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How human capital interacts with the early development of academic spin-offs

Sven H. De Cleyn · Johan Braet · Magnus Klofsten

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Abstract This paper focuses on venture team characteristics with respect to human capital dimensions in early stage ventures emerging from academic research (institutions). Three major groups have been investigated: founders, top managers and directors. Data was obtained using personal interviews with 185 product-oriented academic spin-offs in nine European countries, including those of 17 failures. The results show a significant positive—but diminishing—impact of team heterogeneity on venture success, as well as a positive impact from legal expertise within the board of directors. At management level, the results further indicate that larger management team are better equipped to face the challenges in academic spin-offs. Furthermore, the added value of serial entrepreneurs is questioned, since they seem to negatively impact a spin-off's survival chances. Several implications are addressed, dealing with an appropriate team composition (on the levels of both top management and the board of directors) as well as the importance of paying attention to team development.

Keywords Academic spin-offs · Human capital · Team characteristics · Early development · Failure · Survival

Introduction

Since the Bayh-Dole Act was passed in the U.S. in 1980 (this was followed by similar changes in the legislative framework in most European countries in the 1990s), attention to academic entrepreneurship has continued to increase. One of the most visible ways of transferring technology to society and the marketplace is through the

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creation of academic spin-offs (ASOs; see Klofsten and Jones-Evans 2000; Klofsten et al. 1999; Rasmussen et al. 2006; Shane and Stuart 2002; Vohora et al. 2004). In Silicon Valley, ASOs have become the main technology transfer mechanism (Carayannis et al. 1998), although in many other regions the use of ASOs is still in its infancy (Pirnay et al. 2003).

Similar to any other start-ups, new ASOs face a number of challenges and risks inherent to their early development process (Song et al. 2008). The main risks stem from the absence of a past track record and of a resource buffer at a venture level (Davidsson and Klofsten 2003; De Coster and Butler 2005; Lerner 2005), which are closely connected to the liabilities of newness/adolescence and smallness (Stinchcombe 1965; Brüderl and Schussler 1990; Fichman and Levinthal 1991). The absence of a prior track record for a venture often hampers their ability to obtain sufficient resources (Wright et al. 2006; Harrison et al. 2004), as this absence forces external entities to base their assessment mainly on the characteristics of the key persons (Ostgaard and Birley 1996) in terms of human as well as social capital. The characteristics of the key persons—in terms of their education, work and entrepreneurial experience and social relations—thus become a major source of credibility and legitimacy (Reagans and Zuckerman 2001; Packalen 2007). Furthermore, these key persons play a crucial role in the early development of the venture (Shrader and Siegel 2007). The key persons for a venture are the founders, the top management team (TMT) and/or the board of directors (BoD).

Despite the relatively large attention in prior literature on human capital issues, a number of topics have been under-researched. Given the specific nature of ASOs as described above, few scholars have investigated team characteristics and their impact on the survival likelihood of early stage ASOs. This study then adds both on the ASOs aspect (as compared to other technology-based ventures), as well as on the early stage aspect (most studies focus on growth stages). Additionally, few studies take team involvement over a longer period of time into account. This study adds to current literature by evaluating the effects of different team characteristics over time.

The aim of this study is to further explore the relationships between human capital aspects of early-stage ASOs and their survival likelihood. After a literature review of prior studies on this subject, “[Research framework](#)” deals in detail with the research scope and research questions addressed. The same section provides more insights into the contribution of this study to theory and practice.

Literature review: human capital and ASOs

Early studies make a clear distinction between *human capital* and *social capital* (Davidsson and Honig 2003): human capital refers to the knowledge and experience of individuals (Schultz 1961; Watson et al. 2003), whereas social capital relates to the ability to extract resources (e.g. information or financing) from the external network (Nahapiet and Ghoshal 1998).

Human capital refers to an individual’s knowledge, skills, abilities and experiences, which increase knowledge accumulation and business acumen (Schultz 1961; Kaasa 2009; Unger et al. 2011). Human capital can be increased through education, training, and other experiences (Schultz 1961; Gimeno et al. 1997; Kaasa 2009). Higher initial human capital endowments at start-up have been demonstrated to increase the likelihood of a new

venture's survival (Wetter and Wennberg 2009). Furthermore, Human Capital Theory (HCT) argues that firms with higher human capital should better be able to plan, solve problems, and respond to the challenges imposed by the environment in which they operate (Florin et al. 2003). The contribution of human capital to (new) venture success runs via various mechanisms, and as such, human capital is considered to be resource that can directly affect the achievement of a (sustainable) competitive advantage (Schultz 1961; Coleman 1988). Furthermore, as human capital serves as main source of a start-up's credibility and legitimacy (Ostgaard and Birley 1996; Pennings et al. 1998; Packalen 2007), higher human capital stocks lead to a significantly improved ability to attract resources (Pennings et al. 1998; Delmar and Shane 2004; Packalen 2007). In this regard, Delmar and Shane (2004) have argued that credibility and legitimacy of a venture are most critical in the earliest development stages, since "disbanding depends most on the perceptions of external stakeholders, rather than on actual financial performance" (p. 388). According to Drori et al. (2009), legitimacy stems from a venture possessing advantages over others; in the earliest development stages human capital characteristics are one of the few variables available to assess this advantage (Ostgaard and Birley 1996). As such, credibility and legitimacy stems (largely) from human capital. Another effect of human capital is also indirect: higher levels of human capital usually lead to higher earnings at personal level, which makes start-ups founded by people with higher human capital endowments less vulnerable to financial constraints (i.e. possible constraints in firm development; Colombo and Grilli 2005).

In new ASOs, like in any start-up, the amount of resources is limited and a significant part of the start-up's value is therefore determined by its human capital stock (Shrader and Siegel 2007). Although employees—if any—make up an important part of a firm's human capital stock, in the early stages of ASOs the venture almost always coincides with the founding team and/or the TMT (Colombo and Grilli 2005; Packalen 2007; Shrader and Siegel 2007). Chief executive officers (CEOs) of new ASOs should be able to understand the technology and develop the business proposition for this technology (Clarysse and Moray 2004). This combination of skills, knowledge, and expertise is difficult to find in academic researchers (Franklin et al. 2001; Mosey and Wright 2007), which makes them often less suited to fulfil the challenging task. Especially in new ventures, the human capital stock can be increased by making use of additional sources of human capital, such as a board of directors, advisory board, external advisors, science park managers and, in the case of ASOs, technology transfer offices (TTOs; Nicolaou and Birley 2003). An additional source of human capital (and one that is increasingly used in high-tech start-ups) can be obtained by attracting experienced (serial) entrepreneurs to strengthen the key persons (Rosenblatt and Thelen 1997; George et al. 2010). Recent research by Parker (2013) has, however, indicated that the benefits that serial entrepreneurs contribute venturing disappear over time. Furthermore, through entrepreneurial euphoria, the pros of serial entrepreneurs are sometimes over-emphasized in relation to the cons (Cooper et al. 1995). Overall, prior research has indicated that team formation currently fails in most ASOs (Ensley and Hmieleski 2005): i.e. most ASO teams are too technically-oriented, which increases the need for a better understanding of the effect of human capital in new ventures on their subsequent performance. For a recent in-depth meta-analysis of the relationship between human capital and (new) venture success, see Unger et al. (2011).

Research framework

Aim and scope

Despite the existence of numerous studies on human capital-related issues in new ventures development, we believe that there is room for new studies in this research field. This is based on various reasons, and these can, on the most part, be placed into three categories: academic spin-offs (and the individuals behind the venture), policy-related matters, and the response of academia.

Firstly, an academic spin-off at foundation is a collection of individuals with almost no accrued knowledge at firm level (Ostgaard and Birley 1996). This situation makes the human capital of the individual key people a key resource for converting codified and tacit knowledge into commercial products and services (Mosey and Wright 2007; Wright et al. 2007). This human capital and the management thereof are heavily context and time-related, due to factors including the increasing complexity of technology and markets and the shift towards an information society (Barney 1991; Schuller and Field 1998; Unger et al. 2011).

Secondly, at both the EU and individual country levels there is a need to develop accurate policies that inspire, foster, and facilitate entrepreneurial behaviour in the society. Several studies, including these on the GEM data, have shown that most European countries are consistently lagging behind the U.S. when it comes to entrepreneurial attitude, culture, and entrepreneurial outcomes (Klofsten and Jones-Evans 2000; Goldfarb and Henrekson 2003). In response to this lack of entrepreneurship in Europe, the EU Commission has undertaken a number of initiatives to foster entrepreneurship and the commercialisation of research results (through, for example, the Framework Programmes and Horizon 2020; European Commission 2013).

Thirdly, academia has responded to these two challenges by making commercialisation of their research output the third pillar of their mission (in addition to the two pillars of research and teaching; Etzkowitz 1998; Leydesdorff 2000; Rasmussen et al. 2006), by increasing their efforts in entrepreneurship education and training, and by developing the human capital for both students and researchers (Bienkowska and Klofsten 2012; Kuratko 2005; Etzkowitz and Klofsten 2005). Therefore, from both management and policy perspective, it is necessary to repeatedly study human capital, as this is a crucial factor in the increasing importance of the relation between individual capabilities and new venture outcomes.

The scope of the present study is limited to European product-oriented ASOs in their early development stage (post-start-up). It is important to recognise that ASOs are not a homogenous group (Birley 2002; Mustar et al. 2006): they exist for different reasons, emerge from different origins, and conduct different activities. A clear definition of the boundaries of the study, therefore, will contribute to the level of comparability of the results with other studies. In this sense, within the scope of this study an academic spin-off or ASO is defined as “a new legal entity (company) founded by one or more individuals from an (academic) parent organisation to exploit some kind of knowledge gained in the (academic) parent organisation and transferred to the new company” (De Cleyn and Braet 2009, p. 327). As this definition is still rather broad and covers new ventures deeply rooted in academic research as well as new ventures established by (highly) educated people based on knowledge gained through education or lectures at

academic institutions, the scope of this study is further limited to those ASOs directly emerging out of academic research efforts.

Given the longer use of ASOs as technology transfer mechanism, it is not surprising that the majority of the studies on ASOs focus on the North-American situation (Degroof and Roberts 2003; Clarysse et al. 2005; Rothaermel et al. 2007; Yusof and Jain 2010). In order to increase the validity of the research stream (Rothaermel et al. 2007) and grasp the influence of intercultural differences through cross-country studies (Yusof and Jain 2010), this study adopts a multi-country approach in Europe. Data have therefore been collected in nine European countries.

Technology-based ventures face higher risks than service-oriented ventures (De Coster and Butler 2005). The challenges imposed by the technology (or by product development trajectory) require additional sets of capabilities, knowledge, and resources (Zeithaml et al. 1985; de Brentani 1991). This study only includes product-oriented ASOs, which require an active involvement in new technology and/or (physical) product development (including software). Purely service-oriented ASOs (e.g. consulting firms) are excluded, given the different development path and risk associated to a product versus service-oriented venture. Product-oriented ventures are typically more capital intensive, have a more complex product development process with more inherent risks, have a longer time-to-market, require a different supply chain and have different scalability-aspect when compared to service-oriented ventures (Griffin 1997; Braet and Verhaert 2007).

A third boundary for the sample is the choice to study the early development process of ASOs. New ventures, especially in their earliest years, live through highly turbulent development periods (Davidsson and Klofsten 2003). For product-oriented ventures, the risks associated with the early development are even higher, since they face novelty in many dimensions (De Coster and Butler 2005). In this regard, product-oriented ASOs face three concurrent risks: a market risk (i.e. if the market will adopt the product or technology), a technological risk (i.e. if the technology will be able to be developed to a market-ready solution), and a risk originating from their non-commercial background (i.e. if the entrepreneurs will be able to adapt from an academic, non-business-oriented environment to a commercial business environment; De Coster and Butler 2005; Lerner 2005). Furthermore, the strategic choices made in the earliest stages have a greater impact on future development (this is idea of path dependency; see Degroof and Roberts 2003). Additionally, given the absence of a prior track record (Bathelt et al. 2010), the characteristics of key persons (in terms of human capital) to be foregrounded in the early development of new ventures, as these offer a source of credibility and legitimacy (Reagans and Zuckerman 2001; Shrader and Siegel 2007).

Early development, then, refers to the phases after the (legal) foundation of the new venture (i.e. post start-up; De Cleyn and Braet 2010), in which the (further) development of the first generation technology and product takes place (De Cleyn 2011). In line with the boundaries of the early development used in other studies, the early development in this study refers to the first 10 years after the legal foundation of the ASO (Bamberger et al. 1989; Chamanski and Waagø 2001; Song et al. 2008). Furthermore, this 10 year period additionally counters the effect of varying environmental and economic conditions (Terpstra and Olson 1993), as both periods of economic downturn and peaks of the business cycle are included in the time-frame of this study (1999–2009).

This scope of this study is not limited to successful (surviving) ASOs, as this approach attempts to avoid the survivor bias common to many studies on new ventures (Davidsson et al. 2001). Although organisational failure is a common event, the subject has been under-researched (Blackburn and Kovalainen 2009) and is to some extent—at least in Europe—‘unmentionable’ (Wilkinson and Mellahi 2005). The term failure in this study refers to its most basic definition: namely, bankruptcy. It is our belief that valuable lessons can be learnt from failure cases: this study therefore incorporates the lessons of 17 failed ASOs (in a total sample of 185 ASOs). The ASOs that survived at least up to the point of the interview are considered to be successes in the context of this study.

Even though the share of failed venture in the total sample seems small (17 out of 185 or 9.2%), this is in line with the typical failure rate as suggested by a number of prior studies on ASOs. Despite the combination of the aforementioned technological and commercial risk on one hand and their emergence out of a non-commercial environment on the other, ASOs surprisingly tend to face lower failure rates. In a large-scale study on NTBFs in the Göteborg region (Sweden), Dahlstrand (1997) found that of the 240 ASOs originating from Chalmers University between 1960 and 1993, 87% were still alive in 1993 and the other 13% had been terminated. Another large-scale study reported that of the 2,578 ASOs founded between 1980 and 1998 in the U.S., 70% were still in operation in the latter year (Di Gregorio and Shane 2003). In two smaller samples, other scholars have found ASO failure rates of 10.7% over 10 years (sample of 26 Welch ASOs in the period 1990–1999) (Brooksbank and Thomas 2001) and 27.3% over 12 years (sample of 22 Canadian and U.S. ASOs in the period 1989–2001) (Gurdon and Samsom 2010). Lyskey (2008) confirmed the low ASO failure rate of about 10% among ten U.K. universities, compared to the much higher rate of 60 to 70% for other high-tech firms (timeframe: 1998–2002, sample of 173 U.K. ASOs). In a sample of 3,115 European ASOs established between 1985 and 2008, an independent survival rate of 86% was found, while 4% continued in a dependent setting (merger or acquisition) and 10% ceased operations (liquidation or failure) (De Cleyen et al. 2010).

This low failure rate might be explained by the fact that other NTBFs are better equipped to exploit and market their own inventions, while ASOs develop new technologies that are subsequently exploited by other companies (Dahlstrand 1997). As a consequence, ASOs might be able to survive as independent, small and highly innovative ventures with a low failure rate (Dahlstrand 1997). Alternatively, Nerkar and Shane (2003) put forward that firms exploiting more radical technologies and broad patent scopes have higher survival chances. ASOs often fulfil both criteria, especially product-oriented ASOs (who are the focus of this study). Furthermore, some ASOs might survive in an artificial way using subsidies. Overall, ASOs seem to face relatively high survival rates.

Research questions

In an attempt to unravel the impact of different types of human capital endowments on ASO survival, this study addresses three research questions. These are discussed below.

Research questions one and two

This study builds upon prior scholarly work on human capital in technology-based ventures and investigates the importance of complementary teams in terms of prior

functional background and prior education of the founders, managers and directors. Complementary teams have been shown to achieve greater likelihood of survival (Shane and Stuart 2002; Aspelund et al. 2005; Knockaert et al. 2011). However, in academic environments new ventures are, often established by teams who have predominantly technological or scientific backgrounds (Mosey and Wright 2007; Franklin et al. 2001). Building on this prior evidence, the first two research questions investigate if the positive impact of complementarity (functional and educational) teams on new venture development remains present for product-oriented ASOs:

- RQ 1: How important is complementarity of team composition in terms of prior functional background for survival in the early development of academic spin-offs?
- RQ 2: How important is complementarity of team composition in terms of prior education for survival in the early development of academic spin-offs?

Research question three

The third research question differentiates between different types of prior entrepreneurial experience. The impact of prior entrepreneurship experience on new venture success has been researched frequently (e.g. see Honig 1998; Davidsson and Honig 2003; Delmar and Shane 2006). Thus far, these studies have been inconclusive on the direction of the effects (Delmar and Shane 2006; Unger et al. 2011). Currently, the majority of scholarly studies on prior entrepreneurial experience take for granted a uniform impact on any type of entrepreneurial experience. Having taken into account the example of serial entrepreneurs (in terms of entrepreneurial euphoria and diminishing positive effect of prior experience), we assume a potentially different effect that depends on the type of prior entrepreneurial experience. In the context of product-oriented ASOs, the type of new venture the founders and/or managers had previously founded and the outcome of this venture (success, bankruptcy, deliberate cessation, merger, acquisition) may be relevant. As such, the third research question not only investigates the overall importance of this prior experience, but also the underlying differences according to the nature of these experiences:

- RQ 3: Are different types of prior entrepreneurial experiences in the early development of academic spin-offs correlated with its survival probability?

With respect to these research questions, the aim is to analyse whether there is a variation in the correlation between the human capital composition of the key persons and the success of academic spin-offs. By studying a European data set, the effect of initial human capital endowments in the early development of ASOs will be discussed and compared to prior literature on the subject.

In this regard, the contribution of this study to both human capital and academic spin-off literature is expected to be threefold. Firstly, at a theoretical level, this study adds to current understanding of the effects of prior entrepreneurial experience by differentiating between various types. We contribute to the theoretical stream on human capital endowments. Secondly, this study contributes to ASO practice by further disentangling the relationships between human capital characteristics and subsequent new venture survival. The results will be helpful in building entrepreneurial teams in academic environments. Finally, this study should confirm that entrepreneurial teams

should change over time to better respond to changing challenges over the development of new ventures (Colombo and Grilli 2005; Mosey and Wright 2007). We contribute to the understanding of team evolution by measuring the effects at various points in the development of product-oriented ASOs.

Research methodology

Data collection

Data were collected using a two steps procedure, and by adopting a mixed-method approach. Firstly, 17 exploratory case studies were conducted using personal interviews with one of the active founders (mostly the CEO or CSO/CTO) of Belgian ASOs (random sampling). These interviews (1–1.5 h duration) were guided by a semi-structured questionnaire, which aimed at gaining insights into the relevant key persons' aspects during the early development stage of ASOs. The semi-structured approach allowed a rich set of both qualitative and quantitative data to be collected (Wengraf 2001). The questionnaire was further developed based on the outcome of the case studies the new insights that had been gained through eight expert interviews (1–3.5 h duration). These experts covered most stakeholders involved in the ASO process (entrepreneurs, TTO managers, incubator managers, financiers, consultants, and professors).

The outcomes of these exploratory, more qualitative case studies and expert interviews have been used as input to develop the more quantitative questionnaire for a larger data collection effort. The rich input from the qualitative phase has enabled us to develop a strong, more quantitative questionnaire grounded in practice. After a pre-test with ten early stage, product-oriented ASOs, these efforts together led to the development of a final questionnaire, which only contained closed-end questions on early ASO and team development.

The second step concerned the actual data collection. Data were collected on 185 ASOs in nine countries using personal interviews (about 1 h in duration) with the CEO or active founder (effective response rate of almost 93 %). The ASOs were selected using a combination of probabilistic (random) sampling and purposive (snowball) sampling, to ensure that multiple European countries are addressed. The former helps in achieving external validity, while the latter allows achieving higher response rates and increasing the usefulness of the selected cases (Goodman 1961; Welch 1975; Tashakkori and Teddlie 2003). However, all 185 ASOs interviewed were part of a database collected in an earlier research effort, which contains over 8,000 ASOs in Europe (see De Cleyn et al. 2010). Within this database, a number of regions and academic institutions have been chosen (in order to cover a variety of regions and cultures). Interviews were conducted in Belgium, Denmark, Germany, Italy, Norway, Spain, Sweden, the Netherlands, and the United Kingdom. Through referrals of local contacts (mostly TTO managers from the academic institutions in these regions), i.e. snowball sampling, and some randomly sampled ASOs, the final sample was constructed.

For each of the founders, managers and directors, we collected general data (gender, age, and full or part-time commitment), data on (type of) prior functional experience, data on (level and type of) prior education and data on the nature of prior entrepreneurial experience. With regard to performance variables, data have been collected on

success versus failure (dichotomous variable) and yearly data on EBIT, total assets and turnover. Finally, data on employment (FTE or full-time equivalents) was collected, in order to effectively correct the data for ASO size.

After the interviews, the data was triangulated using other data sources: including the ASO's website, the financial database *Amadeus* (edited by Bureau Van Dijk; this also contains information on TMT and BoD members), the professional network site *LinkedIn* for personal profiles, and internet searches (mainly using *Google*). This procedure avoided the risk of hindsight bias and the risk associated with self-reported data (Rocco et al. 2003; Davidsson 2005).

In order to obtain a sample that was representative of the overall population of early stage product-oriented ASOs, the sample included ASOs that were still active ($n=151$), had failed ($n=17$), had been acquired by ($n=11$) or merged with ($n=2$) other firms, or had realised an initial public offering (IPO; $n=4$). The sample focused on early stage ASOs (the age range was limited to 11 years or less) and covered a variety of industry sectors, with a strong representation of electronics, ICT, biotechnology, and pharmaceuticals. All ASOs in our sample were product-oriented ventures.

Data analysis

Two types of techniques were used for the data analysis, depending on the type of data. To distinguish the two groups of ASOs (a dependent variable), the dichotomous success versus failure variable was used. In case of ordinal variables (e.g. level or type of education or type of prior functional experience) differences between the two groups were tested using logistic regression, which provides information on the direction and significance of the effect of explanatory (independent) variables on the dependent variable (Kuhnert et al. 2000; Hastie et al. 2001; Keller 2005) and the likelihood of correctly classifying the presence (or absence) of an event (Tansey et al. 1996). One of the main advantages of logistic regression is that it does not necessarily assume a linear relationship between the independent and dependent variables (Lo 1986; Youn and Gu 2010).

In the case of interval dependent variables (e.g. EBIT/FTE, total assets/FTE, and turnover/FTE) the second type of analyses concerned *t*-tests (Keller 2005). In this case, the two populations were the independent groups of failed and surviving ASOs. The Levene's test, with the correction for unequal sample sizes, was used to analyse the homogeneity of variances across the populations (Levene 1960; Brown and Forsythe 1974). The relationship of these variables with the heterogeneity of management team and board of directors (in terms of prior functional experience and educational degree) was tested on years 2, 4, 6, and 8 after the ASO's foundation (year 1 being the first year after its foundation).

A major limitation of this study concerns the operationalising of the dependent variable (binary success-failure). One could argue that, especially in the early development of ASOs, a certain share of ventures did not really face the market test, as their first core product was still under development. As long as these ASOs did not realise any turnover, it might be questionable to categorise them as successes (they might be 'false positives'). In this sample, 59 ASOs did not realise any product sales at the time of the interview, of which ten were failures. Even though the number of failures in this subsample was small, two robustness checks were performed. Firstly, the 49 surviving ASOs without product sales were excluded from the sample. In this new dataset, all the results obtained were

confirmed. One additional result was obtained: ongoing founder involvement turned out to have a significant positive impact on ASO success; although not if this involvement occurred as CEO. Secondly, by means of an experiment, ten randomly selected surviving ASOs without core product sales were categorised as failures instead of successes. Again, all the prior results were confirmed. Therefore, the results obtained in this sample of 185 European early stage ASOs can be considered to be robust.

Results

The impact of human capital characteristics on ASO success was analysed on three levels: top management team, board of directors, and founders.

Top management team

The results of the *t*-test in Table 1 suggest that larger TMTs are better equipped to face the challenges associated with new ASO development. On average, failed ASOs seem to have smaller TMTs (an average of 2.0 TMT members compared to 2.6 for the surviving ASOs). This finding is in line with prior studies on the subject, which have suggested that a large TMT will provide several benefits for a venture: including a larger pool of knowledge, experience and expertise, and a greater likelihood of attracting external funding (e.g., see meta-analysis: Song et al. 2008; Unger et al. 2011).

Further results in Table 1 suggest a significant and positive impact from TMT members with prior experience in financial functions (significant at $\alpha=5\%$). The relationship between ASO success and prior entrepreneurial experience of TMT members is, however, less clear (Florin et al. 2003; Baum and Silverman 2004; Unger et al. 2011). Delmar and Shane (2006) have already pointed to the complex and indirect relationship between prior entrepreneurial experience and new venture success. In our study, the presence of top managers who have prior entrepreneurial experience (whether in any type of start-up or in high-tech start-ups) had a significant positive influence on ASO survival odds (significant at $\alpha=1\%$). However, this positive effect disappeared in case of serial entrepreneurs. In the current sample, 54 ASOs (out of the total sample of 185) had managers in the team with prior entrepreneurial experience (in at least one other start-up), while 33 had managers on board with multiple other prior start-ups. This is in line with prior findings, which indicated that serial entrepreneurs tend to search less for relevant information and become subject to entrepreneurial euphoria and overconfidence (Cooper et al. 1995).

None of the other variables (TMT age and gender diversity, other types of educational background, or types of prior work, management or industry experience) seem to have exerted a significant impact on ASO success.

Heterogeneous teams have been said to better be equipped to recognise signals of changes in a venture's environment, leading to a higher probability of success (Shane and Stuart 2002; Aspelund et al. 2005; Knockaert et al. 2011). According to human capital theory, this heterogeneity can—amongst other sources—stem from education (see e.g. Cooper et al. 1994; Sapienza and Grimm 1997; Watson et al. 2003; Amason et al. 2006) and prior work experience (see e.g. Brüderl et al. 1992; Zacharakis and Meyer 2000; Watson et al. 2003; Mosey and Wright 2007).

Table 1 Top management team *t*-tests

	Levene's test for equality of variances		<i>t</i> -test for equality of means			
	Equality of variances	<i>F</i>	Sig.	<i>t</i>	df	Sig. (2-tailed)
<i>N</i> = 185						
TMT_Number	Assumed	0.750	0.388	-1.735	183	0.084**
TMT_Male	Assumed	0.118	0.732	0.170	182	0.865
TMT_Senior	Assumed	0.241	0.624	0.615	182	0.539
TMT_Founder	Assumed	0.034	0.855	-0.109	182	0.913
TMT_BADegree	Assumed	0.117	0.732	-0.151	182	0.880
TMT_MADegree	Assumed	0.037	0.848	-1.443	182	0.151
TMT_PhDDegree	Assumed	0.237	0.627	1.475	182	0.142
TMT_ExtraDegree	Assumed	1.817	0.179	-0.721	182	0.472
TMT_Fulltime	Assumed	0.566	0.453	-0.082	182	0.935
TMT_Heterogeneity_Degree	Assumed	0.389	0.534	-0.368	182	0.713
TMT_Degree_Science	Not assumed	2.986	0.086	0.864	16.838	0.400
TMT_Degree_AppliedScience	Not assumed	3.422	0.066	0.201	16.361	0.843
TMT_Degree_ProductDevelopment	Assumed	0.781	0.378	-0.437	182	0.663
TMT_Degree_Economics	Assumed	0.000	0.991	-0.663	182	0.508
TMT_Degree_Law	Not assumed	14.125	0.000	1.136	15.696	0.273
TMT_Degree_Arts&Humanities	Assumed	1.593	0.209	-0.620	182	0.536
TMT_Degree_Other	Assumed	0.384	0.536	-0.308	182	0.759
TMT_Heterogeneity_Experience	Assumed	0.061	0.806	-1.303	182	0.194
TMT_Experience_R&DTechnology	Assumed	1.153	0.284	-0.687	182	0.493
TMT_Experience_Production	Assumed	0.013	0.908	-0.192	182	0.848
TMT_Experience_Marketing_Sales_BusinessDevelopment	Assumed	0.392	0.532	-0.653	182	0.515

Table 1 (continued)

	Levene's test for equality of variances		<i>t</i> -test for equality of means		
	<i>F</i>	Sig.	<i>t</i>	df	Sig. (2-tailed)
<i>N</i> =185					
TMT_Exp_Financing	5.530	0.020	-2.357	38.742	0.024*
TMT_Exp_Legal	2.977	0.086	0.858	17.167	0.403
TMT_Experience_HRM	0.707	0.402	-0.416	182	0.678
TMT_Experience_Management	0.641	0.425	0.341	182	0.734
TMT_Experience_Same industry	1.505	0.221	-0.125	182	0.901
TMT_Entrepr Start-up 0	0.225	0.636	0.914	182	0.362
TMT_Entrepr Start-up 1	16.458	0.000	-4.298	49.100	0.000*
TMT_Entrepr Start-up 1 plus	3.254	0.073	0.623	16.288	0.542
TMT_Hightech Start-up0	0.079	0.779	0.167	182	0.868
TMT_Hightech Start-up 1	9.247	0.003	-3.163	44.971	0.003*
TMT_Hightech Start-up 1 plus	7.475	0.007	0.856	15.894	0.405
TMT_Failure0	1.098	0.296	0.516	182	0.607
TMT_Failure1	0.699	0.404	-0.414	182	0.679
TMT_Failure1 plus	0.384	0.536	-0.308	182	0.759

*Significant at $\alpha=5\%$; **Significant at $\alpha=10\%$

The results in Table 2 suggest an additional effect between TMT human capital on one hand and ASO success on the other. These heterogeneous TMTs in terms of prior education and work experience have a significant positive impact on ASO success (measured by EBIT per full-time equivalent [FTE], total assets per FTE, and turnover per FTE). The effect was, however, strong in the first years after ASO foundation (often significant at $\alpha=1\%$ for year 2), but disappeared over time. The heterogeneity of a TMT is, thus, an important aspect in the earliest development of ASOs; while over time—due to learning curves—its importance fades away (as other TMT member become better acquainted with the requirements of other tasks and responsibilities). Although

Table 2 Relationship TMT heterogeneity—performance

$\alpha=5\%$					
Dep. var.	Indep. var.	Number observ.	Stand. coeff.	Adj. R ²	Sig.
EBIT/FTE					
EBIT/FTE Y2	TMT_Hetero_Experience	123	-0.310	0.089	0.000*
	TMT_Hetero_Degree	123	-0.404	0.156	0.000*
EBIT/FTE Y4	TMT_Hetero_Experience	98	-0.288	0.073	0.004*
	TMT_Hetero_Degree	98	-0.255	0.056	0.011*
EBIT/FTE Y6	TMT_Hetero_Experience	51	-0.199	0.020	0.162
	TMT_Hetero_Degree	51	-0.134	-0.002	0.349
EBIT/FTE Y8	TMT_Hetero_Experience	32	0.011	-0.033	0.952
	TMT_Hetero_Degree	32	-0.258	0.036	0.153
Total assets/FTE					
Total assets/FTE Y2	TMT_Hetero_Experience	122	0.152	0.015	0.094**
	TMT_Hetero_Degree	122	0.216	0.039	0.017*
Total assets/FTE Y4	TMT_Hetero_Experience	99	0.082	-0.003	0.417
	TMT_Hetero_Degree	99	0.119	0.004	0.240
Total assets/FTE Y6	TMT_Hetero_Experience	52	0.212	0.026	0.131
	TMT_Hetero_Degree	52	-0.033	-0.019	0.818
Total assets/FTE Y8	TMT_Hetero_Experience	32	0.309	0.066	0.085**
	TMT_Hetero_Degree	32	-0.016	-0.033	0.932
Turnover/FTE					
Turnover/FTE Y2	TMT_Hetero_Experience	123	0.154	0.016	0.089**
	TMT_Hetero_Degree	123	-0.111	0.004	0.221
Turnover/FTE Y4	TMT_Hetero_Experience	99	0.140	0.010	0.166
	TMT_Hetero_Degree	99	0.048	-0.008	0.639
Turnover/FTE Y6	TMT_Hetero_Experience	52	0.043	-0.018	0.763
	TMT_Hetero_Degree	52	-0.116	-0.006	0.412
Turnover/FTE Y8	TMT_Hetero_Experience	32	0.070	-0.028	0.702
	TMT_Hetero_Degree	32	-0.242	0.027	0.181

*Significant at $\alpha=5\%$; **Significant at $\alpha=10\%$

heterogeneous TMTs have been attributed better survival chances by earlier studies (Shane and Stuart 2002; Aspelund et al. 2005; Knockaert et al. 2011), especially in ASO TMTs which are often dominated by technological profiles (Franklin et al. 2001; Ensley and Hmieleski 2005), this effect phasing out over time is new.

Board of directors

The BoD has been considered an important source of human capital, and as complementary to that of the TMT. Directors add additional insights through their expertise and increase legitimacy towards external entities (Bjørnåli and Gulbrandsen 2010).

In our sample, 47 ASOs (25 %) did not install a BoD. However, merely having a BoD or not does not seem to affect ASO survival probability. Table 3 provides the results of the *t*-test, which did not find any significant effect from BoD size on ASO survival chances. The results indicate, however, a significant impact from BoD diversity in terms of age and gender on ASO success. The BoDs with a higher share of male directors faced a significantly lower failure risk ($\alpha=10\%$). This result might be mitigated by the relative low number of BoDs containing female directors (34 of out 185 or 18 %). These results are, however, in line with prior findings of van der Walt and Ingley (2003). Furthermore, prior research has suggested that more diverse BoDs (in terms of seniority) face lower failure risks (Siciliano 1996; van der Walt and Ingley 2003). Directors of different ages (and therefore with diverse experience levels) might have different worldviews and ideas, thereby increasing their creativity and problem-solving skills. The results indicate that BoDs with a lower share of senior directors (i.e. with a more diverse BoD in terms of seniority) enjoy higher survival chances (statistically significant at $\alpha=5\%$).

In line with the results found for the TMT, heterogeneity of the BoD in terms of education and prior work experience plays a significant positive but diminishing effect (see Table 4). This result confirms prior findings on the importance of BoD heterogeneity (Erhardt et al. 2003; Clarysse et al. 2007; Bjørnåli and Gulbrandsen 2010) and adds new insights on its effects phasing out over time over the development of ASOs.

Although heterogeneity adds significantly to ASO survival probability, one individual discipline stands out. If the BoD contains directors with legal expertise (education and/or prior work experience), the ASO will enjoy significantly higher odds of achieving success (significant $\alpha=1\%$; see Table 3). In our sample, 65 ASOs (out of 138 ASOs with a BoD) had directors with a law degree, and 62 of these had directors with experience in legal functions.

Founders

Surprisingly, none of the founder characteristics (education, work experience, heterogeneity, participation, or prior entrepreneurial experience) had a significant effect on ASO success. This result might be attributed to the fact that only 23 ASOs in the sample (12 %) did not have any founders involved at the time of the interview. This finding contradicts prior research (even given the low occurrence of ASOs having no founders involved anymore in our sample), which placed emphasis on the importance of an ongoing involvement and relationship of the founders (Doutriaux 1987; Rothaermel and Thursby 2005; Gurdon and Samsom 2010).

Table 3 BoD *t*-tests

	Levene's test for equality of variances		<i>t</i> -test for equality of means		
	<i>F</i>	Sig.	<i>t</i>	df	Sig. (2-tailed)
	Equality of variances				
<i>N</i> =185					
BoD_Number	0.589	0.444	0.120	183	0.905
BoD_Male	8.934	0.003	-1.884	14.135	0.080**
BoD_Senior	5.972	0.016	2.375	26.929	0.025*
BoD_BAdegree	0.144	0.705	-0.166	138	0.868
BoD_MAdegree	1.524	0.219	0.013	138	0.990
BoD_PhDdegree	3.602	0.060	0.801	18.946	0.433
BoD_Extradegree	1.297	0.257	-1.146	138	0.254
BoD_Heterogeneity_Degree	2.600	0.109	0.332	183	0.740
BoD_Degree_Science	4.904	0.028	1.188	14.519	0.254
BoD_Degree_AppScience	0.348	0.556	-0.845	137	0.400
BoD_Degree_ProductDevelopment	44.489	0.000	1.000	13.000	0.336
BoD_Degree_Economics	0.319	0.573	-0.573	137	0.567
BoD_Degree_Law	12.820	0.000	-4.557	124.000	0.000*
BoD_Degree_Arts&Humanities	0.073	0.787	0.198	137	0.843
BoD_Degree_Other	2.332	0.129	-0.736	137	0.463
BoD_Heterogeneity_Experience	1.438	0.232	0.618	183	0.537
BoD_Experience_R&DTechnology	0.415	0.521	0.361	137	0.718
BoD_Experience_Production	2.325	0.130	0.975	137	0.331
BoD_Experience_Marketing, Sales, BusinessDevelopment	0.686	0.409	-0.502	137	0.763
BoD_Experience_Financing	0.002	0.966	0.688	137	0.493
BoD_Experience_Legal	9.468	0.003	-4.073	124.000	0.000*

Table 3 (continued)

	Levene's test for equality of variances			t-test for equality of means		
	F	Sig.	df	t	Sig. (2-tailed)	df
$\alpha = 5\%$						
N=185						
BoD_Experience_HRM	0.452	0.502	137	-0.334	0.739	137
BoD_Experience_Management	1.064	0.304	137	0.125	0.901	137
BoD_Experience_Same Industry	2.284	0.133	137	-1.247	0.215	137
BoD_Entrepr_Start-up 0	0.969	0.327	137	0.003	0.997	137
BoD_Entrepr_Start-up 1	0.001	0.970	137	-0.071	0.944	137
BoD_Entrepr_Start-up 1plus	0.000	0.999	137	0.093	0.926	137
BoD_Hightech_Start-up 0	0.000	0.991	137	-0.017	0.987	137
BoD_Hightech_Start-up 1	0.009	0.926	137	-0.213	0.832	137
BoD_Hightech_Start-up 1plus	0.026	0.872	137	0.218	0.828	137
BoD_Entrepr_Failure0	0.009	0.923	138	-0.072	0.943	138
BoD_Entrepr_Failure1	0.622	0.432	138	0.430	0.668	138
BoD_Entrepr_Failure1plus	1.414	0.236	138	-0.580	0.563	138
BoD_Founder	3.102	0.080	17,241	-0.878	0.392	17,241
BoD_Exec	0.190	0.664	138	0.170	0.865	138
BoD_Nonexec	0.003	0.956	138	-0.185	0.853	138
BoD_Indep	0.034	0.855	138	-0.033	0.974	138
BoD_Adjunct	0.908	0.342	138	-0.469	0.640	138

*Significant at $\alpha = 5\%$; **Significant at $\alpha = 10\%$

Table 4 Relationship BoD heterogeneity—performance

Dep. var.	Indep. var.	Number observ.	Stand. coeff.	Adj. R ²	Sig.
EBIT/FTE					
EBIT/FTE Y2	BoD_Hetero_Experience	124	-0.322	0.097	0.000*
	BoD_Hetero_Degree	124	-0.392	0.147	0.000*
EBIT/FTE Y4	BoD_Hetero_Experience	99	-0.293	0.076	0.003*
	BoD_Hetero_Degree	99	-0.271	0.064	0.007*
EBIT/FTE Y6	BoD_Hetero_Experience	52	-0.107	-0.008	0.452
	BoD_Hetero_Degree	52	-0.020	-0.020	0.890
EBIT/FTE Y8	BoD_Hetero_Experience	32	0.164	-0.005	0.368
	BoD_Hetero_Degree	32	-0.043	-0.031	0.815
Total assets/FTE					
Total assets/FTE Y2	BoD_Hetero_Experience	123	0.182	0.025	0.044*
	BoD_Hetero_Degree	123	0.213	0.038	0.018*
Total assets/FTE Y4	BoD_Hetero_Experience	100	0.210	0.034	0.036*
	BoD_Hetero_Degree	100	0.135	0.008	0.179
Total assets/FTE Y6	BoD_Hetero_Experience	53	0.294	0.068	0.033*
	BoD_Hetero_Degree	53	0.215	0.027	0.122
Total assets/FTE Y8	BoD_Hetero_Experience	32	0.304	0.062	0.091**
	BoD_Hetero_Degree	32	0.287	0.052	0.112
Turnover/FTE					
Turnover/FTE Y2	BoD_Hetero_Experience	124	0.127	0.008	0.160
	BoD_Hetero_Degree	124	-0.024	-0.008	0.793
Turnover/FTE Y4	BoD_Hetero_Experience	100	0.081	-0.004	0.421
	BoD_Hetero_Degree	100	0.100	0.000	0.324
Turnover/FTE Y6	BoD_Hetero_Experience	53	0.199	0.021	0.153
	BoD_Hetero_Degree	53	0.193	0.018	0.167
Turnover/FTE Y8	BoD_Hetero_Experience	32	0.167	-0.004	0.360
	BoD_Hetero_Degree	32	0.028	-0.032	0.877

*Significant at $\alpha=5\%$; **Significant at $\alpha=10\%$

Discussion and conclusions

Discussion

In a new venture's early development, the characteristics of key persons (in the form of human capital) play a crucial role by providing a source of legitimisation and credibility. This study has attempted to unravel the significance and direction of the effect of human capital endowments on the success of early stage product-oriented ASOs. Within the framework of this study, two main forms of human capital have been investigated: complementarity in terms of functional background and education on one hand, and prior entrepreneurial experience on the other.

The results have pointed to the important role of heterogeneity, both at TMT and BoD levels. Given the complexity of the tasks in early stage ASOs (being the simultaneous development of a new technology/product, a new organisation, and a market for the product), the required expertise is unlikely to be found in a single person (Franklin et al. 2001). In the complex high-tech environments in which ASOs often operate, the importance of heterogeneity is even more apparent, especially given the domination of people with a technological background in most ASOs (Mosey and Wright 2007). In this sense, the result support our first two research questions, that related to the importance of team heterogeneity (in terms of functional background and education) on ASO survival.

A second important finding relates to the significant positive effect of legal expertise in the BoD. Given the role of BoDs in a venture's strategic decision making and control of TMT operations, this important effect is in a certain way natural. Furthermore, the increasing interest of contracts and—certainly in a high-tech environment—intellectual property rights call for more expertise in this domain.

The third important finding relates to the third research question that explored the relationship between different types of prior entrepreneurial experience and ASO survival. At TMT level, this relationship turned out to be most important. This is not surprising, since the TMT is the most operational part of the overall ASO team and as such has most direct impact on ASO success. Contrary to prior studies, our results did not confirm the strong and positive impact of serial entrepreneurs on ASO survival. In fact, entrepreneurs engaged in their second venture have been demonstrated to be still eager to make it a true success, while in subsequent new ventures the (negative) effect over entrepreneurial euphoria and overconfidence tend to over-compensate the positive effects of prior entrepreneurial experience.

These results contribute to our current understanding of human capital in ASOs in many regards. From a theoretical viewpoint, the study has shown that prior entrepreneurial experience is not a homogeneous concept. The effect of prior entrepreneurial experience on subsequent new venture success varies according to its nature. Furthermore, the effect is different for managers and directors. Further research could elaborate on this subject.

From a more practical perspective, this study has demonstrated a number of effects that further contribute to our understanding of entrepreneurial teams and their 'optimal' composition. On one hand, our results have pointed to several individual elements that could foster ASO survival and success, which have not appeared in scholarly research before (e.g. the strong and positive effect of legal expertise at BoD level or the different effect of prior entrepreneurial experience at TMT and BoD level). On the other hand, the need for entrepreneurial teams to change over time is not new (see Morgan and Salas 1993; Clarysse and Moray 2004; Vanaelst et al. 2006; Bjørnåli and Gulbrandsen 2010; Gurdon and Samsom 2010); however, the disappearing positive effect of heterogeneity over time is. These new insights can strengthen research on both human capital as well as ASOs.

Policy implications

The results obtained have important implications for entrepreneurial academics, ASO managers, and TTOs. These results indicate that more attention should be devoted to team composition and to the added value in terms of human capital of new team members. Heterogeneous teams are better equipped to face the multi-faceted challenges

imposed by the early stage development of ASOs. Likewise, ASO might benefit from experienced entrepreneurs in their team. Both the results in this study and prior literature on entrepreneurial euphoria (see [Literature review: human capital and ASOs](#)), however, suggest some negative effects of serial entrepreneurs in new venture performance. For this team development process, various mechanisms have been developed to find a balance between technological expertise and entrepreneurial skills at TMT level and to compose a BoD that brings substantial added value and supports the TMT. In this regard, entrepreneurs-in-residence, independent directors, and/or advisory boards could be used to add human capital to an ASO team (see e.g. Rosenblatt and Thelen 1997; Deakins and Boussouara 2000; Clarysse and Moray 2004; Clarysse et al. 2007; Bjørnåli and Gulbrandsen 2010; George et al. 2010).

This study has pointed to the importance of team composition in early stage product-oriented ASOs: both at TMT and BoD level. This confirms the call for more attention to the team development process, as put forward by Ensley and Hmieleski (2005). The main results concern the significant positive effect of TMT and BoD heterogeneity, which disappears over time, and the strong positive impact of directors with legal expertise.

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