loadings (Cenfetelli and Bassellier (2009)). The novelty using this approach for measuring diversity effects is that the PLS model makes it possible to obtain information of different diversity items during the estimation minimizing the problem that the results are biased due to data that is measured on an aggregated level. Additionally, the effect and the absolute and relative importance of each diversity item can be analyzed. Similar approaches can be found by Talke et al. (2010) and Naranjo-Gil et al. (2008).

4 Empirical findings

The empirical results for the model estimated with the PLS method are undertaken by a two-step analysis. First, we analyze the results for the formatively

Table 1 Measured items and corresponding labels

Survey items	
Team composition	
1. The diversity of the team members for:	Study programs and degrees
2. The diversity of the team members for:	Doctorates
3. The diversity of the team members for:	Other titles
4. The diversity of the team members for:	Soft skills (e.g., leadership)
5. The diversity of the team members for:	Contacts and network
6. The diversity of the team members for:	Industrial experience
7. The diversity of the team members for:	Age
8. The diversity of the team members for:	Character
9. The diversity of the team members for:	Nationality
10. Quantity of team members	Team members
Finance	
1. To what extent the firm is funded by:	Bank
2. To what extent the firm is financed by:	Venture capital
3. To what extent the firm is funded by:	Business angels
4. To what extent the firm is financed by:	Private equity
5. To what extent the firm is funded by:	Friends and family
6. To what extent the firm is financed by:	State funding and government aid
7. To what extent the firm is financed by:	European funding programs
Network	
1. Cooperation with:	Small- and medium-sized enterprises
2. Cooperation with:	Industry
3. Cooperation with:	Universities
4. Cooperation with:	Research centers
5. Cooperation with:	Connected researchers in universities
6. Cooperation with:	Connected researchers in research centers
7. Cooperation with:	International firms
8. To what extend the firm has:	Interdisciplinary cooperations
9. To what extend the firm has:	Short-term cooperations
10. To what extend the firm has:	Long-term cooperations
11. To what extend the firm has:	Informal contacts
12. To what extend the firm has:	University infrastructure
Performance	
1. Employee growth rate	Employee growth rate
2. Sales growth rate	Sales growth rate

Except for the items used for measuring the performance variable and quantity of team members, we use 5-point Likert-type scales for all other items

measured team diversity construct to obtain a more sophisticated view on the effects of the different team diversity items for the construct and the model. This means we are able to observe (a) the relative importance and (b) the absolute importance of the diversity items for the construct (e.g., Cenfetelli and Bassellier (2009)). Second, we examine the path coefficients between the latent variables to examine the validity of our hypotheses. According to Lohmöller (1989), they must be greater than 0.1 to constitute statistical evidence. Due to the lack of distribution assumptions in PLS models (e.g., Vinzi et al. (2010), Chin and Newsted (1999)), the statistical significance for the measurement model weights and path coefficients is tested with the

Table 2 Team diversity construct results

Item	Path weight	*t* value	Loading
Study programs and degrees	0.694	3.509***	0.3651
Doctorates	− 0.416	2.094*	− 0.0134
Other titles	0.109	0.739	0.1159
Soft skills	− 0.149	0.805	− 0.1383
Contacts and network	0.160	0.884	0.1130
Industrial experience	0.363	1.752†	0.3540
Age	− 0.477	2.426*	− 0.3109
Character	− 0.103	0.423	− 0.3156
Nationality	0.444	2.089*	0.4557
Team members	− 0.456	2.212*	− 0.3908

The limits for statistical significance are $t > 1.645 = p \leq 0.1^{\dagger}$, $t > 1.960 = p \leq 0.05*$, $t > 2.576 = p \leq 0.01**$, $t > 3.291 = p \leq 0.001***$

bootstrapping method (Bollen and Stine (1993), Efron and Tibishirani (1993)).

4.1 Team diversity construct results

Table 2 shows the result for the team diversity construct.

Six of the ten items of the team diversity construct are statistically significant on a 10% significance level. The items have positive and negative weights (standardized regression coefficients). A positive path weight indicates a positive impact on team diversity, while a negative path weight implies a negative impact on team diversity. Hence, a positive weight increases the diversity of a team, whereas a negative weight creates none of the heterogeneous effects mentioned in the former team composition debate. These results for the formatively measured team diversity construct show that study programs and degrees, industrial experience, and nationality have a statistically positive impact on team diversity. By contrast, the items doctorates, age, and team members (size) generate a negative impact on team diversity, meaning that they detract from the heterogeneous effect. These negative effects must be discussed carefully. In a formative measurement model like in the case for team diversity, the measured items are equal to predictors in a multiple regression.

The team diversity construct results show how the different diversity items influence diversity in our model for USOs in the biotechnology sector. In addition to the statistically significant items for the diversity construct, the nonsignificant items are also interesting. We cannot observe a significant contribution to the diversity construct by the items other titles, soft skills, contacts and network, and character. The diversity of these items therefore has no relevance for our model, but might have when tested in a different context or method.

4.2 Structural model results

The PLS estimation process aims to maximize the correlation between the construct variables (*Team Diversity*, *Network*, *Finance*, and *Performance*) where the construct values are framed by their formatively or reflectively measured items. Figure 2 illustrates the path coefficients and *t*-statistics for the structural model following the bootstrapping process, and the Appendix depicts the entire results including the measurement models.

As suggested from the findings in the literature, the impact of team diversity on firm performance is nearly zero. The path coefficient c takes on the value of − 0.058 ($t = 0.377$). Thus, we cannot observe a direct effect of team diversity, specifically a heterogeneous team composition on performance. The direct effect from *Team Diversity* to *Network* (path a, Hypothesis 2) is statistically significant with a positive path coefficient (0.421, $t = 3.129$). Therefore, our assumption that team diversity affects firm networks positively can be confirmed. We observe a positive impact of *Team Diversity* on *Finance*; hence, Hypothesis 6 (0.457, $t = 2.784$) can be confirmed. The access to financial resources is therefore influenced by team diversity within our data.

The impact of the firm's network in our model is represented in Hypotheses 3 and 4. There is a statistically significant positive impact of the firm's network on the access to financial resources (0.438, $t = 2.586$). Thus, Hypothesis 4 can be confirmed. A greater network enhances the probability of obtaining access to financial resources. The direct effect of network to firm performance captured by Hypothesis 3 cannot be confirmed (− 0.110, $t = 0.919$). This result regarding the network success hypothesis and social capital theory is fairly surprising. We observe a positive impact of financial resources on firm performance (0.434, $t = 2.081$). Hypothesis 5 (path d) can be confirmed. The access to financial resources leads to higher firm performance.

The results reveal two indirect effects. Instead of the assumed two mediation effects a*b and c*d, we only observe c*d as statistically significant mediation. Thus, Hypothesis 7 must be rejected, and Hypothesis 8 can be confirmed. The second mediation we observe concerns the relationship between the firm's network and

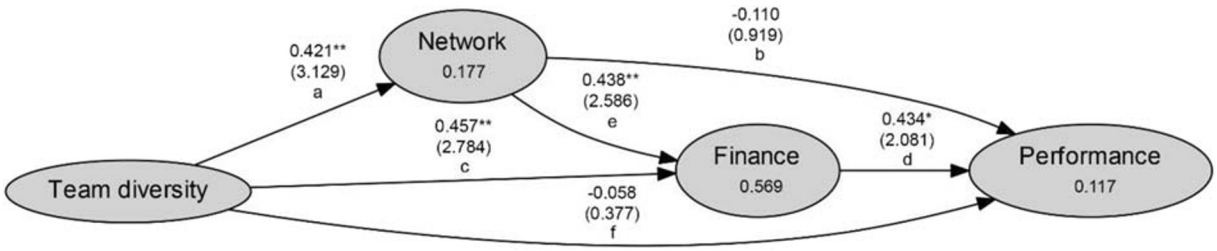

Fig. 2 Structural model results: Each arrow contains (a) the path weight, (b) the t value, and (c) the path label. The limits for statistical significance are $t > 1.645 = p \leq 0.1^{\dagger}$, $t > 1.960 = p \leq 0.05$*, $t > 2.576 = p \leq 0.01$**, $t > 3.291 = p \leq 0.001$***. The nodes contain the R^2 values

performance. This nonsignificant direct effect is mediated by *Finance*.

4.3 Model evaluation

To check the validity of our approach, we evaluate the structural model and the measurement models. The quality of the structural model can be described by parameters R^2, f^2, and Q^2. The R^2 statistic is well known from OLS regression and is calculated with the endogenous and exogenous variables as dependent and independent variables. Chin 1998 identified $R^2 \geq 0.67$ as a substantial and $R^2 \geq 0.33$ and $R^2 \geq 0.19$ as an average result. To analyze the substantial impact of an exogenous variable on an endogenous variable, the effect intensity f^2 is used. According to Cohen (1988), $f^2 > 0.35$ describes a large intensity, $f^2 > 0.15$ a medium intensity, and $f^2 \geq 0.02$ a small intensity. Stone-Geisser's Q^2 is determined by a blindfolding process (Chin (1998)) and evaluates the forecast relevance of the dependent variables in a structural model (Chin (1998), Tenenhaus et al. (2005)). It should be greater than 0 (Fornell and Cha (1994)). Figure 3 exhibits the R^2, f^2, and Q^2 values.

With regard to the recommendations of Chin (1998), the R^2 values for *Network* (R^2 = 0.177) and *Performance* (R^2 = 0.117) can be considered to be weak results. These variables cannot have a greater R^2 value because the exogenous variables apparently are not able to explain the majority of the total variance of the endogenous variables. The network variance cannot be explained entirely by *Team Diversity*. By the same token, the performance variable cannot be explained perfectly by the firm's network, team diversity, and finance. $R^2 = 0.569$ for *Finance* could be stated as moderate. Generally, a small R^2 value does not necessarily imply faulty model assumptions. Where the research field of success factors is concerned, small R^2 values can be evaluated as substantial as well (e.g., Bauer (2002)). The $Q^2 > 0$ criterion is fulfilled for each variable. The strongest effects with respect to f^2 are observed for the impact of *Team Diversity* on *Network* (path a, $f^2 = 0.215$) and *Finance* (path c, $f^2 = 0.332$) and for the impact of *Network* on *Finance* (path e, $f^2 = 0.341$). A small effect intensity could be observed for the impact of *Finance* on *Performance* (path d, $f^2 = 0.091$). Consistent with the PLS coefficients, the impact of *Team Diversity* on *Performance* (path f, $f^2 = 0.007$) and *Network* on *Performance* (path b, $f^2 = 0.010$) carries the lowest influence in the model. The structural model quality criteria confirm that the structural model is valid, although a slight weakness due to the two average R^2 values in the model is inevitable.

Regarding the measurement models, there are two methods with which to determine the latent variables, namely, a reflective and a formative one. For reflectively measured latent variables, we control the average variance extracted (AVE) (Fornell and Larcker (1981)) and the composite reliability (Chin (1998)). According to Chin (1998), composite reliability should be greater than 0.6 and the AVE greater than 0.5. Furthermore, the factor loadings of the reflectively measured variables should be greater than 0.707 if they are to make an explanatory contribution to the latent variable (e.g., Johnson et al. (2006)). Formatively measured latent variables have to be tested for multicollinearity. We thus analyze the correlations between the measured variables and the variance inflation factor (VIF) of the team diversity and finance items. Henseler et al. (2009) considered VIF values greater than 10 as critical, whereas Diamantopoulos et al. (2008) found multicollinearity problems for VIF values greater than 5. The VIF values for the items of the two formatively measured constructs in our model do not exceed 2.9; hence, we do not see difficulties with multicollinearity. The Appendix (Table 4) shows the results.

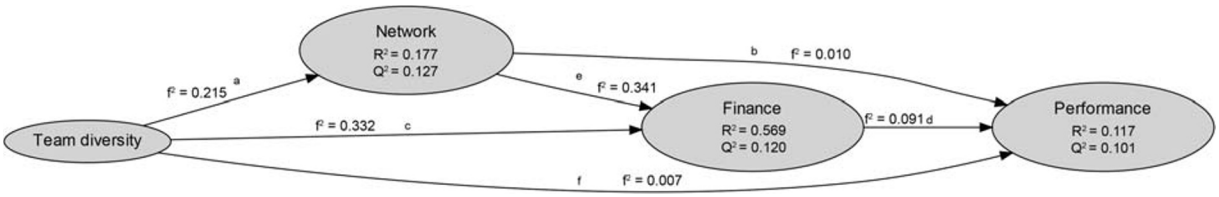

Fig. 3 Structural model evaluation

Table 3 shows the AVE, composite reliability, and factor loadings for the reflective measured constructs. The factor loadings of the items for the network construct do not always achieve the minimum requirement (0.707), and thus, the AVE criterion will not be met (AVE = 0.237). The PLS model allows the omission of items in reflectively measured constructs if their loadings are not high enough to increase the validity of the construct. Therefore, we omitted all variables with loadings smaller than 0.707. In sum, our model is valid (AVE = 0.681). The variables that are ultimately used in the analyses are marked with a star.

4.4 Robustness checks

To test for the existence of nonlinear relationships, we run the regression equation specification error test (RESET) by Ramsey (1969). No significant results indicate nonlinear effects. To test for endogeneity, we adapt the procedure proposed by Hult et al. (2018) using Gaussian copulas into a PLS-SEM framework. The bootstrapping results show no significant Gaussian copulas. We consequently conclude that there is no endogeneity issue in the data. To check for unobserved heterogeneity, we use the finite mixture PLS (Hahn et al. (2002)) that tests if subgroups exist that lead to substantially different model estimates. The one-segment solution reveals the highest AIC value. A two-segment solution also shows a low AIC value with a segment size of 0.95% for segment one and 0.05% for segment two. Following Sarstedt et al. (2011), this result leads to the conclusion that unobserved heterogeneity does not significantly affect the data because the 0.05% segment has no management relevance due to its small size.

5 Discussion and limitations

The results in this study examine the impact of team diversity on performance and important success factors, in response to the plea by Mathisen and Rasmussen (2019) and Nikiforou et al. (2018) for a greater focus on team diversity and its effect of firm performance. We obtain interesting and novel insights that are helpful to understand better the effects of diversity in teams.

In the following, we highlight (1) our detailed results and how they relate to the previous literature, (2) the specific results and our contribution to research on academic entrepreneurship and entrepreneurial teams, and finally (3) limitations (especially those related to the research design) and (4) implications for theory and practice.

5.1 Detailed discussion of results

5.1.1 Direct effects

Prior literature findings are ambiguous concerning the direct effect of team diversity on the firm performance of USOs (e.g., Knockaert et al. 2011, Visintin and Pittino (2014), Huynh et al. (2017), as well as Ensley and Hmieleski (2005), Amason et al. (2006), Webber and Donahue (2001)). Our study emphasizes that the investigation of a direct effect is insufficient to analyze the effect of team diversity on USO performance. Thus, more sophisticated models in regard to measurements or methods are necessary to open the black box of team diversity effects (Hahn et al. (2019), Carpenter et al. (2004), Mathieu et al. (2008), Klotz et al. (2014)), and we provide the requisite empirical evidence to this debate.

The current study finds statistically direct positive effect of team diversity on the access to financial resources for USOs. This is in line with other studies, where the team composition is considered to be an important signal to potential investors to trust the team to bring an invention to the market and run a USO successfully. When team diversity is built on a balanced mix of academics and non-academics, investors (either VCs or business angel of universities) are willing to finance the USO or to invest higher and sufficient amounts of money (Beckman et al. (2007), Zimmerman

Table 3 AVE, composite reliability, and factor loadings

Condition	Factor loadings ≥ 0.707	AVE ≥ 0.5	Composite reliability ≥ 0.6
Network		0.681	0.810
SME	− 0.038		
Industry	− 0.508		
Universities	− 0.034		
Research centers	0.565		
Connected researchers in universities	0.531		
Connected researchers in research centers	0.778*		
International firms	0.505		
Interdisciplinary cooperations	0.705*		
Short-term cooperations	− 0.244		
Long-term cooperations	0.138		
Informal contacts	0.654		
University infrastructure	0.336		
Performance		0.766	0.868
Employee growth rate	0.885*		
Sales growth rate	0.865*		

*Variables kept for the final model

(2008), Franke et al. (2008)), showing that functional diversity attracts investors either in early stage financing or in the latter stages (Huynh (2016), Clarysse and Moray 2004, Wright et al. (2006)).

We further find a direct positive impact of team diversity on the network. This relationship is not surprising regarding network theory (e.g., Burt (1992), Granovetter (1973)) and is in line with USO research as well. Rasmussen et al. (2011), Rasmussen et al. (2015), and Scholten et al. (2015) revealed in their studies that a USO team obtaining a mix of skills, including entrepreneurial experience and innovative capabilities, will positively affect the networks of the USO team. Similarly, Mosey and Wright (2007) showed that the diversity of human capital skills in a team enhances the ability of a team to build social capital and networks, especially when there exists prior experience in owning a firm and having commercial experiences in the team. This could lead to easier network building with business managers and financial investors.

The positive and highly statistical significant impact of the firm's network on the access to financial resources shows that network ties are highly relevant in obtaining finance. This result confirms previous findings concerning the interaction between network and financial resources (Hoang and Antoncic (2003), Zhao and Aram (1995)). Thus, our results are in line with the outcomes of prior researchers, which as well underscores the important effect of the founding team's networks on financing using the reputation (capabilities) of the team and the team member networks (Heuven and Groen (2012), Rasmussen and Sørheim (2012)) and Shane and Cable (2002), Shane and Stuart (2002)). Our results partially contradict the results of Huynh (2016) who did not find a direct but rather an indirect effect of networks on financing. This might be because the USOs we analyze are in a later stage than those in the study of Huynh (2016). Thus, our USOs might have a chance to obtain different forms of financing. Finally, the indexing of financing forms might explain this difference as well.

Another direct effect is reflected by the relationship between network and performance. We posited a positive relationship because a stronger network should increase productivity and thus performance (Reagans and Zuckerman (2001)). Instead, our results reveal no significant impact of networks on performance. The effects of the network variable show that USOs in the high-tech sector should have a great diversified network, having other positive effects on essential resources like financing. However, network diversity does not influence performance directly in our study. This is in line with the results of Huynh et al. (2017) who do not find a direct effect of the network of USO teams on

performance but rather an indirect effect. This result limits the network success hypothesis for USOs in the biotechnology sector in some way. Unsurprisingly, the impact of the financial resources of USOs on performance is significantly positive and confirms the importance of financial resources of firms (Wernerfelt (1984)). Thus, our study confirms former results and research that the more diverse financial resources a USO can gain, or the more effective the fundraising is, the better will be the performance of the USO (Powers and McDougall (2005)). If this is not the case, USOs will tend to exit from the market at any stage (Rosman and O'Neill (1993)).

5.1.2 Indirect effects

The upper echelon approach (Hambrick and Mason (1984)) states that team effectiveness leads directly to firm outcomes. Our results are in line with the organizational behavior and entrepreneurship literature suggesting a more complex relationship between team diversity and outcomes (e.g., Knockaert et al. (2011)). Hence, it seems reasonable to test team diversity effects in mediation models (e.g., Huynh (2016), Huynh et al. (2017), or as recommended by Mathisen and Rasmussen 2019). We do not find direct team diversity effects on USO performance. Nonetheless, does this really mean that team diversity has no impact at all on USO performance? To answer this question, we test and identify two mediation effects in our model creating two sources of the distinctiveness and originality of our paper. One of these is the mediation of the relationship between team diversity and performance by the access to financial resources.

USOs are specific due to their business idea and development because this is related to a unique technological or research invention (Shane (2004), Knockaert et al. (2011)). In general, the teams of USOs start with academic founders incorporating this specific knowledge to develop USOs to enter the prototyping or market stage. Thus, involved team members show a kind of homogeneity (Knockaert et al. (2011)). Prior research has confirmed that, often, founding teams in USOs do evolve in parallel with the stages of USO development because of financing issues, or other context and success factors, i.e., universities providing access to staff triggering this (Clarysse and Moray (2004), Huynh et al. (2017), Huynh (2016), Vohora et al. (2004), Wright et al. (2006)). As a consequence, often the structure of the USO team changes and is influenced to procure fundraising or financial support, implying that the direct effect of team diversity might be affected by the access to financing. Thus, the fine tuning or balancing of the USO team has a strong relationship with financial issues (Vanaelst et al. (2006)).

The second mediation concerns the relationship between network and USO performance—mediated by access to finance. The analysis of the indirect effects shows that team diversity has a positive indirect impact on USO performance and that the relevance of firm networks and social capital must be emphasized. Our results can be linked to the work of Brinckmann and Hoegl (2011), Vissa and Chacar (2009), Balkundi and Harrison (2006), and Walter et al. (2006) who consider firm networks and social capital as two of the most important success factors. In our model, networks are highly relevant for the access to financial resources and for firm performance. The results show that team diversity is positively related to firm performance, and we therefore conclude that a heterogeneous team composition is favorable for USOs, because of the link between network ties and the access to financial resources.

The same holds true regarding the network of USOs, as Ferretti et al. 2019, Ben-Hafaïedh et al. (2018), and Huynh (2016) found. They show that ways that are different from social capital and networks of a USO team develop and change over time due to more market contact or different kinds of the involvement of the university institutions (e.g., TTOs) and governmental support programs. These network relations might influence the team composition and diversity of a USO team and thus the direct effect by changing or enlarging the team composition, bringing in non-academics or academics with commercial or market experience (Clarysse and Moray (2004), Vohora et al. (2004), Vanaelst et al. (2006)). Huynh et al. (2017) found that, in the USO development stage, the networks of a founding team indirectly affect performance. Universities commonly provide the chance to "staff" a USO team with new members with industry background (Clarysse and Moray (2004)), fine tuning and balancing the USO team composition (Vanaelst et al. (2006)), which enhances later performance.

5.1.3 Team diversity construct results

A main contribution of this paper is the multifaceted measuring of diversity working with the PLS method:

this makes it possible analyzing the importance of diversity items simultaneously. The diversity of teams measured by item study programs and degrees, doctorates, industrial experience, age, nationality, and the quantity of team members has a significant impact in the model where the items other titles, soft skills, contacts and network character have no significant impact. This delivers new insights to better understand the effects of diversity in teams.

To discuss this more in-depth, does the negative significant values of the items age and doctorates mean that an increase of heterogeneity in these items leads to lower team diversity? At first glance, this appears to be a paradox, but a more detailed analysis provides a compelling resolution. Team members with different ages are more similar to one another than team members with equal ages. In other words, the probability for diverse human and social capital is higher if team members have a homogeneous age. This can be explained by the specific USO context and the formation of a team: As Knockaert et al. (2011) and Visintin and Pittino (2014) and other studies (Mathisen and Rasmussen (2019), Hossinger et al. (2019)) have found, the starting team of a USO is often built around the technology or invention and typically created in a research group or project (Clarysse et al. (2007b), Markman et al. (2008), Heirman and Clarysse (2004)). In these groups, the scientific and technological background is more or less the same, due to the research aspect. At the same time, these teams generally consist of different hierarchy levels in the scientific context, e.g., research group leaders and professors/chair holders, PostDocs, PhDs, or technical assistants; thus, the technological background of team members might be close, but age levels might be different. The explanation for the diversification of doctorates is almost the same: in these research teams, all people are interested in the same technology or research focus, especially in biotechnology; often professors or PhDs from different departments or fields from academia are involved, e.g., biology, medicine, or physics. Thus, the more team positions are blocked from the beginning with these different PhD academics, the less diversity might exist regarding non-academic experience or hierarchy levels. Another explanation for these negative path weights in formatively measured constructs could be suppressor effects (Cohen and Cohen (1983)). In this case, one or more of the predictor variables explains the variance in other predictor variables and thus reduces or reverses the path weight of these predictors with the construct variable even if there are no great problems of multicollinearity (Cenfetelli and Bassellier (2009)). We see no indications for a suppressor effect; hence, we analyze the absolute importance of an indicator to its construct with the help of the zero-order correlation of the item with the construct (loadings in Table 2). The absolute importance of an indicator helps us identify how the item correlates with the construct value. The correlation for doctorates is nearly zero; this item is not of such an absolute importance for the construct. The relative importance measured by the negative path weight occurs if doctorates are estimated in the multiple regression controlling for all other predictors in the measurement model.

We contribute as well to the discussion on entrepreneurial teams with our results for the formatively measured team diversity construct. We find that study programs and degrees, industrial experience, and nationality have a statistically positive impact on team diversity. The industrial experience result underlines the result of other studies that a balanced combination and mix of the former homogeneous team of academics needs a non-academic component to develop an USO and enhance the performance (e.g., Knockaert et al. (2011), D'Este et al. (2012), Hayter (2013), Visintin and Pittino (2014), Ciuchta et al. (2016), Huynh et al. (2017), Ferretti et al. (2018)). The result of an increase in nationality diversity delivers helpful insights, too, to generate effective mixed USO teams because this diversification might open new kinds of social capital and enhance the chances to develop an internationalization path for USOs (Burer et al. (2013), Civera et al. (2019a), Ferretti et al. (2018), Ferretti et al. (2019)). Moreover, bringing together international researchers might enlarge diversity regarding research or management culture, methods how to deal with questions, and approaching a problem (Civera et al. (2019a), Ben-Hafaïedh et al. (2018)). Thus, this delivers a real effect on diversity. The study programs and degrees as positively enhancing diversity deliver a new insight, too, that when team members still have a PhD in the same field, their study field and degree could be different ones. Thus, the spread in study fields like in the case of nationality can increase the diversity in the way that methods to approach a problem or the point of views and research tools are different (Ferretti et al. (2019)). Therefore, this also contributes to increase the heterogeneity of teams.

Finally, the negative path weight of the quantity of team members also appears to be surprising at first

glance. Does this mean that a higher number of team members leads to a lower team diversity? We explain this effect in two ways. (1) Imagine that a team with two team members has completely different soft skills. One of them is a professional in LaTeX, and the other knows Microsoft Word well. The two founders intend to expand their team with two more colleagues. Suppose that the two new team members are both professionals in Microsoft Word as one of the originally team members. In this case, the relative team diversity concerning soft skills decreases if the number of team members increases. (2) Moreover, imagine how teams are built: in general, individuals prefer other individuals when they have something in common (Zacharakis (2010), Jungwirth and Moog (2004)). This means that, even increasing the team size, it does not at all mean increasing the team diversity in the same ratio and effect. Thus, we can imagine that there might exist a number of team members that is most effective or diminishing effects of team size regarding the advantages of big versus small teams (e.g., Backes-Gellner et al. (2006)).

Keeping in mind that we observe the relation of team diversity, network, finance, and the performance of USO in the biotechsector, the team diversity construct results confirm that the diversity of "soft characteristics" does not play a significant role. Those characteristics are difficult to observe for investors and could be secondary for network building and maintaining ties. It seems that, for USOs diversity, the "hard characteristics" of the team have a significant stronger influence on performance as well as the indirect effects. These insights are new.

We observe the same for the quantity of team members. Teams with a high number of team members are more homogeneous than work groups with fewer team members. These results indicate that age heterogeneity and the quantity of team members should be used carefully as a proxy for team diversity in single item or simple index measures. We must distinguish here between age and team size as single proxies for success (e.g., Kilduff et al. (2000), Eisenhardt and Schoonhoven (1990)) and age and team size as items that are a component of a team diversity construct. The question that occurs here is if investors or network partners evaluate this situation equally. In other words, do investors or network partners realize team diversity as a whole construct, or do they concentrate on selected diversity items to evaluate diversity of the team? We cannot answer this question at this point, but we find that team size and age diversity could stand for a homogenous team composition and therefore emphasize the use of more complex statistical methods to analyze diversity effects. The use of the PLS method and the analysis of the team diversity construct make it possible to detect relationships of different diversity items in an entire model and minimize the probability of biased results.

5.2 Contribution

With regard to the controversial results and prior literature findings of the impact of team diversity on USO performance (Mathisen and Rasmussen (2019)), there are several key original contributions of the paper:

A first new and exciting contribution to the literature, with some important managerial and practical implications (cf. Diánez-González and Camelo-Ordaz (2019)), is that team diversity matters in USOs because it helps to access a variety of resources. So, from a managerial perspective, team founders and members should be much more aware of this effect and leverage the strength of their network much more.

Moreover, as a second contribution to academic entrepreneurship and entrepreneurial team research, our results provide insights that team diversity seems to overcome the typical difficulty to access resources and gain credibility which inherently characterizes USOs and which hampers their success (Rasmussen et al. (2011)). This helps to overcome a typical problem confronting USOs—the inability to transition from the university to the business world; the results make these outcomes relevant for questions related to mainstream management research (Fini et al. 2019).

Third, the single effects of diversity aspects on the overall diversity of a USO team provide new insights for research and practitioners, because it is neither the size of a team nor the accumulation of multiple different team aspects, but rather the focus on some specific ones and their combinations, making the difference on the overall diversity and direct and indirect effects. Thus, increasing team size has a negative impact, whereas more nationalities deliver a positive influence on overall diversity, thereby creating positive effects on networks, financing, and indirectly on performance. This means that great is not always best, but a focused team composition can deliver advantages for USOs in their development and performance, especially with respect to industry and academic experience, mixed teams of research field backgrounds, and nationality. For all our

other tested aspects, a USO team should think carefully about how to generate more heterogeneity into the team.

Fourth, our unique data set of 64 USOs in the biotechnology area in Switzerland and Germany provides new insights regarding the direct and indirect effects of the overall diversity of USO teams. The indirect effects that are caused by team diversity are highly relevant for USO performance. Thus, we find that, mediated by financing and networks, the diversity of USO teams has a positive impact on performance. This means, especially in developing USOs, a change of the diversity and homogeneity of a team toward a more elaborated heterogeneous team contributes to a positive performance of USOs.

A sixth contribution is that the selection of an adequate statistical method is crucial for the new insights regarding the subject of team diversity (Barrick et al. (1998)). The PLS method we choose makes observing a bunch of diversity items in one model minimizing the probability of biased results possible (Carpenter et al. (2004)). Furthermore, looking at the importance of different diversity items and analyzing mediation effects directly are possible. Because the PLS algorithm maximizes the correlation of the construct variables in the model that are framed by their measured items, we are able to investigate how diversity interacts with networks, access to financial resources, and the performance of the firm. We show with our study how context-sensitive diversity research could emphasize the use of sophisticated statistical methods to open the black box of diversity research a bit more.

In summary, providing these new insights, our paper contributes to the team composition literature in an innovative way discussing the single effects of the different items of diversity and disentangling the direct effects of team composition from indirect effects mediated by two other important success factors.

5.3 Limitation and future research

The present study has several limitations, which in turn suggest ideas for future research. We use data from USOs in the life science field and industry. In addition to the positive effects mentioned to focus on this specific group, this special context could have an influence on the research results and reduce the generalization of our research results for USO team diversity in other industry contexts. Thus, we propose either to replicate this kind of focus in other university and academic fields, such as applied physics or mechatronics or sensoric, IT, to identify if these team diversity effects can be found in the same way with these direct and indirect effects or to replicate this kind of study on team diversity over a broader spectrum of USOs, controlling for the different academic fields.

Moreover, our study provides insights in a specific German-speaking context in universities, specifically Switzerland and Germany. Regarding the different policies and management cultures in universities, i.e., in other countries, our study is not comparable with those and limited. However, an international comparison might deliver interesting results, controlling for university cultures and political settings.

Our data are cross-sectional; hence, the interesting point is to study team development and team diversity effects in USOs over time from the seed phase over the market entry and growth or even an exit like being sold or bringing the USO to stock market. The interesting question is how and why teams change in their diversity aspects, what are drivers and antecedents, and what might be effects of these changes.

A methodical limitation refers to the need of imputing missing values because all survey participants are personally contacted and denied some answers. Due to the small sample size in the special context of USOs in the biotech industry, excluding the missing values is impossible. Another limitation concerns the concentration on the most crucial success factors where a more complex model including the other important success factors of firms could lead to more convincing results.

Finally, we focus on traditional performance measures. However, following Beck et al. (2019), it would be interesting to measure and acknowledge the diversity impact on other outcome or performance variables like non-pecuniary benefits when undertaking USO activities as a researcher as a so-called form of outbound—pecuniary innovation. Not all USO activity is knowledge commercialization for profit but may also aim at engaging with different stakeholders for the public good or fulfill individual or team values. Future research should check for the impact of diversity on these outcomes (goals) or analyze different value settings as part of analyzing the impact of diversity on performance.

5.4 Implications

Providing new results regarding the different aspects triggering the diversity effects of USOs and the insight

on indirect effects underlines the importance of the team composition of USOs, either for the early stage or for the development phases. These results have important implications for the management of USOs themselves and institutions working and supporting USOs, such as universities and policy makers. For financing institutions, there can be some observed interesting and helpful suggestions, too.

Universities, which can serve as the "breeding" institutions of USOs, have an important role to play in supporting USOs to find their way to the market and achieving success (Meoli et al. (2019), Meoli and Vismara (2016)). The importance of a diverse team in a specific composition for USOs might help bring together the more homogeneous funding teams with "fitting" potential new team members to generate a more heterogeneous team. This could be done either by enlarging the network of USOs or by offering training and workshops to enable USO teams to understand that they must generate a more heterogeneous but balanced team. Thus, universities should try to set up an even more supportive environment for USOs and team-up possibilities (Meoli and Vismara (2016), Meoli et al. (2019)). For instance, universities could start a general PhD or PostDoc policy enabling new faculty and junior or assistant and associated professors to take part in courses offered in spin-off creation and intellectual property. Such a program would bring together researchers from different fields and enable them to become acquainted with each other. Business planning courses or competitions or teaching in joint master programs might support this by bringing together researchers and getting to know one another, which is commonly the first step for a team building activity. In the same line, a support by TTOs or university management to bring in industry experienced managers or USO managers might help search and find new potential USO team members (e.g., Muscio and Ramaciotti (2019), Ferretti et al. (2019), Huynh (2016), Huynh et al. (2017)).

For USO teams themselves, this study offers them a starting point to reflect the current team situation regarding diversity and ways how that team composition could be changed to facilitate USO development (e.g., Shane (2004)). We provide critical insights to discuss characteristics and the mix of the team to understand if the current team diversity is sufficient, and if not how it could be changed; i.e., regarding a USO to become a born global or early internationalizing founded company, the effect regarding diversity and positive heterogeneity effects in networking or getting financed is now evident. Therefore, they might search for a more international team member fitting in to the team, regardless of field knowledge or parallel industry experience (e.g., Zacharakis 2010, Jungwirth and Moog (2004)). Thus, the team members of USOs become more aware of the need to develop a team dynamically. On top of this, the study suggests to team members how to better use the existing network, i.e., in search for a new member or other resources.

Finally, for VCs, the implications are quite similar. As former studies have shown (Zacharakis (2010), Jungwirth and Moog (2004)), VCs like to invest and support USOs or other firms, where team founders have similar skills or backgrounds. In this case, homogeneity-positive effects and trust building will prevail. However, VCs should know that to bring in a new team member, for example, with industry experience, requires that the new team member must provide a better fit with the existing team members (e.g., same skill, same university, or same research field). At the same time, this new team member should still bring in a very important component of diversity, such as industry experience. Thus, VCs might learn about the most effective aspects of team diversity and how to figure this out and in a later stage, enabling them to create a more effective USO team (Zacharakis (2010), Jungwirth and Moog (2004)).

For public entities wanting to increase the number of USOs in general or successful USOs, this study shows the necessity of supporting universities and their institutions, such as TTOs, accelerators, or incubators, to bring together USOs with potentially fitting new team members. Thus, financial support should offer the generation of the mentioned courses or events. Moreover, due to the importance of USOs revitalizing technological fields and parts of the economy, our study provides some practical social and policy implications. To make it easier for USOs to bring in new diverse team members, with different experiences, policies could allow universities and other potential shareholders to invest money and to obtain shares and in doing so bring in important team members. Moreover, labor law restrictions for university researchers and contracts could be developed in a more flexible way to make it easier and more appealing to researchers to stay in USOs and engage more strongly (regarding working time), thus helping to make USO more successful due to the fact that research teams can stay in USOs easily.

Beyond the limitations discussed, we contribute new insights regarding team diversity and USO performance to the ongoing discussion on team effects and hope to emphasize the need for sophisticated mediation models within a different academic field context or over time to open the black box between team diversity inputs and USO performance.

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Appendix

Table 4 Descriptive statistics measured items

Items	Mean	Standard deviation	VIF
Study programs and degrees	2.59	1.377	1.612
Doctorates	2.48	1.357	1.444
Other titles	2.78	1.453	1.300
Soft skills	3.45	1.083	1.567
Contacts and network	3.48	1.168	1.770
Industrial experience	3.38	1.148	1.642
Age	2.58	1.499	1.256
Character	3.25	1.069	2.659
Nationality	2.08	1.238	1.680
Team members	2.95	1.444	1.322
Bank	2.59	1.488	1.688
Venture capital	2.70	1.840	1.785
Business angels	2.33	1.574	2.559
Private equity	3.81	1.194	1.812
Friends and family	2.36	1.441	2.995
State funding and government aid	2.16	1.087	1.546
European funding programs	1.56	0.710	1.967
Small- and medium-sized enterprises	3.73	1.198	
Industry	3.22	1.588	
Universities	3.11	1.286	
Research centers	3.22	1.362	
Connected researchers in universities	3.41	1.205	
Connected researchers in research centers	3.45	1.436	
International firms	3.72	1.278	
Interdisciplinary cooperations	3.50	1.321	
Short-time cooperations	2.64	1.146	
Long-time cooperations	2.91	1.050	
Informal contacts	3.38	1.485	
University infrastructure	3.08	1.313	
Employee growth rate	2.079	1.954	
Sales growth rate	189.375	212.198	

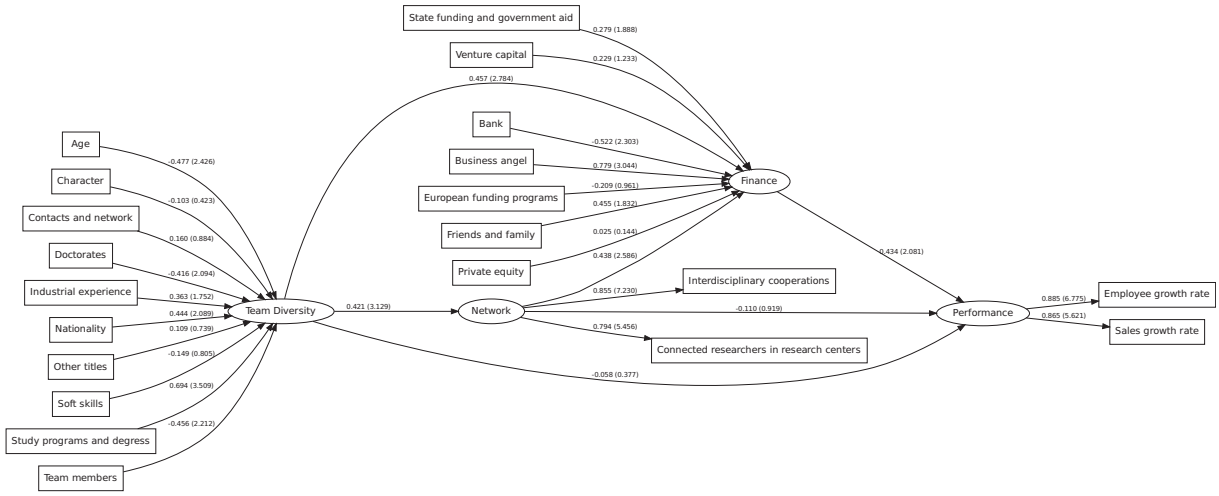

Fig. 4 Results of structural model and measurement models: Each arrow contains (a) the path weight, (b) the *t* value. The limits for statistical significance are the following: $t > 1.645 = p \leq 0.1$, $t > 1.960 = p \leq 0.05$, $t > 2.576 = p \leq 0.010$, $t > 3.291 = p \leq 0.001$

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