

“To have and have not”: founders’ human capital and university start-up survival

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Abstract In order to preserve innovation, knowledge development and diffusion, as well as the transfer of new technologies, the emergence of University Start-Ups (USU) and their survival as a particular dimension of performance represents a relevant research topic. As USU generally have scarce initial resources, the human capital of their founders is one of their main business assets. Although the survival of such firms is supposed to be heavily dependent on the human capital characteristics of their founders, this has not received enough attention in existing research. In this paper we investigate the contribution of founders’ specific human capital characteristics to the survival of USU, building on Gimeno et al. (Adm Sci Q 42:750–783, 1997) threshold model of entrepreneurial exit. We divide USU founders’ specific human capital into three components (entrepreneurship, industry and university) in order to better understand its impact on firm survival. Our theoretical model is empirically tested on a unique sample of Catalan USU through a logistic regression analysis. Coherently with our theoretical reasoning, the results show that industry human capital negatively affect USU survival, while university human capital and entrepreneurship human capital enhance the likelihood of USU survival.

Keywords Human capital · Survival · University start-up · University spin-off · Academic entrepreneurship · Threshold

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1 Introduction

Firms spun-off by universities are significant agents for regional economic development (Lowe 2002). They generate considerable economic value, create new jobs (Cohen 2000) and foster the commercialization of university technologies, especially the most uncertain ones (Thursby et al. 2001). They can be thus considered as effective vehicles for encouraging the development of new products and services (Lowe 2002). In order to preserve the impact of such companies in terms of economic and technological development, it is important to study the factors that enhance their development. The objective of this study is thus to disentangle the effect of founders' human capital characteristics on the probability of survival of firms spun-off by universities. The novelty of our approach relies on applying and extending Gimeno et al. (1997) threshold model of entrepreneurial exit in order to explain such dynamics in the specific context of academic entrepreneurship.

Firms spun-off by universities are usually founded by academics with the objective of exploiting distinctive technologies created at the parent university, which are then transferred to the spin-off company (Vohora et al. 2004; O'Shea et al. 2008). Nevertheless, these types of companies tend to be heterogeneous (Mustar et al. 2006) as one of the two key dimensions (i.e. academic founder and technology transfer) is often missing (Criaco et al. forthcoming). As a consequence, a lack of a common definition is evident in previous studies (Clarysse and Moray 2004): some authors refer to them as university spin-offs (e.g. Walter et al. 2006) university spinouts (e.g. Lockett and Wright 2005) or university start-ups (e.g. Shane and Stuart 2002). Others use alternative labels such as research-based scientific organizations (e.g. Mustar et al. 2006), academic spin-offs (e.g. Fini et al. 2011) or academic start-ups (e.g. Colombo and Piva 2012). It may thus be an oversimplification to define as university spin-offs new companies in which both dimensions (i.e. academic founder and technology/knowledge) are simultaneously transferred from a parent organization, as "only one or the other or both of these two factors may be transferred" (Carayannis et al. 1998, p. 10). Thus, based on Carayannis et al. (1998) we define a university spin-off as a "company that is established by transferring its core technology, founders, or other resources from a parent organization" (p. 10). We refer to these companies as University Start-ups (USU).

As USU play an important role in contributing to both economic and technological development, their study has become a relevant topic in entrepreneurship research (see Rothaermel et al. 2007; Djokovic and Souitaris 2008). A significant proportion of the literature focuses on the definition, characteristics and typology of USU (see Mustar et al. 2006 and Criaco et al. forthcoming for a survey), on their creation determinants (e.g. Ndonzuau et al. 2002; Di Gregorio and Shane 2003; Link and Scott 2005; Lockett and Wright 2005; Fini et al. 2009) or on the links between USU and the parent university or other networks (e.g. Nicolaou and Birley 2003; Wright et al. 2008).

On the other hand, only few studies explore the performance of USU (e.g. Walter et al. 2006; Wennberg et al. 2011; Zhang 2009) and their success factors (e.g. Grandi and Grimaldi 2005; Niosi 2006). Among the different dimensions of entrepreneurial performance (see Murphy et al. 1996), survival becomes particularly relevant in a USU context since it encourages innovation and fosters the commercialization of new technologies (Shane 2004; Kroll and Liefner 2008). Moreover, firm survival is sometimes a more

reliable indicator of firm performance in a USU context (Meoli et al. 2013). First, it has been argued that the financial information of firms in fast-changing, technology-based industries is of limited value. Telecommunications, biotechnology, and software producers for instance invest heavily in intangibles such as R&D; yet such investments are either immediately expensed in financial reports or arbitrarily amortized (Amir and Lev 1996). Consequently, while significant market values are created in these industries through production and investment activities, key financial variables, such as earnings and book values, are often negative or excessively depressed and appear to be unrelated to market values. Secondly, academics often create USU as a mean of continuing a line of research they are interested in or as a *life-style* company (Migliorini et al. 2010) targeted not at maximizing returns for its shareholders but at keeping their lead researcher status at the parent university (Vohora et al. 2004; Siegel et al. 2007). Thus, commonly used firm financial performance dimensions such as profitability may not be adequate measures of USU development.

USU are generally small companies with scarce initial resources, with the human capital of their founders as their main business asset (Shane and Stuart 2002; Shane 2004; Colombo and Piva 2012). Therefore, the survival of this type of firm is heavily dependent on the human capital characteristics of their founders. Moreover, the uniqueness of USU founders' human capital is expected to convey specific survival dynamics to such firms. Therefore we maintain that founders' human capital is a key element in understanding and explaining why some USU survive while others do not.

In this study we investigate the contribution of founders' human capital characteristics to the survival of USU, throughout the lenses of Becker (1975) human capital theory and based on Gimeno et al. (1997) *Threshold Model of Entrepreneurial Exit* (TMEE). We aim to answer the following research question: (1) how do founders' human capital characteristics influence the likelihood of USU survival? Using a unique sample of 80 Catalan USU, this study confirms that different types of specific human capital characteristics impact on firm survival in different ways. The results show that while industry human capital has a negative impact on survival, university human capital positively affects firm survival. Moreover, entrepreneurship human capital partially enhances USU survival.

This study is positioned at the crossroads of three research streams in entrepreneurship literature: academic entrepreneurship and the role of USU in fostering economic and innovative performance; the survival of USU as a unique and relevant dimension of firm performance; and founders' human capital as a key determinant in the entrepreneurial process (see Reynolds et al. 2004) and venture emergence. While several studies exist that link entrepreneurs' human capital with SME survival, and some explicitly do this in the domain of new technology-based firms (NTBF) and high-technology firms (e.g. Aspelund et al. 2005; Gimmon and Levie 2010; Grilli 2010; Minola and Giorgino 2011) there exist a lack of studies¹ that explicitly investigate such relationship in the context of USU. Our research aims to fill this gap.

We proceed as follows. Section 2 reviews the literature, Sect. 3 sets our theoretical approach, Sect. 4 develops the hypotheses. Section 5 describes the method and data and Sect. 6 presents our empirical results. Section 7 discusses the results of this study and Sect. 8 concludes.

¹ This understanding is sustained by recent state-of-the-art literature surveys on academic entrepreneurship and on research-based spin-off companies (Helm and Mauroner 2007; Rothaermel et al. 2007; Djokovic and Souitaris 2008; O'Shea et al. 2008) where no studies that assess the relationship between founders' human capital and firm survival are found.

2 Literature review of founders' human capital and firm survival

Given that a USU can be considered as a subset of a particular type of companies, generally known as a new technology-based firms (NTBF) (Colombo and Piva 2012), we begin by surveying the related literature on the relationship between founders' human capital and firm survival in a NTBF context. We then explain the peculiarity of USU and identify the gaps in literature that address the relationship between founders' human capital characteristics and USU survival.

2.1 Founders' human capital and NTBF survival: Evidence from previous studies

Human capital is a key element in technological progress since it enhances the development and adoption of new technologies and the improvement of existing ones (De la Fuente and Ciccone 2002). Thus, individuals' human capital is particularly crucial to the development and success of NTBF. Founders' knowledge and skills are deemed important especially in the context of NTBFs, since they determine firms' competitive advantage (Feeser and Willard 1990). A number of studies highlight the importance of founders' human capital with regard to the different dimensions of firm performance in a NTBF context. For instance Colombo and Grilli (2005) find that, thanks to the so-called 'capability effect' of founders, NTBF created by entrepreneurs with greater human capital outperform others. Indeed, in a NTBF context, founders' human capital is found to be positively related to firm growth (Colombo et al. 2004) and receiving venture capital funding (Hsu 2007). Finally, the fit between strategy and team experience is assessed as a key determinant of the long-term performance of high-tech entrepreneurial ventures (Shrader and Siegel 2007).

Survival can be considered as the overall antecedent of firms' performance, and thus of their success.² Moreover, NTBF survival is considered to be very important as it preserves the continuity of the development of new technologies, which in turn facilitate technological progress and general welfare (Storey and Tether 1998). Nevertheless, survival as main and explicit focus tends to remain a minor interest in NTBF research.³ Empirical studies show that links with higher education institutes, incubators, and science parks are key elements in NTBF survival (Westhead and Storey 1995; Ferguson and Olofsson 2004).

² One common definition of successful businesses relies on those firms that are still operating within the market while unsuccessful ones are associated to such ventures that have been discontinued or have failed (e.g. Cressy 1996). Survival versus discontinuance has often been used, particularly in population ecology studies. Other authors concentrate instead on either multimodal (Sandberg and Hofer 1987) or continuous ranking of success (e.g. Cooper et al. 1994). Continuous levels of success are mainly associated with Venkatraman and Ramanujam (1986)'s framework. In fact, many authors are accustomed to borrowing such frameworks of firm performance and approximating them to firm success. Although such approximation can be useful in industrial organization studies, it may not be valid for small entrepreneurial entities for whom financial gain is not one of their crucial objectives. In order to defend such distinct facets, a subsequent trend among researchers has focused on the more sociological and motivational definitions of success associated with concepts such as personal satisfaction, pride and the flexible lifestyle of the entrepreneur (Walker and Brown 2004). As a result, both the financial and the physiological consideration of success depend on the objectives of the firm and the entrepreneur. Such a definition of success can thus become more subjective and, to a certain extent, harder to generalize and extrapolate. Therefore, concentrating on assessment of survival may help to overtake such subjectivity.

³ This is also confirmed by Bollinger et al. (1983) who does not consider survival as being among the variables that can determine the performance and value of new technology-based firms.

Moreover, both firm and industry level characteristics (Strotmann 2007; Box 2008) have been assessed as attributes of NTBF survival.

While several studies exist that mention the importance of human capital for new venture survival (e.g. Baptista et al. 2007; Geroski et al. 2010), fewer studies have used human capital as an antecedent of survival in the specific case of NTBF (Colombo and Grilli 2005). An example is given by Aspelund et al. (2005), who find a negative effect of the size of the founding team and a positive effect of team heterogeneity (in terms of skills and abilities) on NTBF survival. Gimmon and Levie (2010), on the other hand, find that the general technological expertise and business management expertise of founders enhance NTBF survival.

2.2 The specific case of USU: evidence and research gap

As mentioned above, USU can be considered as academic NTBF (Colombo and Piva 2012). The emergence and persistence of USU is central to R&D policies and innovation in SMEs, as well for policies trying to foster a link between academia and industry (Djokovic and Souitaris 2008). USU indeed represent tools for implementing the new mission of universities (Etzkowitz and Leydesdorff 2000) and therefore understanding the differences between USU and other NTBF is important.

As suggested by Colombo and Piva (2012) in an empirical analysis on an Italian sample, differences between NTBF and academic spin-off usually relate to performance, knowledge and funding gaps. Most importantly, the main difference relies on the characteristics of the founders. The characteristics of founders of USU differ from those of NTBF in three main ways. Firstly, USU founders are usually better educated and possess deeper technological experience (Colombo and Piva 2012). Secondly, USU founders generally have little knowledge of industry and present loose or weak ties (Granovetter 1973) with actors located outside their original research institutions. In this sense USU founders lack industry-specific human capital compared to NTBF's founders (Colombo and Piva 2012). Thirdly, USU founding teams possess a lower degree of entrepreneurial and managerial experience (Iacobucci et al. 2011) compared to those of non-academic NTBF (Colombo and Piva 2012). In order to address this limitation, Franklin et al. (2001) suggest the effectiveness of a mix of entrepreneurs endogenous to the university and surrogates (i.e. external). As a result of such differences, the peculiarity of USU founders' human capital is expected to convey specific survival dynamics in those firms.

If survival studies have started raising initial attention from scholars and are becoming more common in NTBF literature (De Massis et al. 2012), this trend has not similarly pervaded studies focusing on the specific case of USU. Besides some general descriptive research into survival rates of USU (e.g. Lowe 2002), little evidence is available on the determinants of USU survival. Shane and Stuart (2002) and Nerkar and Shane (2003) examine respectively how organizational endowments (especially social capital) and patents increase the probability of survival of new technology ventures originating at Massachusetts Institute of Technology. Finally, Meoli et al. (2013) show the importance of academic affiliation for biotech USU through a survival analysis. However, there is a lack of studies that explicitly investigate the relationship between founders' human capital and survival in a USU context. Since founders' human capital is considered to be a fundamental initial asset influencing survival in this type of firms, this represents a relevant gap to fill.

3 Conceptual framework

In order to study the effect of founders' human capital on USU survival, we draw our theoretical framework on Gimeno et al. (1997) TMEE model. Authors argue that the drivers of firm survival are not only related to the absolute level of firm performance, but rather to the establishment of a correct equilibrium between a firm economic performance and the performance threshold requested by entrepreneurs to stay in the business. The application of TMEE is highly relevant to this research since it helps to take into account the effect of founders' human capital characteristics first in terms of organization economic performance and organization thresholds of performance, and finally of organization survival. Moreover, with USU founders being embedded with a different stock of human capital, the application of the TMEE is also relevant in our context since it allows for conceptually disentangling the influence of different human capital characteristics on firm survival and studying in detail the dynamics of how incentives to persist or exit from entrepreneurship arise. The TMEE model has proved its effectiveness over two decades and has been widely applied in research into both entrepreneurship and management literature (e.g. De Tienne and Cardon 2012; De Tienne and Chirico forthcoming). In the next paragraph we will describe the TMEE.

The *economic performance* of the new venture is the first element determining firm survival and it consists on the monetary returns obtained by entrepreneurs from their business activity. On the other hand, the model suggests that entrepreneurs also set organizational performance thresholds as a reference, below which they decide to exit the firm. An *organization's threshold of performance* is thus the minimum level of economic performance required by entrepreneurs to maintain their business and is determined by three dimensions or elements: (1) the opportunity cost of remaining in the business, (2) the psychic income deriving from entrepreneurship and (3) the costs of switching to an alternative occupation. Owners' *opportunity cost* is the expected monetary returns available in any alternative occupation. *Psychic income* from entrepreneurship is determined by the non-monetary returns (e.g. personal satisfaction) obtained from being self-employed (instead of having an alternative employment). Finally, *switching costs* include all the difficulties, obstacles and monetary costs entrepreneurs may encounter if they move from their current career in entrepreneurship to any alternative employment. The former dimension, i.e. opportunity cost, positively affects the organization's threshold of performance because the higher the opportunity cost, the better the performance required by the entrepreneurs to remain in the business (see also Cressy 2006). The latter two factors negatively impact on the threshold because they represent a barrier to exiting the current business despite bad economic results. As a result, the higher the organizational threshold of performance, the smaller the probabilities of survival, since high levels of threshold encourage entrepreneurs to move away from entrepreneurship (in the current venture). Thus an organization tends to remain active if and only if the economic return from the business as perceived by its entrepreneurs is higher than their individual threshold of performance.

Economic performance and threshold of performance are both influenced by founders' human capital (Gimeno et al. 1997). Authors claim that an organization's *economic performance* can be positively impacted on by the general and specific human capital of its founders. *General human capital* refers to entrepreneurs' general knowledge obtained through formal education and professional experience, which may be applicable to a wide range of occupational alternatives (Gimeno et al. 1997; Colombo and Grilli 2005). On the contrary, *specific human capital* characteristics refer to the skills and capabilities gained by entrepreneurs through education, job training and work experience, which have a limited

scope of applicability (Gimeno et al. 1997). Knowledge about the industry where a new firm operates or knowledge about how to manage the new firm are good examples of entrepreneurs' specific human capital (Colombo and Grilli 2005).

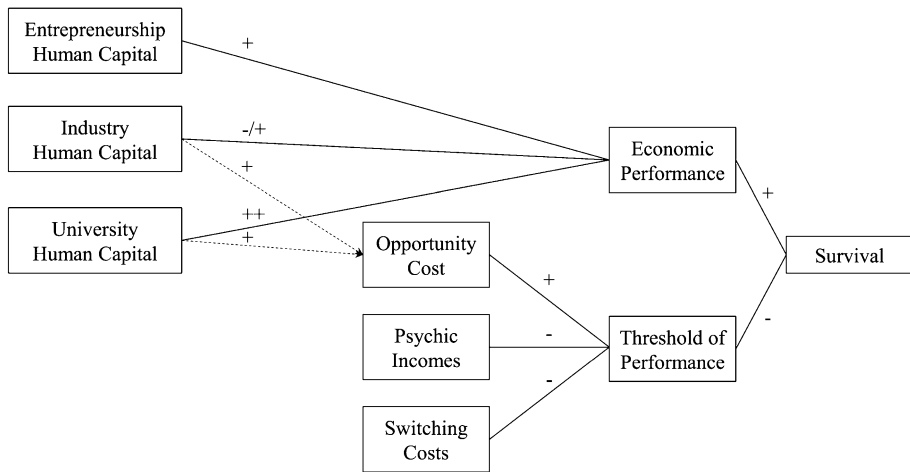
Opportunity cost is also affected positively by founders' general human capital. General human capital increases the likelihood of entrepreneurs finding a better occupation in the job market since it can be exploited in all dimensions and directions. On the other hand, specific human capital positively affects opportunity cost only if the alternative occupation can benefit from the specific knowledge and training gained by the entrepreneur in the current job. Finally, *psychic income* and *switching costs* are considered to be independent dimensions and thus not related to founders' human capital.

If we finally project the relationships between different dimensions of human capital on firm survival, Gimeno et al. (1997) claim that general human capital has an indeterminate effect on organization survival as it impacts positively on both economic performance and the threshold of performance through opportunity cost. On the other hand, specific human capital characteristics impact positively on organization survival since it only affects economic performance positively. The reason why specific human capital only affects economic performance and not the threshold of performance lies on the assumption that the founders' future occupation is unknown a priori, as it is the specific exploitable human capital associated with it, that being a limitation for wholly understanding the ultimate effect of specific human capital on firm survival.

4 Hypothesis development

In this study we draw on Gimeno et al. (1997) TMEE model to predict the effect of founders' specific human capital characteristics on the probability of USU survival. We do not include USU founders' general human capital in our model for several reasons. Firstly, as demonstrated by Gimeno et al. (1997), the influence of general human capital on survival is unknown as it positively affects both economic performance and the threshold level of performance, which in turn have opposite signs when impacting on firm survival. Secondly, general human capital has not been found to be a distinctive characteristic among academic entrepreneurs (Colombo et al. 2004). Indeed, most USU entrepreneurs have a similar (and high) level of general education and experience, so that the variance of such variable is usually low and thus it becomes difficult to predict any specific relationship with USU survival.

In order to apply Gimeno et al. (1997) TMEE model to the USU context we divide specific human capital of USU founders into three conceptual constructs providing increased detail about the relationships we aim to study. Similarly to Gimmon and Levie (2010), we divide USU entrepreneurs' specific human capital into entrepreneurship human capital (EHC), industry human capital (IHC) and university human capital (UHC). EHC refers to the knowledge acquired from formal education and personal experience in entrepreneurship, while IHC refers to the knowledge acquired from previous experience in a specific industry (namely the one where the USU is presently involved). Finally, UHC refers to the knowledge acquired from previous experience in research and teaching in higher education institutions. Therefore, founders who worked at a university as a professor or researcher are endowed with UHC. These three human capital components jointly concur to uniquely characterize USU as a sub sample of NTBF. The conceptual framework for studying the effect of founders' specific human capital over the probability of USU survival is represented in Fig. 1.



..... Extension of Gimeno et al. (1997) model for an USU context

Fig. 1 Theoretical model for the study

Before the development of our hypotheses, we need to emphasize that our goal is to test hypotheses that link USU founders' specific human capital characteristics to firm survival. Thus, we shall neither directly hypothesize nor testing about the effect of USU founders' human capital characteristics over firm economic performance or over its threshold of performance. In our study, like that of De Tienne and Cardon (2012), firm performance and threshold of performance are indeed unobserved dimensions used to conceptualize the effect of founders' human capital characteristics over firm survival.

Evidences in the USU and NTBF literature suggest and find that firms founded by teams endowed with EHC outperform other firms (Colombo and Grilli 2005). Prior entrepreneurial experience is argued to provide information about such activities as opportunity identification and resource acquisition (Delmar and Shane 2006). Moreover, due to learning effects, entrepreneurial knowledge and experience present in the team should be considered a valuable asset (De Massis et al. 2012), as team members have previously faced similar challenges in the course of other entrepreneurial efforts (Aspelund et al. 2005). Thus, the new venture might be more capable of facing uncertainty during its development, and then better perform. Thus we expect EHC to positively affect USU performance and therefore to increase the probability of survival.

On the other hand, USU founders' EHC is thought not to affect the threshold of performance of these companies because founders with higher EHC are not necessarily endowed with those competences that would be highly valuable in alternative occupations (e.g. working at the industry or at the parent university). In this sense, USU founders with an entrepreneurial education and/or start-up experience do not necessarily benefit from better opportunities to receive a higher salary working in an alternative occupation just because of their EHC. Thus, EHC does not necessarily increase the opportunity cost of USU founders and therefore does not affect their threshold of performance. Therefore, given EHC's positive effect on economic performance and its negligible effect on threshold level of performance, we set-up our first hypothesis in the following terms:

H_{1a} Entrepreneurship human capital (EHC) of the USU founding team is positively related to the likelihood of firm survival.

Following our theoretical framework (Fig. 1) in order to be able to predict the effect of IHC of USU founders with regard to the probability of firm survival, we need first to understand the effect of IHC on firm performance and on its threshold of performance.

From the literature we know that IHC is linked to industry-related knowledge and experience associated to the resources, processes and people involved in a particular economic sector. In this sense IHC enables the development of strong social ties (Chatterji 2009; Walske and Zacharakis 2009) not only with direct stakeholders of the firm (employees, investors, etc.) but also with individuals and other firms up and down the value chain, such as customers, suppliers, competitors and other industry participants (Shane and Stuart 2002; De Tienne and Cardon 2012). Thus, IHC allows individuals to benefit from a stock of sector specific networking resources (Walske and Zacharakis 2009) that is likely to increase the USU founders' opportunity cost for remaining in the former firm. In fact, individuals endowed with sector specific networking resources may be able to obtain a higher salary in an alternative occupation when considering exiting their current venture. Thus we can conclude that USU founders' IHC will have a positive and strong effect on a firm's threshold of performance by increasing it and thus reducing the probability of USU survival.

On the other hand, the effect of USU founders' IHC on firm performance is uncertain. While Shane and Stuart (2002) find industry experience to be weakly and positively related to university spin-off performance, Shrader and Siegel (2007) find industry experience to be negatively and significantly related to both profitability and sales growth in a NTBF context. In a methodological sense, we believe Shrader and Siegel (2007) study to be sounder than Shane and Stuart (2002) as it includes six dimensions of founders' experience (i.e. industry, technical, marketing, finance, international, and start-up experience) while the latter only includes two dimensions. Indeed, as highlighted in Crook et al. (2011), the effect of founders' human capital on firm performance is stronger when measurements capture more specific dimensions of human capital. Nevertheless, we believe that this relationship needs further research. Thus we can conclude that USU founders IHC will have an uncertain effect on firm performance and a positive strong effect on a firm's threshold of performance. Taking into consideration these two effects of IHC and following our analytical model of (Fig. 1) we can thus conclude that USU founders' IHC will reduce the probability of firm survival. Based on this line of argumentation, we propose to test the following hypothesis:

H_{1b} Industry human capital (IHC) of the USU founding team is negatively related to the likelihood of firm survival.

As stated in our model in Fig. 1, the UHC of USU founders will affect the probability of firm survival through its effect on USU's economic performance and threshold of performance. Although the existing "literature is somewhat conflicting on the role of academic status in venture survival" (Gimmon and Levie 2010, p. 1218), our model predicts a positive effect of UHC on the probability of USU survival.

UHC endows USU founders with academic/research related knowledge and experience. Founders with higher UHC possess a greater understanding of the technology originated at the parent research institution and commercialized by the USU. Moreover, founders endowed with UHC can provide a firm with a high numbers of strong ties with the parent university, which are in turn characterized by a high degree of trust and legitimacy (Johansson et al. 2005). In this sense, the links that the newly founded venture has with its parent university help USU to overcome development obstacles raised by the liabilities of

the newness and the liabilities of the smallness and this helps granting firm development (Westhead and Storey 1995; Vohora et al. 2004). Moreover, USU founders endowed with UHC are likely to establish technological alliances more frequently and they are more likely to participate in international collaborative R&D projects than non-academic USU founders (Colombo and Piva 2012). Following Tsai and Wang (2008), alliances and collaborations have a positive effect on firm performance in R&D intensive sectors. Following this line of reasoning we can conclude that UHC of USU founders will have a positive effect on firm performance and therefore will increase its probability of survival.

On the other hand USU founders' UHC has a weak, almost non-existent effect on a firm's threshold of performance. USU founders endowed with UHC have a greater understanding of the people, resources and processes in the academic/research sector but do not necessarily have the business and managerial experience required to obtain a well-paid job in the industry. As a consequence, the alternative occupation for an USU founder endowed with UHC is very likely to be his/her previous job position at the former university or research institution. In this sense, we can say that the UHC of USU founders does not necessarily increase the opportunity cost of remaining in the former USU. Therefore USU founders UHC does not significantly affect the firm threshold of performance or its probability of survival.

Based on the previous discussion we conclude that the UHC of USU founders will increase firm performance but will not increase a firm's threshold of performance. Therefore we can predict that:

H_{1c} University human capital (UHC) of the USU founding team is positively related to the likelihood of firm survival.

As shown in Fig. 1 we also include in our framework the remaining two dimensions developed in Gimeno et al. (1997) framework, namely *psychic income from entrepreneurship* and *switching costs* in order to maintain the integrity of the holistic model. As suggested by Gimeno et al. (1997), both dimensions negatively affect the threshold of performance and contribute positively to firm survival. There is no reason to believe that such dynamics will change within a USU context. Thus we include two additional hypotheses to be tested in our sample of USU:

H₂ Psychic income from entrepreneurship of the USU founding team is positively related to the likelihood of firm survival.

H₃ The costs of switching to an alternative occupation of the USU founding team are positively related to the likelihood of firm survival.

5 Methodology

5.1 The context

This research has been conducted in Catalonia (Comunitat Autònoma de Catalunya), a Spanish region with an area of 32,114 km² and a population of approximately 7.5 million people. The functioning of a Spanish region is similar to that of a US *state* or of a German *land*.⁴ The regional government is competent in designing technology policies, innovation systems and research plans for the region. The main distinctive characteristic of the regional R&D system of Catalonia is its level of resources, which are above the Spanish average

⁴ German for federated state.

(CIDEM 2006). According to the 2009 estimates from the Statistical Institute of Catalonia (IDESCAT), the region spends 1.68 % of its GDP on R&D activities (IDESCAT 2009). With only one-sixth of the Spanish population, Catalonia generates more than one-third of Spain's high-technology exports (34.6 %) and almost a quarter of the R&D expenditure (22.84 %), as well as a quarter of the industrial GDP (25.52 %) (CIDEM 2006).

After Universities' 'third mission' was defined and outlined with regard to the commercialization of research outcomes (Etzkowitz and Leydesdorff 2000), institutions started to facilitate this process by providing some policy solutions and thus act as a bridge between academia and businesses. In Catalonia the three institutions that design and execute these policies are the Centre for Innovation and Business Development (CIDEM) for the regional level, the Ministry of Education and Science (MCYT), and the Centre for the Development of Industrial Technology (CDTI) for the national level.

The CIDEM was established in 1999 by the regional government to improve the competitiveness of the Catalan Industrial sector, which is largely occupied by SMEs. At present, CIDEM concentrates its efforts on innovation, as the backbone of its industrial policy. The positive results obtained by the CIDEM for the Catalonia Innovation plan have been acknowledged by the European Commission as the role model for its businesses (EC 2002). CIDEM's actions are carried out within six programs, one of which emphasizes on new venture creation support mechanisms at universities (CIDEM 2006).

The MCYT launched a nation-wide Innovation Plan for 2004–2007 including support of new technology-based firms' creation through incubators and venture capital, improved coordination between the public and private sector (with specific measures targeting scientific and technological parks) and additional support for Technology Transfer Office (TTO) and other technology centers.

Finally, the CDTI is a national public organization, which aims to help Spanish companies to raise their technological competence. Its various activities include:

- (a) The promotion of technology transfer and technological cooperation between enterprises and
- (b) Support in the development of new technology-based firms, through the Neotec initiative. The Neotec actions range from financial aid, training services or expert advice to the design of specific actions to facilitate the interaction between entrepreneurs and investors.

All the institutions and initiatives mentioned above belong to the public system. However, there are also private actors that promote mechanisms and programs that complement the public system. The main organizations (Fidem, CP'AC, MITA, CEDEL) focus on fostering entrepreneurship among women, youth, unemployed managers and ethnic groups.

5.1.1 Technological Trampoline at Catalan Universities

Catalonia, a trigger for Spanish industrial, technological and economic development, has promoted the creation of university spin-offs throughout Technological Trampolines (TT). A Technological Trampoline is a public independent entity integrated into a TTO from a university. A TT maintains its own functioning and budget system, which is independent from both the university and the TTO. It obtains funds from the CIDEM, while the university usually provides the spaces and other physical resources.

The Technology Trampolines created by the CIDEM in 2000 are support units with the aim of increasing the number of knowledge-based and technology-based companies created in Catalan universities. To achieve these objectives, the TT performs the following activities:

- Increases awareness about patents and creation of spin-offs
- Identifies and select good technology initiatives
- Provides new businesses with consulting, specialized training and advisory services
- Ensures access to specialized funding sources
- Provides spaces for business incubation
- Helps companies with portfolio management

Technology Trampolines are organized in a TT network (XTT), which consists of ten units in different universities and business schools in Catalonia: Universitat Autònoma de Barcelona, Universitat de Barcelona, Universitat de Girona, Universitat de Lleida, Universitat Politècnica de Catalunya, Universitat Pompeu Fabra, Universitat Ramon Llull (ESADE and La Salle), Universitat Rovira i Virgili, Universitat Oberta de Catalunya and IESE. The main objective of the XTT is to increase knowledge transfer between academia and business through the creation of technology-based companies.

In order to be enrolled in the XTT, companies generally need to have a relevant relationship with the hosting university. In some of the projects that the TT assist, an academic of the parent university is involved. In addition, in other cases there is also a formal technology transfer from the parent university (where the technology is originated) to the USU created (where it is commercialized) in the form of patents or licensing agreements.

5.2 Data collection process

The database used for this study combines an exploratory study conducted between January 2008 and June 2008 with an integrative follow-up contribution released in May 2011. The first study included a census of all those companies supported by Catalan TT along with an understanding of the main characteristics of the firms and their founders. On April 2008, Catalan TT provided us with an updated list of 348 university-based companies. By analyzing this list, we found that some companies had received support from two or more TTs (13 firms), thus reducing the number of companies to 335. Some others were closed or inactive⁵ (33 companies) and some could not be contacted because the data was inaccurate or did not exist (32 companies). Others, despite being in the database, indicated that they had no relationship with the trampoline when contacted (8 companies), leaving a total of 262 firms active and accessible. Based on the preliminary list of university-based companies supported by Catalan TT, a sample of 15 university-based companies was selected to conduct a pilot test with the founders in order to test the suitability of the questionnaire. Additionally, the director of the Technology Park of the University of Girona, the director of Acció (public agency that supports innovation and internationalization of Catalan companies) and the manager of XTT were also interviewed so that their comments could be incorporated into the questionnaire. A final questionnaire was then sent to all the university-based companies (262).

The questionnaire was administered to the key founders of the USU. The reason why we only focused on the key founders relies on Vanaelst et al. (2006). Based on 10 Belgian academic spinout, Vanaelst et al. (2006) find that once the firm is legally created, the

⁵ As usual in studies that use survey-based data, the analysis presented in this paper suffers from a survivorship bias (Colombo and Piva 2012) that might have significant consequences for our study. Indeed, if we divide the number of closed or inactive firms (33) by the total (and corrected) number of UBC (294), we would find a mortality rate of 11 percent. If we find a similar evidence in our study, we can safely claim not to suffer from a survivorship bias.

boundaries of the founding team disappear and evolve into two other teams which may overlap: the management team and the board. The key members of the founding team (i.e. researchers leading the spin-out trajectory) have a position in the management team and seat in the board of directors. Others, such as the *privileged witnesses* (e.g. coaches or consultants who helped the firm to start the USU with the market opportunity screening projects or other market oriented tasks) usually become members of the board of directors. Therefore, targeting the key members of the founding team represents the most comprehensive option to obtain information about relevant key players and decision-makers in USU. Moreover, members who only seat on the advisory board have been excluded given that they do not fit the TMEE requirements in terms of career decision and evaluation of the opportunity cost related to it.

With the aim of more efficiently controlling the data collecting process, contact with the university-based companies evolved through a series of different steps. Firstly, a collaboration request was sent to companies via email. This request explained the objectives of the study and also reported that a member of the research group would contact with them via phone to solicit their cooperation in the following days. Phone calls were made and the respondents were offered the possibility of completing the questionnaire online, by phone or through a personal interview. This phase received the support of the TT that sent out e-mail reminders to the companies that were not responding to the questionnaire in a timely manner. Primary results obtained from the questionnaires were reviewed in order to detect errors or inconsistencies. Those entrepreneurs whose answers could lead to confusion were thus contacted again. Financial data was contrasted with secondary data by using both SABI (Bureau Van Dijk's database, which includes balance sheets, income statements and other indicators) and Acció Concept Capital database. Of 262 companies identified, 94 (35.9 %) returned the survey completed.

A follow-up study was conducted 3 years later (in June 2011) with the aim of monitoring the development of the firms. In this way, we could assess the mortality rate of the companies studied in the first phase. The SABI database was used in order to view the actual legal status of the company. Two companies were detected as being liquidated. Furthermore, those university-based companies whose operating revenues were not updated in the dataset were contacted by telephone and asked what their actual status was. Additional information was found in the local press and the Internet with the intention of collecting additional news for those companies that did not answer our calls and for inoperative landline numbers. Table 1 presents the data sheet for the study.

Due to the fact that firms in our sample received the support of the TT, the question may arise whether our research may suffer from sample selection problems and what may be the implications for the empirical results. On one hand, one may presume that survival rates are higher among USU supported by the TT in comparison with those that are not: in fact, the formers enjoy a more 'privileged' situation, due to the seedbed role played by the TT. However less innovative, under-performing firms may be the type of firms that mostly seek the help offered by the TT; we can expect those firms to have higher mortality rates. Thus, following this line of thought the sample selection bias would turn in the opposite direction—i.e. more innovative and long lasting firms would be underrepresented in the TT sample. Altogether, evidence suggests that opposed forces are at work, and following Colombo and Delmastro (2002) we can claim this mitigates the potential selection bias related with our sample.

Considering the heterogeneity of the university spin-off phenomenon in Catalonia (see Criaco et al. forthcoming), we include in our final sample only those companies that received at least one type of resource transferred from the parent university to the firm (Carayannis et al. 1998). We also draw on the work done by Barney (1991), Brush et al. (2001) and Mustar

Table 1 Datasheet of the study

Parent university	Exploratory study (2007)						Follow-up study (2011)
	Population	Personal interview	Telephone interview	Web	Responses obtained	Response rate (%)	Response rate (%)
Universitat Politècnica de Catalunya (UPC)	139	0	1	27	28	19.4	100
La Salle (URL)	59	1	2	30	33	55.9	100
Universitat de Barcelona (UB)	20	1	1	6	8	40.0	100
Universitat Autònoma de Barcelona (UAB)	18	10	2	1	13	72.2	100
Universitat de Girona (UdG)	8	5	0	0	5	62.5	100
ESADE (URL)	6	0	1	1	2	33.3	100
Universitat Rovira i Virgili (URV)	6	0	0	2	2	33.3	100
Universitat Pompeu Fabra (UPF)	4	0	0	2	2	50.0	100
IESE	1	0	1	0	1	100.0	100
Universitat de Lleida (UdL)	1	0	0	0	0	0.0	100
Total	262	17	8	69	94	35.9	100

et al. (2006) to identify four basic types of resources that can be transferred from the parent university to the spin-off company: (1) human resources, (2) technological resources, (3) financial resources and (4) physical resources. The parent university may transfer human resources in the form of an academic-inventor who may be in charge of the R&D department of the firm. It may also transfer knowledge and technology to the firm in the form of patents, know-how or R&D contracts. The parent university may also directly invest in the start-up created by transferring monetary resources to it. Finally the parent university may provide some incubation space and other physical resources to spin-off firms. By adapting such filters, our sample size decreased from 94 to 80 university start-ups (USU), created between 1999 and 2007 with the support of the XTT programs.

5.3 The variables of the model

5.3.1 Dependent variable

USU status as of 2011 is chosen as our dependent variable. Apart from the centrality of survival in our theoretical framework and the relevance of survival in new technology based firms (see Sect. 2), survival versus failing is often preferred to other continuous performance indicators since survival is an easier measure to track since financial and operational reporting can often be incomplete and inaccurate (Lyles et al. 2004). Similarly, Catalan USU economic turnover is rather limited and discontinuous, at least in the beginning of the activity (Serarols et al. 2011). Following Lyles et al. (2004) we consider all those USU in our sample and we further assess their status in a 3-year period (May

Table 2 Variables description and measurement

Dimension	Variable	Measurement
Survival	USU survival	Taking value 1 if USU is still active after a 3 year period, 0 if not
Entrepreneurship human capital	Entrepreneurial education	Taking value 1 if there is at least one member in the founding team who took undergraduate, graduate and post-graduate studies in entrepreneurship and/or business management before creating the current company, 0 if not
	Start-up experience	Taking value 1 if there is at least one member in the founding team who has created a company prior to the current USU, 0 if not
Industry human capital	Industry experience	Taking value 1 if there is at least one member in the founding team who has previous working experience in the same industry of the current USU or has taken part to a R&D cooperation contract with industrial firm(s) while working at the parent university, 0 if not
University human capital	University experience	Taking value 1 if there is at least one member of the founding team whose previous job was that of either academic or doctoral/ post-doctoral student at the parent university, 0 if not
Psychic income	Entrepreneurial family	Taking value 1 if there is at least one member whose relatives owned or owns a business, 0 if not
Switching costs	Team age	Average age of the founding team
Control	Bio Tech	Taking value 1 if USU operates in the biotechnology sector, 0 if not
	ICT	Taking value 1 if USU operates in the ICT sector, 0 if not
	USU age	Number of years since firm's foundation

2011) and we code 1 active USU, while 0 failed or inactive ones. Survival over a 3 years period is a quite common indicator found in the literature (e.g. Kalleberg and Leicht 1991; Lyles et al. 2004).

5.3.2 Explanatory variables

Specific human capital As stated in Sect. 3, we divided founders' specific human capital into three dimensions, namely EHC, IHC and UHC.

EHC consists of those skills and knowledge that the founders gained in entrepreneurship, both through formal education and experience. Indeed, entrepreneurship human capital is measured with two variables. *Entrepreneurial Education* refers to undergraduate, graduate and post-graduate studies in entrepreneurship and/or business management. Founders were asked if they have received any formal education in those subjects by the time that they have started their business; the variable is coded 1 if at least one member of the founding team has received such formal education, 0 if not. *Start-up Experience*, on the other hand, is coded 1 if at least one member of the founding team has previously launched a new company and 0 if not, similarly to other studies (Aspelund et al. 2005; Shane and Stuart 2002; Colombo and Grilli 2005).

On the other hand, IHC relies on the different skills and knowledge that founders achieved through past working experience in private companies (industry). Similarly to Shane and Stuart (2002), we measure industry human capital through *Industry Experience*, which is a dummy variable coded as 1 (otherwise 0) if at least one member of the founding team has had previous working experience in the same industry of the current USU or has

taken part to a R&D cooperation contract with industrial firm(s) while working at the parent university.⁶

Finally, UHC relies on different skills and knowledge founders achieved through past working experience at the university. Such specific human capital is assessed with *University Experience*, which is coded 1 if at least one member of the founding team has been employed at the university, either as a professor or as a researcher and 0 if not, similarly to Colombo and Grilli (2010).

Psychic income from entrepreneurship To assess psychic income we rely on Gimeno et al. (1997) measurement, known as *Entrepreneurial Family*. This variable has been assessed in terms of the presence on the founding team of at least one member whose close relatives (parents, grandparents, brothers or sisters) were entrepreneurs at the time of the survey or had been self-employed in the past. That is, family pursuit of self-employment is expected to encourage the development of entrepreneurial values within an individual as well as increasing one's familiarity with the small business scene (Bates 1990).

Switching costs Following Gimeno et al. (1997), we measured switching costs with *Team Age*, defined as the average age of the founding team. Indeed, one of the main assumptions resides on the fact that as entrepreneurs get older, the costs associated with switching from current status to alternative status (e.g. wage-employment) are higher.

5.3.3 Control variables

Since firm level characteristics are also shown to be associated with firm survival, we controlled for firm age and sector.⁷ Both variables are often controlled for in previous survival studies (e.g. Gimeno et al. 1997; Delmar and Shane 2006). Generally, firm age is positively associated with subsequent survival. *USU Age* was measured as the number of years since founding. Our sample is also controlled by the sector or industry where the USU is operating. USU are usually concentrated in few industries, of which the most common are biotech and ICT (Shane 2004). Mustar (1997) found that 28 % of French spin-offs were in biotechnology and 27 % in ICT. Gupte (2007) found a prevalence of ICT (37.4 %) and biotechnology (20.6 %) fields in German spin-offs. We thus follow OECD (2009, 2011) definition of biotech⁸ and ICT⁹ for classifying firms' industry, based on their

⁶ In this way we also acknowledge those founders who have an academic background but, at the same time, have built knowledge, expertise and contacts within the industry through R&D collaboration. Indeed, "academic researchers who interact with industry through a wider set of mechanisms are more likely to build the capabilities necessary to bridge the gap between scientific research and application" (D'Este and Patel 2007: 1297).

⁷ We also controlled the model by the University of origin of the USU and the results did not change substantially. We therefore decided not to include such variables in our model in order to avoid unnecessarily soaking up degrees of freedom in the model (Bono and McNamara 2011).

⁸ The OECD developed both a single definition and a list-based definition of biotechnology. The single definition is deliberately broad: "The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services" (OECD 2005). This definition covers all modern biotechnology but also many traditional or borderline activities. For this reason, the single definition should always be accompanied by the list-based definition. The list-based definition, which serves as an interpretative guideline to the single definition includes seven categories: DNA/RNA; proteins and other molecules; cell and tissue culture and engineering; process biotechnology techniques; gene and RNA vectors; bioinformatics; nanobiotechnology (OECD 2011).

⁹ The OECD developed both a single definition and a list-based definition of ICT. The single definition is again broad: "ICT goods are those that are either intended to fulfill the function of information processing and communication by electronic means, including transmission and display, or which use electronic

products or services. Therefore, we use two dichotomous variables, *BioTech* and *ICT*, in order to assess USU sector affiliation, taking 'other sectors'¹⁰ as category of reference.

At this point of the study we need to make two clarifications about the variables used in our model of analysis. First, we considered founding teams' human capital characteristics at founding. It is particularly appropriate to consider founders' skill and other conditions at the birth of a venture since these factors impact on how firms evolve (Cooper et al. 1994). Indeed, the characteristics at founding can affect an organization's strategy and thus influence its subsequent development (Boeker 1989). As a result, a number of studies have found that founders' pre-entry knowledge and experience enhance firms' long-run performance and survival (e.g. Gimeno et al. 1997; Aspelund et al. 2005; Delmar and Shane 2006; Dencker et al. 2009; Geroski et al. 2010). Second, the founding teams' human capital characteristics, our independent variables, are individual level variables while USU probability of survival, our dependent variable, is a firm-level variable. If our hypothesis is that specific founders' human capital characteristics (individual-level variables) affect the probability of venture survival (firm-level variable), then it is reasonable to relate micro level and meso level variables in our model of analysis. This is a common practice in human capital research. For example Gimeno et al. (1997), Shane and Stuart (2002) and Grilli (2010) all use founders' human capital characteristics measured at an individual level (micro level) to predict the probability of firm survival (organizational level).

Table 2 summarizes the nature and description of all the variables used in the model.

6 Results

Table 3 presents means, standard deviations and simple pair-wise correlation among dependent and explanatory variables.

Since there is some correlation among the explanatory variables, a multicollinearity test was undertaken in order to see if such correlations would blur the model. As a consequence, we used the Variance Inflation Factor (*VIF*) test. The *VIF* shows us how much the variance of the coefficient estimate is inflated by multicollinearity: *VIF* of 10 or higher (or equivalently, tolerances of .10 or less) may be reason for concern. As shown in Table 3 no variable has a *VIF* higher than 10, therefore no relevant multicollinearity is found between the independent variables (Hair et al. 2006).

Concerning our dependent variable, Table 3 shows that 82.5 % of the USU sampled were still operating, while the remaining 17.5 % were either inactive or had failed by May 2011. Such a result is in line with previous studies investigating USU survival (e.g. Shane

Footnote 9 continued

processing to detect, measure and/or record physical phenomena, or to control a physical process" (OECD 2003). The list based definition includes the following products or services: computers and peripheral equipment; communication equipment; consumer electronic equipment; miscellaneous ICT components and goods; manufacturing services for ICT equipment; business and productivity software and licensing services; information technology consultancy and services; telecommunications services; leasing or rental services for ICT equipment; other ICT services (OECD 2009).

¹⁰ Examples of other sectors are: industrial and manufacturing (especially in the food industry); health care industry (excluding those in biotech and ICT), construction and building industry; technical and knowledge-intensive business services.

Table 3 Mean, standard deviation, correlation table and multicollinearity test

	Mean	SD	1	2	3	4	5	6	7	8	9	VIF
1. USU survival ^a	0.825	0.382	–									
2. Entrepreneurial education ^a	0.525	0.503	0.06	–								1.34
3. Start-up experience ^a	0.438	0.499	–0.02	0.17**	–							1.32
4. Industry experience ^a	0.725	0.449	–0.05	0.09	0.09	–						1.33
5. University experience ^a	0.438	0.499	0.08	–0.06	–0.11	0.14*	–					1.58
6. Entrepreneurial family ^a	0.750	0.436	0.06	0.11*	0.02	0.01	–0.03	–				1.11
7. Team age ^b	35.065	7.328	0.17	0.20	0.20	0.27*	0.30**	–0.05	–			1.34
8. USU age ^b	6.775	2.117	0.06	–0.15	–0.04	0.12	0.10	–0.12	0.00	–		1.08
9. Bio Tech ^a	0.238	0.428	0.01	0.05	–0.01	0.13*	0.20**	0.02	0.18*	0.00	–	1.76
10. ICT ^a	0.450	0.501	–0.04	0.03	0.01	–0.10*	–0.15*	0.00	–0.13	–0.06	–0.22**	1.39

^a Correlation has been assessed by using Kendall tau rank correlation coefficient^b Correlation has been assessed by using spearman correlation coefficient

* Significance level <0.05, ** significance level <0.01

and Stuart 2002). Moreover, this percentage is similar to the total rate of survived university-based companies from their creation up to 2008 (see Sect. 5.2 for clarification) allowing us to state that our sample selection does not suffer from a survivorship bias. Table 3 also shows the percentage of USU with university experience (43.8 %), start-up experience (43.8 %), entrepreneurial education (52.5 %) and industry experience (72.5 %). Moreover, 45.0 % of the USU operate in the ICT sector while 23.8 % in biotech.

A binary logistic regression serves as our econometric model to test the impact of the explanatory variables on the dependent variable. The use of such a technique is adequate since the dependent variable is dichotomy and such practice allows for estimating the probability of singular independent variables to assume either one or the other value of the dependent variable, coherently with other studies on firm survival (e.g. Lyles et al. 2004).

Table 4 presents the results obtained from the logistic regression analysis. Model 1 includes only control variables. Such a model is not significant and none of the variables have a significant impact on USU survival. Both control and specific human capital variables are added in Model 2. Such a model thus analyzes the impact of specific human capital characteristics of the team on the survival of USU. The results obtained from such a model partially support H_{1a} , as entrepreneurial education is positively related to USU survival ($p < 0.05$), while start-up experience has no effect on the dependent variable. With regard to industry human capital, Model 2 supports H_{1b} in that industry experience is negatively related to USU survival ($p < 0.05$). Finally, H_{1c} is also supported: university human capital, assessed through university experience, is positively and significantly related to USU survival ($p < 0.05$). The robustness of Model 2 is verified by the increase of the *pseudo R-square* and by the reduction of the value of the $-2 \log \text{likelihood function}$ from 72.20¹¹ to 56.98. In fact, while the first factor measures the likelihood of the model when only the intercept is introduced, the second takes into account also the explanatory variables in the model. Therefore, a reduction of the likelihood confirms a better suitability of the model in respect of the data. The Chi-quadratic (χ^2) test also proves that such a reduction is statistically significant with a 95 % level of confidence.

In Model 3 we add the remaining components of the TMEE, i.e. psychic income and switching costs. Entrepreneurship and university human capital relationship and significance with regard to USU survival remain unchanged with respect to previous models, allowing us to partially confirm H_{1a} and fully confirm H_{1c} . In the same vein, industry human capital has a negative impact on USU survival ($p < 0.05$), which gives support to H_{1b} . Finally, while psychic income is significant and positively associated with USU survival ($p < 0.05$), switching costs do not affect USU survival. Therefore, Model 3 only provides support to H_2 , while H_3 is not supported. The robustness of Model 3 is also confirmed by the reduction of the value of the $-2 \log \text{likelihood function}$ from 72.20 to 50.87. This reduction is greater than the one experienced by Model 2, which confirms a better suitability of Model 3 with respect to the data. The Chi-quadratic (χ^2) test proves that such a reduction is statistically significant with 99 % of confidence. This shows that TMEE, as a whole, is able to account for the highest variance of USU survival. Additionally, Hosmer and Lemeshow's Chi-quadratic test of goodness of fit is run for all models. This test is considered to be more robust than the traditional Chi-quadratic test where a finding of non-significance, as illustrated in Table 4, confirms the model to adequately fit the data. Table 5 finally resumes the corroboration of our hypotheses and the models used to support them.

¹¹ This value is associated when only the intercept is included within the model and it is equal in all models.

Table 4 The effect of human capital on USU survival—logistic analysis

	Model 1	Model 2	Model 3
Constant	1.522 (1.147)	2.081 (1.593)	−3.146 (3.130)
USU age	0.068 (0.142)	0.107 (0.175)	0.176 (0.190)
Bio Tech	−0.296 (0.882)	−1.877 (1.226)	−2.651* (1.444)
ICT	−0.720 (0.737)	−1.471 (0.964)	−1.685 (1.059)
Entrepreneurial education		2.362** (0.950)	2.039** (0.998)
Start-up experience		−0.090 (0.796)	0.246 (0.902)
Industry experience		−2.566** (1.115)	−3.720** (1.589)
University experience		2.732** (1.100)	2.966** (1.213)
Entrepreneurial family			1.847** (0.926)
Team age			0.140 (0.087)
χ^2	1.38	17.22**	23.33***
−2 Log likelihood	72.821	56.977	50.866
Hosmer–Lemeshow goodness of fit	17.32 ^a	36.69 ^a	3.11 ^b
Pseudo R ²	0.019	0.232	0.314
N	80	80	80

Standard error in parentheses

* Significance level <0.1, ** significance level <0.05, *** significance level <0.01

^a Hosmer–Lameshow's Pearson χ^2 ^b Since the number of covariates is equal to the number of observations, the Hosmer–Lameshow test was calculated by subdividing observations in 10 groups (<http://www.ats.ucla.edu/stat/stata/output/old/lognoframe.htm>)**Table 5** Corroboration of hypotheses

Logistic regression			
H _{1a} : Entrepreneurship human capital (EHC) of the USU founding team is positively related to the likelihood of firm survival	Partially supported	Model 2, 3	
H _{1b} : Industry human capital (IHC) of the USU founding team is negatively related to the likelihood of firm survival	Supported	Model 2, 3	
H _{1c} : University human capital (UHC) of the USU founding team is positively related to the likelihood of firm survival	Supported	Model 2, 3	
H ₂ : Psychic income from entrepreneurship of the USU founding team is positively related to the likelihood of firm survival	Supported	Model 3	
H ₃ : The costs of switching to an alternative occupation of the USU founding team are positively related to the likelihood of firm survival	Not supported	–	

7 Discussion

Mixed results are usually found when founders' human capital is considered as a determinant of venture survival or failure (Unger et al. 2011). This may derive from a lack of theoretical specification to such relationship. By adopting Gimeno et al. (1997) TMME model we provide a grounded theoretical approach that disentangles the dynamics through which founders' specific human capital impacts on firm survival in the context of USU. Our theoretical reasoning is that the impact of founders' specific human capital on firm survival depends upon its effect on the antecedents of survival, namely economic performance and threshold of performance. Since these two dimensions affect firm survival in contrasting ways, the prevailing dimension (which is the one most strongly associated to such specific human capital) becomes the ultimate determinant of firm survival.

With regard to EHC, we only find entrepreneurial education to positively influence USU survival, while start-up experience has no effect on the dependent variable. Many USU entrepreneurs are researchers and scientists who are deeply focused in their field of research and inventions (Franklin et al. 2001); as a consequence they may lack a fundamental understanding of and training in subjects such as business administration and entrepreneurship. Such a shortage can eventually lead to inaccurate evaluations of opportunities and strategies. Therefore, a deeper understanding of such subjects becomes a critical advantage for the survival of the USU. For the other variable, start-up experience, Nerkar and Shane (2003) discover a similar finding in a university spin-off context. Nevertheless, authors refrained from attempting to offer a comprehensive explanation of this. A possible explanation of this finding may be that serial entrepreneurs are usually unsuccessful and they may persist with the same strategies within the new venture despite the fact that those strategies have not been prolific in the past (Aspelund et al. 2005). Consequently, the probability of survival for the new venture does not increase. Recent studies highlight the importance of quality of start-up experience in subsequent entrepreneurship (e.g. Mungai and Velamuri 2011). Thus, the presence of experienced but not successful entrepreneurs may alter the results. More detailed research is thus needed to shed light on the effect of successful versus unsuccessful start-up experience on firm survival in a USU context.

On the other hand, USU entrepreneurs endowed with IHC are more likely to exit their firms. This result is in line with Grilli (2010), although in a different empirical context. The explanation for this result lies in the fact that founders' IHC strongly influences the entrepreneurs' threshold of performance since it increases his/her opportunity cost. Therefore, such founders are more exposed to possible alternative occupations with higher salaries (compared to the actual one). As a result the threshold of performance plays a prevailing impact thus significantly lowering the USU likelihood of survival. On the other hand, UHC impacts positively on USU survival. This particular dimension of human capital influences firm performance to a higher extent compared to opportunity cost. Indeed, founders' UHC provides the firm with strong technical expertise and competences, which are of main importance for such companies that rely on the development of new technologies as their core competitive advantage (Colombo and Piva 2012). On the other hand, the influence of UHC on founders' threshold of performance is not as high. In fact, the most likely alternative occupation for founders endowed with UHC is to go back to the place they first left in order to start up the USU, i.e. the university or research institution. Thus, the prevailing dimension stimulated by UHC is firm performance, which in turn has a positive impact on firm survival.

8 Conclusion

We have examined the role of specific and distinct components of human capital in a relevant and unique setting (i.e. USU) through the lenses of the TMEE. Our research validates and extends the TMEE, confirming its modeling and explanatory power and its robustness for different type of entrepreneurial settings. With respect to this, the adoption of the TMEE is particularly adequate under our investigation perspective due to the need to better understand how unique human capital dynamics impact USU survival.

Our research adds to the literature in several ways. *First*, it addresses the lack of research and theoretical advancement in USU survival studies. Given their well-known contribution to regional development (Clayman and Holbrook 2003), high survival rates of USU are to be studied, pursued and possibly fostered more and more, as a measure of the effectiveness of research funding (Clayman and Holbrook 2004). Whereas the importance and relevance of survival for this type of firms has been acknowledged, it has not attracted sufficient effort from scholars.

Second, our research contributes to the understanding of entrepreneurial dynamics, with particular regard to the existence of different types of specific human capital with a different and theoretically justified impact on survival. By disentangling different types of human capital, we claim to provide a necessary contribution to understand the specific effect of founders' human capital on firm survival in the case of USU, answering to Unger et al. (2011) call for more studies that investigate survival appropriately by linking it to founders' specific human capital.

Third, this research adds to the work of Gimeno et al. (1997) by opening the *black box* concerning the indeterminate effect of specific human capital on the threshold of performance and, thus on firm survival, in a specific USU context, where different types of specific human capital dynamics come into play. The general TMEE in fact predicts that specific human capital in present occupation, whereas impacting positively firm's economic performance it cannot reveal anything about the opportunity cost embedded in it since the future occupation of the founders will be unknown. Therefore Gimeno et al. (1997) suggest that specific human capital should impact positively on the survival of the start-ups. However, we claim that when the founders' future occupation is considerably similar to the present one (in terms of the specific knowledge required) founders' specific human capital becomes valuable since it can be successfully and efficiently transferred from present to future occupations, thus raising opportunity cost. When USU entrepreneurs face a career choice they will most likely consider occupations where their knowledge could be valorized. Indeed, it is quite unusual that an entrepreneur, for example in the biotech industry exits the company to engage in a completely different industry (e.g. low-tech or retail market, or even high-tech such as laser or software). An individual actually engaged in a USU can therefore legitimately be expected to leave that start-up to join a R&D lab or a high-tech firm; in any case though, his/her industry specific knowledge will be nearly equally valorized.

Despite these contributions, our study is not free of limitations. A limitation of this lays in data availability, which impacts both the size of the sample and measurements. Although our sample is representative of the phenomenon in Catalonia, a larger and more heterogeneous sample would allow investigating survival factors more in depth. Nevertheless, studies exist in the same vein whose sample size and methodological approach is similar to our own (e.g. Aspelund et al. 2005; Knockaert et al. 2010). A larger sample would also allow us to distinguish among different exit strategies (e.g. mergers and acquisitions, employee takeover). The total number of failed companies is also scarce (14) in our case

and some potential parametric tests are not undertaken since not fully reliable. Besides, more accurate measurements of human capital would help to better quantify the impact of such dimensions. This paper presents one last limitation: the unobservability of both economic performance and threshold of performance. While economic performance might be easier to measure, a threshold level of performance is extremely difficult to assess since it requires accurate information about the valuation of entrepreneurs' human capital by external stakeholders. Such difficulties are indeed often overcome by assessing the ultimate effect of founders' human capital on firm survival (see De Tienne and Cardon 2012). Future studies should aim to assess the mediating effect of both economic performance and threshold of performance on USU survival. In addition it would be interesting for future researches to undertake a Longitudinal Survival Analysis in order to understand what are the determinant factors explaining the life-time of USU (rather than explaining the probability of survival).

Regarding practical implications, our study addresses specific insights to the TTO and university managers, policy makers and entrepreneurs. As UHC positively affects USU survival, TTO and university managers should develop programs aimed at fostering entrepreneurship in high-reputation and socially embedded academics (Cassia et al. 2013), in order to legitimate the technology transfer from universities to new firms and have USU with higher survival rates. Moreover, they should provide aspiring USU entrepreneurs with entrepreneurial education. Policy makers are provided with an evaluation framework that can help them to spot individual-level determinants of USU survival. They would receive a further element to effectively allocate resources to those companies founded by entrepreneurs whose specific human capital is more likely to improve firm survival. On the other hand, they would have to allow flexibility in market labor in order to create entry and exit strategies, which could represent different steps of a continuous professional development path. Finally, this study helps USU entrepreneurs realizing what *to have and have not*, with regard to the importance of a complementary founding team, and the significance of seeking members whose human capital can enhance the survival of their firms. This research provides USU entrepreneurs with some insights that could help them evaluate their current situations, their levels of persistence in entrepreneurship and future alternatives.

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