



Non-founder human capital and the long-run growth and survival of high-tech ventures



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ABSTRACT

This paper considers the impact of non-founder human capital on high-tech firms' long-run growth and survival. Drawing upon threshold theory, we explore how lack of access to complementary skills at different points in the life course impacts founders' thresholds for exit. We examine these factors using a unique longitudinal dataset tracking the performance and survival of a sample of UK high-tech firms over thirteen years as the firms move from youth into maturity. We find that firms that survive but do not grow are characterized by difficulty in accessing complementary managerial skills in youth, while firms that grow but subsequently exit are characterized by shortfalls of specialized complementary skills during adolescence. Firms that grow and survive do not report skills shortfalls. We discuss the implications of these resource constraints for entrepreneurs' decisions to persist or exit through the life course.

1. Introduction and key literature

There is a sizeable body of literature on human capital in high-tech firms (Westhead and Cowling, 1995; Aspelund et al., 2005; Colombo and Grilli 2005, 2010; Ganotakis 2012; Delgado-Verde et al., 2016) but, in line with the widely prevalent 'upper echelon' theory (Hambrick and Mason, 1984), nearly all of this literature has focused on the role of founders, CEOs or top management teams. This paper draws from a diffuse but growing body of research on the role of non-founder human capital (Smith et al., 2005; Klaas et al., 2010; De Winne and Sels, 2010; Andries and Czarnitzki, 2014). While founders are clearly important, this paper aims to provide a counterpoint to 'upper echelon' approaches by arguing that the ability to access these workforce skills plays a crucial role in shaping the growth and survival prospects of a firm as it progresses through its life course.

This study's examination of the relationship between non-founder human capital and performance is also informed by recent criticism of the use of single measures such as survival, employment growth, or sales growth (Miller et al., 2013; Coad et al., 2016a). Indeed, research on 'growth' and 'survival' shows that these terms should not be considered in isolation. For instance, many companies may survive for years without generating meaningful economic growth (Nightingale and Coad, 2014; Brown and Mason, 2014). Meanwhile the growing body of literature discussing entrepreneurial exit explores the multi-

tude of reasons why firms may shut down for reasons that are not immediately associated with 'failure', such as retirement or the availability of attractive opportunities for the entrepreneur elsewhere (Wennberg et al., 2010, 2016; Coad, 2014; DeTienne et al., 2015; Luzzi and Sasson, 2016). This has been conceptualised in Gimeno et al. (1997) and DeTienne et al. (2008), who consider entrepreneurs' thresholds for exit and argue that a range of personal and environmental factors may increase or lower an entrepreneur's willingness to persist with their business despite poor performance. This paper builds on this work to consider the role of access to different sources of human capital on firms' tendency to persist despite low growth, exit despite high growth, or thrive by continuing through high growth.

A firm's likelihood to persist, exit or grow is significantly informed by the stage of the life course in which the firm is observed. The firm age literature (Henderson, 1999; Sorensen and Stuart 2000; Thornhill and Amit 2003) demonstrates the range of challenges that firms face as they progress from new firms, into 'adolescence' (see Aspelund et al. (2005), Courderoy et al. (2012) on new technology based firms, or NTBFs), and on into maturity. As firms age they face different requirements for human capital, investment (financial capital) and market challenges. These changing demands of the life course have significant implications on entrepreneurs' threshold for exit, as does entrepreneurs' ability to access resources such as workforce skills. This paper sets forth a model linking skills, threshold theory and firm aging,

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in which it argues that inability to access certain types of human capital at a particular time in a firm's life course may have significant long-term consequences on its performance and/or survival. In particular, it argues that while founders themselves may have sufficient human capital to keep firms from failing, lack of non-founder managerial capital in initial phases of the life course lowers these founders' threshold for acceptable returns required not to exit. Consequently founders accept suboptimal returns instead of exiting the market. Conversely, the paper argues that among firms that have shown higher growth, lack of specific managerial capital later in the life course means that founders may choose to exit rather than continue their successful businesses.

The paper tests this framework on a unique longitudinal study of UK high-technology ventures (also sometimes referred to as New Technology Based Firms or NTBFs), which allows the tracking of firms from their early stages through to adolescence and into maturity over a period of over thirteen years. It uses a performance measure combining growth and survival that allows for the identification of factors associated with a firm's persistence, exit or ongoing thriving. The results suggest that perceived shortfalls in key complementary human capital have different consequences though the life course of the firms, with shortfalls in early stages having a long-term effect on firms' performance.

Consequently this paper makes three main contributions: firstly it demonstrates the importance of workforce human capital to firm performance. It shows that access to these forms of human capital is a prerequisite to growth, and lack of this human capital at key intervals can have a permanent limiting effect on firm performance. Second, it links access to these types of human capital to the entrepreneur's decision to persist with a low performing firm or exit. In doing so this paper argues that inability to access key complementary resources shifts the entrepreneur's ambitions over time, leading them to accept poor performance or exit despite good performance. Finally it shows how the aging process changes the demand for human capital and shapes the entrepreneur's decision to persist or exit. This study has the following structure: [Section 2](#) presents the background literature; [Section 3](#) describes the growth-survival framework; [Section 4](#) discusses data and method; [Section 5](#) describes the results; [Section 6](#) discusses the findings, theoretical implications, policy implications and future work.

2. Literature review

2.1. Founder and non-founder human capital and firm performance

Much of the literature relating to human capital in entrepreneurial firms has considered firm performance through the lens of the 'upper echelon' perspective ([Hambrick and Mason, 1984](#); see [Carpenter et al., 2004](#) for a survey). This view argues that the performance of a firm reflects the experiences, skills, values and motivations of the founder, CEO and/or top management team. This view is commonly used both in the study of larger firms (for instance [Hitt et al., 2001](#), [Lynskey, 2004](#)), as well as entrepreneurial firms and new technology-based firms (NTBFs) ([Cooper et al., 1994](#); [Westhead and Cowling, 1995](#); [Brüderl et al., 1992](#); [Storey and Tether, 1998](#); [Baron et al., 1999](#); [Baron et al., 2001](#); [Colombo and Delmastro, 2001](#); [Aspelund et al., 2005](#); [Colombo and Grilli, 2005, 2010](#); [Ganotakis, 2012](#); [Visintin and Pittino, 2014](#)). This proposition is supported by the literature on survival and human capital, which shows that firms whose founders have lower levels of general and specific human capital are more likely to fail ([Cooper et al., 1994](#); [Ucbasaran et al., 2007](#)). Low levels of founding team human capital in terms of industry and start-up experience have generally been associated with lower survival and performance as well ([Delmar, 2006](#); [Delmar and Shane, 2004](#); [Huang et al., 2012](#)). These findings support the view within the literature using upper echelon theory that founders' skills and experience are vital for identification of entrepre-

neurial opportunities. ([Davidsson and Honig, 2003](#)). In the context of high tech ventures, founders are more likely to come from a technical background ([Cooper et al., 1994](#); [Westhead and Cowling, 1995](#); [Oakey 2003](#)), which gives them the ability to identify opportunities for new innovations ([Shane and Venkataraman, 2000](#); [Colombo and Grilli, 2005](#)).

Founders' importance for a firm's prospects for growth sometimes overshadows the role of other, non-founder forms of human capital ([Klaas et al., 2010](#)). Human capital within the workforce is also hugely important and contributes to organizational performance ([Wright et al., 2001](#); [Smith et al., 2005](#); [Collins and Smith, 2006](#); [De Winne and Sels 2010](#); [Andries and Czarnitzki 2014](#); [Delgado-Verde et al., 2016](#); [Sommer et al., 2016](#)). Yet in the context of innovative firms technical skills are often prioritized at the expense of complementary managerial skills required to bring products to market ([Blaydon et al., 1999](#); [Paradkar et al., 2015](#)). In order for innovative firms to capture value from their innovations, there exists a range of non-technical human capital required, including general human capital (i.e. general management, production) or human capital specialized to the specific knowledge and context of the firm (i.e. R & D); ([Helfat and Lieberman, 2002](#)). These are particularly important in high-tech ventures, given that founders are more likely to have a technical background and therefore need to source these complementary sources of human capital from the workforce. Recent research by [Dahl and Klepper \(2015\)](#) on hiring practices of new Danish firms suggests that employees are effectively sorted by ability, with higher quality employees being paid higher salaries by more resource-endowed firms that have shown higher growth levels and prospects of survival. This finding has been supported by [Sommer et al. \(2016\)](#), who find that perceived innovativeness of a firm makes the firm more attractive to potential employees. This study tests one implication of [Dahl and Klepper's \(2015\)](#) work, which is that firms that are unable to access key skills in early stages will be likely to show lower levels of performance and survival over the long-run.

2.2. Growth ambitions, access to resources and survival

A firm's survival is predicated on the founder or manager's desire to continue the business, and consequently this fundamental decision has been highlighted throughout the literature in a number of ways. This paper's particular focus relates to how this decision evolves over time. The selection model of [Jovanovic \(1982\)](#) highlights that low expectations for firm performance and higher paying options outside the firm will lead firms to exit. This broad expectation is not necessarily empirically demonstrated, as there are many firms that perform poorly yet remain in operation ([Ruhnka et al., 1992](#); [van Witteloostuijn, 1998](#); [Nightingale and Coad, 2014](#)). [Gimeno et al. \(1997\)](#) explored the question of why some businesses survive while others with similar (or superior) resource endowments do not, and ultimately argued that firms (and more specifically entrepreneurs and managers) have a performance threshold that must be met for the firm to remain in business. In particular, entrepreneurs with higher levels of human capital and opportunities for work in alternate jobs are less likely to tolerate lower levels of economic performance, whereas entrepreneurs with lower levels of social capital but higher levels of psychic income (that is, intangible returns to the job) are likely to tolerate poor performance and thus survive. More recent work by [DeTienne et al. \(2008\)](#) builds on those findings by identifying a number of factors that lead entrepreneurs to increase their commitment to a venture despite poor performance, including market opportunities, personal investment, personal options, previous organizational success and perceived collective efficacy of the organization.

Key to entrepreneurs' decisions to persist is the growth ambition or reference point that entrepreneurs have for their business ([Kahneman and Tversky, 1979](#); [Stewart et al., 1999](#); [Westhead et al., 2005](#)). Entrepreneurs' growth ambitions are shaped by a range of demo-

graphic, personal and institutional factors (Davidsson, 1989; Kolvereid 1992; Liao and Welsch 2003; Cassar 2006). Importantly the desire to grow is not the same as the ability grow. Wiklund and Shepherd (2003) show that while there is a positive relationship between growth ambitions and manifested growth, the entrepreneur's human capital (manifested by education and experience) and market dynamism positively moderate this relationship, suggesting that more educated and experienced entrepreneurs with higher levels of ambition are more likely to lead firms with high levels of growth. Dutta and Thornhill (2009) explore the role of different cognitive styles in shaping growth intentions over the evolution of a firm, finding that these styles inform an entrepreneur's response to conditions that differ from what had originally been expected. In these papers and others addressing the topic (e.g Terjesen and Szerb, 2008; Verheul and van Mil, 2011; Douglas, 2013), emphasis is placed on cognitive style and individual human capital, but less emphasis is made on access to key non-founder human resources, those factors contributing to what DeTienne et al. (2008) refer to as 'collective efficacy'. Wennberg et al. (2016) highlight the importance of age, size and performance on shifting entrepreneurs' attitudes toward survival and their use of growth as a response to poor performance. With this said many of these studies, even those that do have a longitudinal component, do not capture the impact of lack of resources or link it clearly to the threshold perspective. Specifically, the lack of non-founder human capital and its impact on growth is not clearly addressed, and even more so the impact of these over the life course of the firm itself.

2.2.1. Growth and exit over the life course

The factors contributing to exit or failure vary over the firm's life course. While in their early years firms suffer from a 'liability of newness' (Stinchcombe, 1965; Bruderl and Schussler 1990) in which they are particularly prone to failure, as they mature they face different challenges, resulting in a 'liability of adolescence', which varies across industry and strategy (Henderson, 1999). While lack of managerial knowledge and financial management skills are reasons for exit in early years, once firms have navigated liabilities of newness and adolescence they then are liable to failure due to external conditions (Thornhill and Amit, 2003). As they age, firms are both more likely to innovate and also more likely to see those innovations become obsolete (Sorensen and Stuart, 2000). Consequently there is an increasing impetus for firms to continue investing in innovation even as they move into maturity.

Even as firms proceed through the life course, 'mortality' and 'survival' are not necessarily straightforward terms. It is a widespread but inaccurate caricature that survival is implicitly 'good' while closure is necessarily 'bad'. The growing literature on exit has recently emphasized the distinction between voluntary entrepreneurial exit, closure and failure (see Bates, 2005, Headd, 2003, Wennberg et al., 2010, Coad, 2014; DeTienne et al., 2015; Khelil, 2016). In the first case, 'entrepreneurial exit' refers to those cases where the founder exits the firm but the firm continues trading (Wennberg et al., 2010). 'Closure' refers to the voluntary winding-down of a business, which takes place if an entrepreneur retires and decides to close her business, or if an entrepreneur chooses to re-enter employment for another company and closes the firm (Hessels et al., 2010; Luzzi and Sasson, 2016). Closure itself is not necessarily bad, but represents a conscious choice to cease trading (Balcaen et al., 2012; Cefis and Marsili, 2011; Wennberg et al., 2010). Of these, only 'failure' (i.e. insolvency, liquidation or closure in face of the pending recognition of these) represents involuntary exit subsequent to poor performance. Indeed, standard economic theory would regard the exit of poorly performing low quality entrepreneurship as an efficient reallocation of resources that could be better employed elsewhere.

The interest here is therefore to link the topics discussed above, specifically to understand the impact of access to complementary skills and broader human capital on a firm's threshold for accepting variable

levels of firm performance prior to exiting. To fully understand this these issues however, one needs long-run data to capture the relative thresholds over performance over an extended period. This paper does this using a dataset containing firm performance over thirteen years. To track persistence it uses a combined measure of growth and survival that allows the differentiation between different forms of exit and survival. To the authors' knowledge this approach is unique, seeing as previous work such as Delmar et al. (2013) and Solomon et al. (2013), estimated separate regressions while this paper uses a common measure that combines these approaches.

3. Framework and hypotheses

Growth (i.e. changes in employment or sales over time) and survival are two of the most common measures of firm performance. Growth is a fundamental process of the life course of firms, and has been widely studied on its own (Storey, 1994; Coad, 2009; McKelvie and Wiklund, 2010). At the same time, there has been increasing recognition that growth is not a standard, unitary measure. While employment growth and sales growth are often used interchangeably on their own as proxies of growth (Davidsson and Wiklund, 2001), these measures are in fact only weakly correlated (Chandler et al., 2009) and are often sequential (Coad et al., 2016a). Consequently, research in this area that focuses on individual measures run this risk of only capturing part of the picture of firm performance, rather than a full portrait (Boyd et al., 2005). Further, as a conceptual tool Miller et al. (2013) argue that performance is an abstract concept that in much research is not appropriately used or understood. Consequently, there is a need for alternate approaches to the consideration of growth.

The discussion of literature provided in the previous section has similarly highlighted the limitations of binary approaches to survival. For the analysis a simple framework is introduced to highlight and contextualize the range of possible outcomes that a firm might demonstrate over an extended period. In particular, the framework highlights the outcomes, rather than processes, of these decisions. Consequently rather than only considering survival and failure, the framework also includes the level of growth shown by the firm in the time period.

The framework emphasizes the differences between the four categories obtained from a 2x2 matrix along the dimensions of high/low growth vs survival/failure. Although survival/failure is a binary outcome, thus naturally fitting into a 2x2 matrix framework, nevertheless growth is a continuous variable, and its inclusion in the 2x2 framework comes at the cost of a loss of statistical information (because a continuous variable is transformed into a binary variable).

This framework, presented in Fig. 1, considers growth and survival in the following ways:

In order to better explain this framework, the subsequent sections draw upon existing literature in order to hypothesize about the characteristics of firms that will end up in these categories, specifically

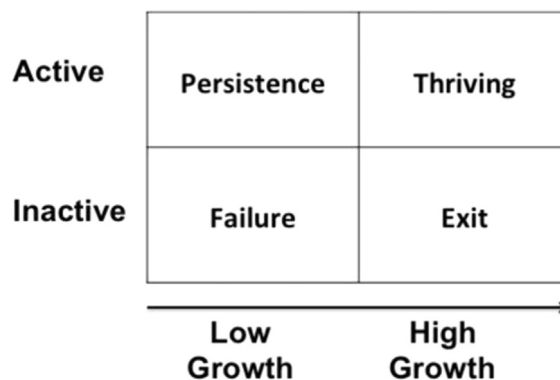


Fig. 1. Schematic of growth and survival.

	Report shortfalls of:	Early stage	Late stage
Persistence	General skills	Yes	No
	Specific skills	No	Yes
Exit	General skills	No	Yes
	Specific skills	No	Yes
Thriving	General skills	No	No
	Specific skills	No	No

Fig. 2. Summary of hypotheses across the life course.

focusing on complementary skills. The low-growth/failure category is considered to be the baseline. Figure 2 summarises the categories and predicted shortfalls of skills through the life course.

3.1. Background assumptions

Examining long-run performance and exit requires certain background assumptions. For this examination of survival without growth, growth followed by exit and growth and survival one must first consider the human capital of the founder. The literature on the importance of founders for high-tech ventures (e.g. Cooper et al., 1994, Westhead and Cowling, 1995; Colombo and Grilli, 2005, 2010) has already been discussed in Section 2, and the aim of the framework is not to understate the importance of individual human capital but to instead take this as a given factor to be controlled. Because the data consider exit after a firm is at least four years old and has already passed the period in which the firm is most likely to fail or entrepreneur is mostly likely to exit (Evans, 1987; Evans and Leighton 1989), it is fair to assume that there must be a baseline of capability supporting the firm's survival. Consequently, following Lazear's (2004) 'jack of all trades' hypothesis, one may propose that in addition to the technical background of founders that they also have some range of diverse skills simply to run a business that survives and negotiates the initial challenges of innovation (Saemundsson, 2005). However while founders of high-tech ventures may have some degree of complementary skills, they also often lack the background, training and time to carry out the range of in-depth duties required for firms to grow (Blaydon et al., 1999). Consequently, the framework proposes that access to these complementary skills and human capital is a factor that informs the founders' ability to grow and/or exit.

3.2. Persistence

One possible long-run outcome is a firm's survival over the long term but failure to grow, which the framework refers to as persistence. To explain this the framework draws upon the threshold explanation of survival discussed above, specifically the suggestion derived from Gimeno et al. (1997) and DeTienne et al. (2008) that founders with lower levels of human capital are more willing to tolerate lower returns. This may also relate to the presence of non-pecuniary entrepreneurial objectives such as the desire for independence that implicitly trades off income for independence. As discussed above, this immediately poses a conundrum, as there must be a baseline of capability in the organization for firms to survive for an extended period. Even if the founder has reasonably diverse levels of personal human capital, in the early stages of the firm's growth he or she will also require complementary skills and human capital, particularly the general management skills identi-

fied in Thornhill and Amit (2003) as vital for navigating the liabilities of newness. Failure to access these skills may not be sufficient for the firm to fail, but may be a significant barrier to growth, which subsequently may reduce the founder's threshold for what constitutes acceptable performance. Following Cassar (2007) and Dutta and Thornhill (2009), this negative, unexpected variance from the expected trajectory of the firm is likely to lower the entrepreneur's growth ambitions. Consequently one may hypothesize that founders' perceived lack of access to these skills in the early periods of the firm will lower the growth prospects of the firm.

H1a. Persistent firms founders will report general complementary skills shortfalls in early stages of the life course.

Although these firms may show a lack of general managerial skills, the entrepreneur is likely to have a technical background (Cooper et al., 1994; Westhead and Cowling, 1995; Oakey 2003) and, as discussed above, a baseline level of capability to keep the firm from failing in its first five years. Consequently these firms are unlikely to report a lack of specific complementary skills such as R & D as these would, if nothing else, be addressed by the entrepreneur's human capital:

H1b. Persistent firms' founders will not report specific complementary skills shortfalls in early stages of the life course.

Having not grown and therefore continuing to rely on the founder's human capital, the entrepreneur's growth aspirations are therefore likely to be limited as he/she realizes that the opportunities for exit via paid employment are likely to result in lower returns than the entrepreneur makes with his/her firm (Luzzi and Sasson, 2016). Consequently with barriers to exit in place and unanticipated difficulty accessing key skills and human capital, the entrepreneur's growth expectations will be lowered (as discussed above per Dutta and Thornhill (2009)). The lowered expectations will raise the threshold to exit per Gimeno et al. (1997) and DeTienne et al. (2008). Consequently the perceived requirement for complementary general managerial skills and human capital – otherwise required to grow – will be diminished:

H1c. Persistent firms' founders will not report general complementary skills shortfalls in early stages of the life course.

Meanwhile, as undersized firms in innovative sectors, these firms lack the complementary skills and human capital to facilitate growth but must continue their innovation activity to survive and remain competitive (per Sorensen and Stuart, 2000). The high risk profile of innovative activity for younger firms means that firms that are less successful at innovation are more likely to record lower performance (Coad et al., 2016b), even while persisting in the marketplace (Wennberg et al., 2016). For these firms, this means that the managerial problems, lack of economies of scale in innovative activity (Nightingale, 2000), and lower growth are likely to lead entrepreneurs to perceive specialized, technical skills as an issue where before they did not:

H1d. Persistent firms' founders will report specific complementary skills shortfalls in early stages of the life course.

3.3. Exit

The converse of persistent firms are those firms which show higher levels of growth but cease operating. As discussed in Section 2, there are a range of reasons why founders of successful firms may wish to exit (and also cause their business to cease operations): they may wish to return to paid employment, retire, or seek lifestyle changes, or exit for other reasons (Wennberg and DeTienne, 2014; Wennberg et al., 2010). Indeed, exit and 'cashing out' after building a successful company is one strategy for exit (DeTienne et al., 2015), so exiting may be a profitable measure. Consequently these firms that have demonstrated growth are less likely to have faced barriers in access general or specific skills and human capital in their early phases. Following the existing

literature linking skills and human capital to firm performance (Smith et al., 2005; De Winne and Sels, 2010; Andries and Czarnitzki 2014), firms that have shown higher performance are also more likely to have higher (or at least acceptable) skill levels and human capital. Given the crucial role of general complementary skills and human capital for growth (Blaydon et al., 1999) firms that have demonstrated growth in the initial period may be hypothesized to have had these general skills:

H2a. Exiting firms' founders will not report general complementary skills shortfalls in early stages of the life course.

Similarly to the argument in Section 3.2 given the human capital of the founders and their likely technical proficiency (Westhead and Cowling, 1995; Oakey 2003; Colombo and Grilli 2005), as well as the evidence of growth as discussed above, this may be similarly extended:

H2b. Exiting firms' founders will not report specific complementary skills shortfalls in early stages of the life course.

As discussed above, founders' threshold regarding cost of exit shifts as firms mature. The liabilities of adolescence (Henderson, 1999) and beyond (Thornhill and Amit, 2003) mean that the demands faced by firms over time change dramatically, as the necessity of innovation and risk of obsolescence requires ongoing investment in new technology and training. This is particularly true for firms that have demonstrated growth over their history, and there is a wide perception (with mixed empirical support) that the skills required to found a company differ from those required to scale up growth, necessitating a change in management (see the review in Pollock et al. (2009)). The threshold perspective (Gimeno et al., 1997; DeTienne et al., 2008) suggests that higher levels of human capital lowers the barriers to exit. However, the challenges of ongoing investment, the loss of key staff (Baron et al., 2001) and the changing market create a scenario in which a founder, reflecting on past success but facing future challenges, may choose to exit or close the company, particularly if returns to returning to employment are likely to be high (Luzzi and Sasson, 2016). Wennberg et al. (2016) suggest that founders will face the choice to grow the firm or close, and that the preference is to grow the firm rather than terminate the business. However in considering those firms that have stopped trading, it seems reasonable to hypothesize that these founders face difficulty in accessing the general or specific skills required for ongoing investment in the firm's innovative activity or growth, they may be willing to consider exiting the firm, even despite the firm's success thus far:

H2c. Exiting firms' founders will report shortfalls of general complementary skills later in the life course.

H2d. Exiting firms' founders will report shortfalls of technical complementary skills later in the life course.

3.4. Thriving

Finally this framework considers those firms that have survived and shown long-run growth, which are here referred to as 'thriving' firms. For these firms one may set out the converse to the arguments above regarding access to skills and human capital. The framework has previously hypothesized that access to sufficient skills and human capital in the early stages will enable a firm to achieve higher growth, drawing upon literature linking skills and human capital to performance (e.g. Smith et al., 2005). Given the previous suggestion that the founder's technical background (Westhead and Cowling, 1995; Oakey 2003; Colombo and Grilli 2005) is likely to provide a baseline sufficient for achieving initial growth, the initial argument from Section 3.3 may be extended:

H3a. Thriving firms' founders will not report general complementary skills shortfalls in early stages of the life course.

H3b. Thriving firms' founders will not report specific complementary skills shortfalls in early stages of the life course.

The challenges facing firms as they mature (e.g. Thornhill and Amit, 2003) has already been discussed, with the suggestions that prior access to human capital lowers founders' threshold to exit (per Gimeno et al., 1997 and DeTienne et al., 2008). As mapped out in Section 3.3 there are a series of challenges facing firms that have grown successfully in the past. Even if they face difficult times, the response to those challenges may be to grow (Wennberg et al., 2016). While some founders might choose to exit rather than invest in the required additional capacity if they face skills shortfalls in technical areas, those that do not face these shortfalls may feel less inclined to exit, and may, therefore, choose to persist with their business. These firms may not face shortfalls due to managerial competence, investment in HR, luck or other reasons but one may logically extend this finding to suggest that those firms that do not report shortfalls later in the life course will be more likely to survive and grow over the long-run.

H3c. Thriving firms' founders will not report general complementary skills shortfalls in later stages of the life course.

H3d. Thriving firms' founders will not report specific complementary skills shortfalls in later stages of the life course.

4. Data and method

The analysis uses a unique longitudinal dataset following 202 high-tech UK firms over the past twenty years. The dataset is based on two surveys that were carried out in 1997 and again in 2003. Managers in these companies were asked about a range of issues including access to skills and human capital, technology strategy, internationalization, finance and a number of other topics. The first wave of the survey in 1997 captured a group of firms that were at that time on average five years old. The definition of 'high technology' reflected the Butchart (1987) definition for high technology manufacturing sectors, which may be roughly translated to include firms in electronics, software, advanced materials, telecommunications and biotechnology sectors. Firms were selected from a panel of all firms with more than three employees operating in these sectors that had been founded between 1987 and 1996. Firms were contacted in late 1997 and early 1998 via a written questionnaire, yielding 362 completed questionnaires. This survey was then followed up with another wave run in 2002 and 2003 in which the same firms were contacted again, yielding 217 completed questionnaires from the same sample, resulting in a panel of 217 firms. Both waves of the survey asked founders about their current position, access to human capital, innovation activities, strategy and other topics.

This paper focuses on the long-term performance implications of configurations of human capital, necessitating a further record of firm performance subsequent to the 2003 survey. These data discussed above were therefore augmented with performance data drawn from the Business Structure Database (BSD) of the UK Office of National Statistics. The BSD is the most comprehensive record of firm performance data in the UK, representing a complete dataset of nearly all firms in the UK economy, with employment data drawn from National Insurance and turnover data derived from value-added tax records from HM Treasury. The BSD was used to create a panel of the performance of firms in the survey from 1997 to 2010. As is common in these exercises, a small number of firms were unable to be matched, resulting in a final sample of 202 firms. Checks found no evidence that the unmatched firms were more or less likely to come from any particular sector, size bracket or other key area. The combination of dependent variables from official sources with survey data, as well as the temporal separation of the waves by 6–7 years is a good way of reducing risk of common method bias (Podsakoff et al., 2003).

4.1. Variables and framework

As presented above, the key 2x2 framework discussed above

combines measures of growth and survival. The schematic has survival (a binary variable, as firms are either coded as being active or not) on the y-axis, and growth on the x-axis; growth is divided into two categories for growth, with firms separated based on whether their employment growth over the period 1997–2010 was above or below the mean of the log growth in employment. The ‘active’/‘inactive’ and ‘high’/‘low’ growth axes allow the generation of a 2×2 matrix of performance. This presents with four categories: ‘Failure’ (low performance, inactive: the firm performed poorly and has now ceased to operate); ‘Persistence’ (low performance, active: the firm has performed poorly but has remained active to 2010); ‘Exit’ (high performance, inactive: the firm grew but is no longer operational; this may include firms that have been intentionally wound-down by owners); and ‘Survival’ (high performance, active: firms that have demonstrated growth and general success). Approximately half the firms fall into the ‘Survival’ category, with one-quarter in the ‘Persistence’ category and approximately 12% each fall in the ‘Failure’ and ‘Exit’ categories.

4.1.1. Variables

A number of forms of human capital were captured in the data. Workforce human capital is measured using a series of questions that asked the founder about whether the firm had suffered from a shortfall of managerial skills (*short_mgmt_97* and *short_mgmt_03*); financial skills (*short_finance_97* and *short_finance_03*); sales skills (*short_sales_97* and *short_sales_03*); marketing skills (*short_marketing_97* and *short_marketing_03*), and R & D skills (*short_research_97* and *short_research_03*). In line with the previous discussion of interest in general management skills, management, sales, finance and marketing skills are classified as general skills and R & D is classified as a specific skill. Importantly, these measures only capture the founders' perception of a shortfall, rather than an absolute measure of individuals/skills working in a given area. This approach captures perceptions that might contribute to shifts in founders' threshold for exit.

A number of controls are used to measure entrepreneurs' human capital, including size of the founding team (*nbr_founders*), previous experience working together (*founder_joint*), previous entrepreneurial experience (*exp_ent*) and a number of questions capturing the range of founders' international experiences: experience living abroad (*exp_abr*), experience working abroad (*exp_intl_work*), and education abroad (*edu_abroad*). Controls for innovative activity include the percentage of staff classed as skilled (*skilled_staff_pct*), the percentage of staff engaged in R & D activities (*rd_employees*) and percentage of turnover spent on R & D (*rd_turnover*). Controls for access to capital include venture capital (*vc_97* and *vc_03*) or angel (*angel_97* and *angel_03*) investment, as well as whether the companies had received public grants (*grant_97* and *grant_03*). Additional controls include sector dummies and a measure of firm size at founding.

4.2. Method

Because the aim of the research is the understanding of the relative probability of a firm being in one of four categories, the most appropriate technique is the multinomial logit model. This approach is preferable as it allows the estimation of both measures at the same time rather than separately as growth and survival.

Multinomial logit models are based on similar principles to traditional binary logit models, but allow calculation of the relative probability not of one event taking place, but of several compared to a reference outcome category. They do this by operating the equivalent of a number of binary models linked together, but in order to generate a coefficient β for the complete equation, an additional β term is required (Greene, 2003); consequently a ‘base’ value for the equation must be specified. The specification presented here uses the category ‘failure’ as the base, allowing the calculation of results from other categories ‘Persistent’, ‘Exit’ and ‘Thriving’. For our analysis we use probability weighting, following the weights discussed in Burgel et al

Table 1
List of variables.

Variable name	Description (* binary)	Mean	Std Dev
<i>nbr_founders</i>	Number of founders	2.227	1.390
<i>new_entr</i>	New entrepreneur*	0.831	0.375
<i>work_abroad</i>	Work experience abroad*	0.439	0.497
<i>work_mnc</i>	Work for international firm*	0.455	0.498
<i>edu_abroad</i>	Education abroad*	0.145	0.352
<i>founder_joint</i>	Founder joint experience*	0.529	0.500
<i>prev_entrepreneur</i>	Experienced entrepreneur*	0.623	0.485
<i>skilled_staff_pct</i>	Percentage high skill employees 1997	35.587	30.544
<i>rd_turnover</i>	Percentage turnover spent on R & D 1997	6.564	10.476
<i>rd_employees</i>	Number of R & D employees 1997	4.244	9.638
<i>rd_intensity</i>	R & D intensity (percentage R & D employees of total employment)	23.418	23.914
Reported skills shortfalls:			
<i>marketing_97</i>	Shortage marketing skills 1997*	0.404	0.491
<i>marketing_03</i>	Shortage marketing skills 2003*	0.253	0.435
<i>sales_97</i>	Shortage sales skills 1997*	0.397	0.490
<i>sales_03</i>	Shortage sales skills 2003*	0.283	0.451
<i>finance_97</i>	Shortage finance skills 2003*	0.325	0.469
<i>finance_03</i>	Shortage finance skills 2003*	0.185	0.389
<i>research_97</i>	Shortage R & D skills 2003*	0.291	0.455
<i>research_03</i>	Shortage R & D skills 2003*	0.404	0.491
<i>vc_97</i>	Received VC in 1997*	0.082	0.275
<i>vc_03</i>	Received VC in between 1997 and 2003*	0.103	0.304
<i>angel_97</i>	Received angel investment in 1997*	0.162	0.368
<i>angel_03</i>	Received angel investment between 1997 and 2003*	0.180	0.385
<i>grant_97</i>	Received grant in 1997*	0.199	0.399
<i>grant_03</i>	Received between 1997 and 2003*	0.214	0.410

(2004). As a robustness check the multinomial logit model was run using each of the four categories as a base, and traditional logit models for each category were also estimated, without significant difference in results. These are not included here but are available from the authors upon request.

5. Results

Descriptive statistics are presented in Tables 1 and 2. These show the means of the main variables as well as a breakdown of firm size by sector at founding, in 1997 and in 2003. The descriptive statistics highlight the skewed distributions but more broadly highlight the relative persistence of size in the firms in question, with median firm size remaining approximately 15 between 1997 and 2003. This shows that despite the growth for many of the firms, the overall firm size, on average, remained fairly small.

The results of the multinomial logit model are presented in Table 3. In examining the firms classed as persistent, the estimations show that early in the life course the founders were more likely to report shortfalls of marketing but not of the other general skills, leaving H1a partially supported. Firms did not report shortfalls of specific skills, supporting H1b. As these firms age, they were not more likely to report shortfalls in general skills, but were more likely to report shortfalls in R & D, supporting both H1c and H1d.

The results for those firms that exit show no evidence that these firms were more likely to report general or specific skills shortfalls early in their life, therefore supporting H2a and H2b. For exiting firms shortfalls of finance skills are associated with exit, but none of the other general managerial skills were associated with exit, therefore only

Table 2
Descriptive statistics by industry.

Sector	IT/Software	IT/Hardware	Engineering	Biomedical	Other High-tech	Total
Age at first observation (mean)	6.65	6.35	7.25	7.18	6.78	6.76
Age at first observation (median)	7	6	8	7	6	7
Employment at birth (mean)	4.89	3.12	3.37	4.85	5.2	4.35
Employment at birth (median)	3	3	2	3	3	3
Employment 1997 (mean)	23.48	20.19	13.48	20.82	19.63	20.01
Employment 1997 (median)	15	11	10	9	15	12
Employment 2003 (mean)	27.11	19.59	123.35	31.72	25.62	46.78
Employment 2003 (median)	12	18	14	18	15	15
Sample size	45	24	44	18	71	202

partially supporting H2c. However there were shortfalls in R & D skills, supporting hypothesis H2d.

The results for firms that have thrived, show that, as hypothesized, these firms are less likely to have reported shortfalls early in their life course, therefore supporting hypotheses H3A and H3B; or later in the life course, supporting H3C and H3D. Consequently most of the hypotheses may be concluded to be broadly supported.

6. Discussion

6.1. Summary

There is a well-developed literature on the role of human capital on the performance of new technology based firms (Westhead and Cowling, 1995; Aspelund et al., 2005; Colombo and Grilli 2005, 2010; Brinckmann et al., 2011; Ganotakis, 2012). This longitudinal study of 245 UK high-tech ventures contributes to this literature in three different ways. First, this paper discusses the importance of workforce skills, rather than the human capital of the founder or top management

team, as is commonly done in the literature. Second, it considers two measures of performance (growth and survival) jointly rather than simply one measure or the other. Third, it examines the changing impact of workforce skills on the firm's performance over an extended period, therefore allowing the tracking of changes as firms progress through their life course.

Following recent but diffuse literature emphasizing the role of workforce skills and human capital for firm performance (Smith et al., 2005; Collins and Smith, 2006; De Winne and Sels 2010; Andries and Czarnitzki 2014), the paper hypothesizes that access to quality general and specific human capital skills in the workforce is also crucial to a firm's long-term success. The study finds that the absence of general skills (particularly marketing skills) in the early years of a firm has a long-term impact on the firm's success, even when the founder has sufficient human capital. The findings suggest that difficulty in accessing skills can be a significant barrier to firm growth and survival. The demonstration of the make-or-break importance of a range of workforce skills (as opposed to the skills of the founder or top management team) for firm performance makes this study an important contribu-

Table 3
Multinomial logit regression for long-run performance 1997–2010 (using failure as the baseline). (* indicates significance at the 0.1 level; ** indicates significance at the 0.05 level; *** indicates significance at 0.01 level)

	Persistence			Exit			Thriving		
	RRR	Std Err	P > z	RRR	Std Err	P > z	RRR	Std Err	P > z
nbr_founders	0.323***	0.071	0.000	1.200*	0.126	0.082	1.034	0.103	0.736
work_abroad	0.598	0.213	0.149	0.812	0.247	0.493	1.152	0.313	0.603
work_mnc	0.745	0.237	0.355	2.378***	0.636	0.001	1.803***	0.398	0.007
edu_abroad	0.101***	0.053	0.000	0.766	0.231	0.377	0.483***	0.132	0.008
skilled_staff_pct	0.988**	0.005	0.016	1.000	0.004	0.929	0.997	0.004	0.475
Skills shortages:									
marketing_97	3.332***	1.138	0.000	1.311	0.401	0.376	1.273	0.361	0.394
marketing_03	0.785	0.272	0.486	1.355	0.402	0.306	0.840	0.230	0.525
sales_97	0.600	0.209	0.143	1.507	0.459	0.178	1.462	0.409	0.175
sales_03	1.265	0.395	0.451	0.953	0.251	0.856	1.050	0.243	0.833
finance_97	0.516**	0.157	0.030	0.769	0.184	0.272	1.106	0.235	0.635
finance_03	0.693	0.246	0.302	0.508**	0.162	0.034	0.745	0.212	0.300
research_97	0.933	0.247	0.793	0.697	0.006	0.144	0.720	0.154	0.125
research_03	2.484***	0.694	0.001	1.722**	0.436	0.032	0.818	0.189	0.385
founder_joint	0.979	0.309	0.945	0.989	0.239	0.963	0.528***	0.113	0.003
prev_entrepreneur	1.004	0.459	0.994	0.207***	0.083	0.000	0.428**	0.149	0.015
tech_skills	1.066	0.048	0.156	1.025	0.045	0.574	1.099**	0.043	0.015
rd_intensity	1.037***	0.006	0.000	1.035***	0.005	0.000	1.024***	0.005	0.000
vc_97	8.332***	4.297	0.000	5.093***	2.260	0.000	1.383	0.612	0.464
vc_03	0.787	0.405	0.642	0.805	0.321	0.588	0.779	0.295	0.511
angel_97	0.086***	0.054	0.000	0.566	0.228	0.158	0.078***	0.033	0.000
angel_03	6.797***	3.593	0.000	1.764	0.757	0.185	3.073***	1.256	0.006
grant_97	0.465***	0.180	0.048	1.012	0.261	0.963	0.717	0.170	0.159
grant_03	1.514	0.498	0.207	0.836	0.247	0.544	1.098	0.276	0.709
Log likelihood	-1693.5071								
Number of obs	1624								
LR chi2(69)	639.79								
Pseudo R2	0.1589								

tion both the literature on high-tech ventures but the entrepreneurship literature more widely.

The study's second contribution is that it takes into account two different performance measures to understand the importance of workforce skills and human capital. The study proposes a measure that combines growth and survival, which facilitates a clear addition to the literature on the thresholds at which entrepreneurs may exit their firms (e.g. Gimeno et al., 1997, DeTienne et al., 2008). The study shows that access to workforce skills and human capital plays a role in firms that are persistent (surviving but showing low growth), that exit despite showing high growth, and that thrive by surviving and growing. Lack of access to these skills early in a firm's life course appears to play a role in the lowering of entrepreneurs' expectations for growth and acceptance of poorer returns. Similarly lack of access to skills later on after periods of growth appears to be associated with the decision to exit despite high levels of growth. In this way, demonstrating the impact of access to workforce skills on growth aspirations and exit decisions makes an important contribution to the literature by extending the previous literature on persistence and thresholds to exit.

The importance of the findings above are magnified by the third contribution, which relates to the time scale of the study. The longitudinal data allows the capture the impact of access to workforce skills and human capital on persistence and exit over a much longer period than is typically seen in the literature, covering a period of nearly twenty years. In this way this paper links the threshold and exit literature to the literature on firms' growth challenges throughout the life course (e.g. Sorensen and Stuart, 2000; Thornhill and Amit, 2003) to present a unified framework of the impact of access to complementary human capital on the long-run performance and persistence of firms. The paper's findings show that access to different types of skills play vital roles at different parts of the life course; in earlier parts of the life course, access to general management skills is crucial, and in the absence of these skills the growth prospects of these firms is permanently limited. In contrast, among firms that have previously grown, inability to access specialized resources to support continued innovation and growth later in the life course is associated with exit despite high performance. This makes a key contribution to the literature by linking these heretofore disparate literatures into a unified framework.

6.2. Theoretical implications

This paper presents a counterpoint to the widely used 'upper echelon' perspective (Hambrick and Mason, 1984) in management by arguing for the vital importance of workforce skills and human capital for long-run firm performance. While existing literature demonstrates the importance of founders and top management teams, this study sets out the beginnings of a theoretical perspective that considers the impact of the other echelons, that is, the workforce and its complementary skills, on firm performance. The findings support and extend the threshold theory literature (Gimeno et al., 1997; DeTienne et al., 2008) by demonstrating that access to these human resources shapes the life prospects of the firm. Whereas other studies consider relative stocks of human capital, this particular study examines the presence or absence of particular skills to demonstrate the presence of these skills as a precondition for successful growth, and track the evolution of these preconditions over time. This supports the firm aging literature (Sorensen and Stuart, 2000, Thornhill and Amit, 2003) but extends it by validating previous findings over the course of a single long-run study and emphasizing the importance of resource access to firms' persistence. In this way this study integrate three literatures into a single framework that places access to resources as the basis for sustainable growth.

6.3. Managerial and policy implications

This study's findings have a number of implications for managers

and policymakers. They emphasizes the role of general and specific workforce skills as preconditions for long-run performance, but the different skills used for different types of firms through the life course is instructive. For new firms, the evidence found here clearly points to the dividends associated with the accumulation of a broad base of skills in early years. In the absence of particular skills in early years – particularly marketing – firms struggle to grow, which has long-lasting effects on the growth ambitions of the firm. Consequently the findings here advise managers to invest in building a broad skills base among the workforce, particularly for general managerial functions, from the early days of the firm as this appears to at least decrease the chances of getting into the 'rut' of being a marginal, undersized, poor-performing enterprise (per Nightingale and Coad, 2014). From a policy perspective, these findings suggest that the government may have a role in influencing young firms to accumulate skills, particularly general managerial skills.

However, as firms age, the recommendations change. In line with the study's findings on growth different capabilities become important, and here innovation incentives become more valuable than they would be for newer firms. For managers who have struggled with growth previously the challenge of assembling necessary resources remains. For those that have done well the challenge becomes the continued investment in innovation. For policymakers this study's findings suggest that mature, low-growth firms may not have sufficient motivation or capability to seek rapid growth, while for higher-growth firms entrepreneurs should be incentivized to invest in innovation and not exit. These conclusions mirror those in recent work by Antolín-López et al. (2015) on effective policies for technology-based firms over the life course. However, more starkly for policymakers, another finding is the importance of time, and the persistence of resource constraints. The study's findings suggest that firms that were constrained by access to skills in the mid-1990s underperformed compared to companies that were not similarly constrained, even fifteen years later. Consequently, the decisions that are made in terms of policy supports have a longer impact than might normally be captured in evaluations. This makes the importance of addressing resource constraints even more prominent.

6.4. Limitations and future research

This research does have some weaknesses. While the data used here captures detailed observations in 1997 and 2003, the data do not capture other subsequent factors that might have contributed to firms' eventual performance. The dataset includes firms that were on average five years old at time of observation, meaning that while the sample selection was random at the time, there was an element of self-selection in terms of firms that had survived to this point. Also, the measure of skills is based on the founder's perception, which suits the specific research question but is not an objective measure. Further, there are a number of other factors not captured here that might impact on performance, including macro-environmental shocks, competition and changes in regulation.

There are a number of areas for future research that naturally come out of the study. While this study focuses on complementary skills, there are opportunities for use of multilevel human capital frameworks to explore the role of human capital for innovation and firm performance. The measures used here only captured the ability of firms to access these skills, facilitating the suggest they might be a precondition for growth but not identifying the magnitude of impact. Consequently more fine-grained measures of skills based on counts of employees or qualifications could clarify whether the effect identified here is simply a precondition, or whether the magnitude or quality of skills used then plays a different effect on firm performance. One final area for further exploration would be the use of fuzzy-set analysis to identify ideal configurations of skills associated with high levels of performance. In this way this study points to a number of interesting frontiers for exploring the factors contributing to firm performance across the life

course.

7. Conclusion

This study investigates the impact of access to non-founder human capital on firms' long-run growth and survival. While there has been extensive research on the impact of founders' human capital on firm performance, there has been considerably less research on the impact of non-founder skills and resources on firm performance. The paper proposes a framework for considering the relationship between growth and survival, hypothesizing a link between access to skills and entrepreneurs' threshold to exit (Gimeno et al., 1997; DeTienne et al., 2008). Results from analysis of 245 UK new technology-based firms over nearly twenty years show that firms that lack access to managerial skills early in the life course lowers entrepreneurs' expectations of growth, while lack of access to specialized skills later in the life course is associated with the decision to exit despite previous high growth.

There are a number of practical and theoretical implications of this study, as discussed in the previous section. In particular one of the most important contributions is presenting a counterpoint to the dominant 'upper echelon' perspective of human capital (Hambrick and Mason, 1984) by emphasizing workforce skills as a prerequisite for long-run growth and survival, regardless of the human capital of the founder. One implication of this is that the long-running emphasis on founders and senior management teams in entrepreneurship and innovation management research needs to be counterbalanced by an understanding from both managers and policymakers of the vital importance of workforce human capital as a contributor to long-run firm growth and survival. Consequently this paper points to the need for further research to explore the contribution of workforce human capital to firm performance.

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