Small Bus Econ
DOI 10.1007/s11187-017-9858-6

High-tech start-up firm survival originating from a combined use of internal resources

Chun Yang · Bart Bossink · Peter Peverelli

Accepted: 29 March 2017

Abstract Although various streams in the existing literature on the resource-based view (RBV) of the firm argue that firm survival and performance can benefit from a combined use of internal resources, relatively limited empirical evidence is provided that supports this argument. To fill this gap in the literature, in this article, we focus on how combinations of internal resources affect the survival chance of technology-based start-ups by using a unique dataset from a high-tech park in Beijing, China. Empirical results show that firms' interconnected internal resources exert a significant influence on these firms' survival chance. Our findings imply that the survival of new technology-based start-ups benefits from the synergetic effect of combining resources. In detail, the data support the hypothesis that the combined use of R&D resources, internal financial resources, and scientifically skilled employees, as posited by the RBV, has an amplifying effect on the chances to survive of high-tech start-ups.

Keywords Resource-based view of the firm · Firm survival · Technological start-ups · China

JEL classifications C41 · L1 · L26 · O32

1 Introduction

Internal resources matter for the development of all types of firms, low-tech as well as high-tech (Barney 1991). Most studies on firm performance and competitive advantage report a positive effect of internal resources on firm survival (e.g., Cefis and Marsili 2005; Esteve-Perez and Manez-Castillejo 2008). During market selection, firms with inadequate resources will be crowded out, whereas the market is occupied by those with unique resources or assets (e.g., Barney and Arikan 2001; Grant 1991; Silverman 1999). As a result, the survival probabilities increase with the resources a firm has in stock (Dutta et al. 1999). Empirically, extant work generally examines and confirms the direct effects of internal resources on firm survival (Boyer and Blazy 2014; Esteve-Perez and Manez-Castillejo 2008; Geroski et al. 2010; Mata and Portugal 2002; Ugur et al. 2016). A question that remains open for further research is how the use of various combinations of internal resources affects firm survival. From the background of this question, in this study, we argue that interconnected internal resources determine firm survival in general and, more

C. Yang (✉) · B. Bossink
Faculty of Sciences, Section of Science, Business & Innovation, Vrije Universiteit Amsterdam, 1081 HV Amsterdam, Netherlands
e-mail: yangchun09@gmail.com

B. Bossink
e-mail: b.a.g.bossink@vu.nl

C. Yang
Institute of Science, Technology and Society, School of Social Sciences, Tsinghua University, Beijing 100084, People's Republic of China

P. Peverelli
Amsterdam Business Research Institute, Vrije Universiteit Amsterdam, 1081 HV Amsterdam, Netherlands
e-mail: p.j.peverelli@vu.nl

Published online: 19 April 2017

specifically, determine firm survival of Chinese high-tech start-up firms.

To this end, we examine the relationship between internal resources and firm survival while using the framework of the resource-based view (RBV) of the firm, which explains firm performance through internal capabilities (Barney 1991; Wernerfelt 1984). We contend that previous studies investigate the survival chances of firms through two distinguished lenses: an external and an internal perspective. The former, which focuses on the determinants of survival that arise from the heterogeneity of industries and market factors (e.g., Audretsch 1995; Fichman and Levinthal 1991; Geroski 1995; Hannah 1998), has been mostly explored. At the internal level, most peer-reviewed literature has ascribed the variation of performance to firm characteristics (e.g., age, size, ownership, etc.) (e.g., Audretsch and Mahmood 1994; Taymaz and Özler 2007). Other studies that concentrate on firms' internal resources to explain firm survival find that internal financial and technological resources, such as R&D capability and employees' know-how, influence survival variance (e.g., Esteve-Perez and Manez-Castillejo 2008; Stuart 2000). However, these studies provide conflicting empirical results. For example, both positive and negative effects of human capital on firm survival have been reported (e.g., Geroski et al. 2010; Subramaniam and Youndt 2005). This difference in outcomes can be caused by enhancing or opposing effects of other internal resources. To date, research into the combined effect of various internal resources on high-tech start-up firm survival has not been conducted on a regular scale. It implies that ongoing research is needed to search for answers to the question: How do combinations of internal resources (i.e., R&D resources, internal finance, and scientifically skilled employees) influence the survival of high-tech start-ups? The RBV emphasizes the characteristics of bundles of resources or internal resource systems of firms to explain why performance varies across firms (Agarwal et al. 2004; Barney 1991; Denrell et al. 2003; Hult and Ketchen 2001; Newbert 2007; Peteraf 1993; Teece 1986). This means, in addition to the individual effects of single resources, that resource configurations, in particular their synergetic relationship, contribute to firm performance. Complementary resources can positively contribute to firm performance, and heterogeneity of such combinations across firms can explain discrepancies between the performance of different firms (Dutta et al. 1999; Teece et al. 1997; Tripsas 1997).

The above discussion highlights the importance of considering the interconnectedness of R&D resources, internal finance, and scientifically skilled employees to understand the variation in the chances for firms to survive. To shed new light on this, we seek to contribute to ongoing discussions by analyzing how combinations of internal resources of Chinese high-tech start-ups influence their chances to survive. The empirical setting of our research is the high-tech start-up zone in the Zhongguancun Science Park in Beijing, China (Z-Park) in the period 2006–2011. As the first high-tech development zone of China, Z-Park is more dynamic, innovative, entrepreneurship-oriented, and competitive than other zones in China. Distinct features of Z-Park include a frequent entry and exit of high-tech firms, rapidly changing technologies in these firms, introduction of a relatively large number of new high-tech products, and a large need for a high-skilled workforce. Z-Park provides a rich context for studying how combinations of internal resources affect the survival of high-tech start-ups. Focusing on a single high-tech area in Beijing does not allow us to draw generalized conclusions. However, Z-Park provides a rare opportunity to empirically disclose the effects of combined internal resources on the survival of Chinese high-tech start-ups, and our results can be leading for further studies in this area.

We argue that our findings are consistent with the implications of the RBV. We have found that combined internal resources have a direct positive effect on the survival chances of start-ups. Although our results indicate that there is a significant effect, they do not explain why firms fail, which provides a point of departure for further research. Our study adds to extant literature (Agarwal et al. 2004; Amit and Schoemaker 1993; Black and Boal 1994; Denrell et al. 2003; Dutta et al. 1999; Hult and Ketchen 2001; Lee et al. 2001; Newbert 2007; Tripsas 1997) in two ways. Firstly, by using longitudinal data and focusing on a high-tech area, we aim to deepen the understanding of the effects of combined resources on the survival of high-tech start-ups. Secondly and more practical, as the research results concern the success rate of high-tech start-ups in a unique advanced high-tech zone in the capital city of China, these results can contribute to a further understanding of the development of the Chinese high-tech industry, especially in the current transitional setting. Our results, together with those of He and Yang (2016), Howell (2015) and Zhang and Mohnen (2013), who exclusively focus on the survival of big companies (annual revenue >5 million Yuan) in China, deepen our understanding of resource-based antecedents of the survival of Chinese high-tech firms.

The organization of this article is as follows. Section 2 provides a review of the existing literature and proposes hypotheses to be tested. In Section 3, we elaborate on our dataset, variables, and methodology. The empirical results and robustness tests of our study will be presented in Section 4. Section 5 discusses the results in the context of the literature and ends with the final conclusion of this study.

2 Literature review and hypotheses

Being one of the most influential perspectives in strategic management literature since the 1980s, the RBV theory stresses that internal resources of a firm are the primary determinants and potentially unique sources of a firm's superior competitive advantage (Barney 1991; Wernerfelt 1984). The resource-concept includes all internal assets, organization attributes, knowledge, and capabilities that are controlled by the firm. However, only those resources that are "valuable," "rare," "inimitable," and "non-substitutable" (VRIN) can be viewed as strategically relevant resources, enabling firms to create and sustain a superior performance (Barney 1991). Although such resources contribute to a firm's competitive advantage, they seldom work individually. As RBV theorists argue, the competitive position of a firm can be ascribed to bundles of interconnected resources (Barney 1991). In detail, each resource may help to enhance or improve a firm's competitiveness, but together, they could also have a synergetic value and provide unique opportunities (Black and Boal 1994; Hult and Ketchen 2001). Therefore, it can be argued that individual resources as well as interconnected resources have a positive effect on corporate performance (Black and Boal 1994; Galbreath 2005).

Obviously, the RBV provides a helpful framework to inspect the survival of technological start-ups (Esteve-Perez and Manez-Castillejo 2008; Geroski et al. 2010). Regarding technology-based enterprises, the dominant resources behind growth and performance are of a technological nature (Stuart 2000), such as R&D (e.g., Harrison et al. 1993; Schoenecker and Cooper 1998), employee know-how (e.g., Robins and Wiersema 1995), and internal financial resources (Bruno et al. 1986; Martin and Justis 1993; Ugur et al. 2016). We will start with a review of the literature that studies how these three types of resources, i.e., R&D, scientifically skilled employees, and internal finance, individually and directly affect the survival rate of technological start-ups. Then we investigate the possible contribution of the interdependence between these three types of resources (Black and Boal 1994; Teece 1986; Tripsas 1997).

2.1 Individual effects of internal resources on high-tech start-ups' survival

In the literature, there is a relative broad consensus on the potential contribution of internal resources to firm performance and survival (Esteve-Perez and Manez-Castillejo 2008; Geroski et al. 2010; Hitt et al. 2001; Mata and Portugal 2002; Ugur et al. 2016). More specifically, former research strongly focuses on the mainly positive effects of the individual resource types, i.e., R&D resources (Esteve-Perez and Manez-Castillejo 2008; Ugur et al. 2016), scientifically skilled employees (Geroski et al. 2010; Mata and Portugal 2002), and financial resources (Bates 1990; Cooper et al. 1994).

To survive and be competitive in a fluctuating market, a high-tech firm must fully use its R&D resources to develop its innovation capacity (e.g., Buddelmeyer et al. 2010; Cefis and Marsili 2005). Although firms can appropriate knowledge and technologies from their environment, they need to establish their own R&D department, function, or group to be able to absorb and master the external knowledge and technologies and then form their own "specific assets" (Cohen and Levinthal 1990; Esteve-Perez and Manez-Castillejo 2008; Freeman 1991; Lee et al. 2001). Investment in in-house R&D appears to be a fundamental way for high-tech firms to generate and improve their market position. Compared with firms that do not invest in in-house R&D, R&D intensive firms display a lower exit rate. Several studies have found that the higher the R&D investments of firms, the higher their survival rates are (Cefis and Marsili 2005; Dzhumashev et al. 2016). Particularly, R&D is distinctly crucial for the survival of start-ups in technology-based industries (Esteve-Perez et al. 2004; Esteve-Perez and Manez-Castillejo 2008; Giovannetti et al. 2011). However, a "the-more-the-better" strategy is not suggested. Empirical evidence indicates that the relationship between R&D intensity and firm survival can be described by an inverted U-shaped curve, i.e., the positive influence of R&D on firm survival will turn to negative when too much resources are spent on R&D (Ugur et al. 2016; Zhang and Mohnen 2013).

Having a group of skilled employees can be seen as a key resource for high-tech start-up firms' survival (Hitt et al. 2001; Koch et al. 2013; Rauch et al. 2005; Youndt et al. 1996). A possible explanation for this effect is that the employees' capabilities, skills, and knowledge to create a firm's specific assets are of a tacit nature, which makes these difficult to imitate by competitors (Autor et al. 1998). It is therefore often suggested that technological firms should hire and organize scientifically skilled employees with experience in certain high-tech industries, e.g., scientists and engineers, who can translate innovative ideas into new products and services (Boyer and Blazy 2014; Geroski et al. 2010; Mata and Portugal 2002). It is argued that firms employing more high-skilled experts have a relatively low probability to exit (Geroski et al. 2010; Mata and Portugal 2002). However, other researchers present an opposing argument. Subramaniam and Youndt (2005), for example, found that human capital itself is not beneficial to radical innovation performance, and Shrader and Siegel (2007) and Criaco et al. (2014) attest that a team's industrial experience negatively affect firm performance and the survival of start-ups. Responding to this, Hitt et al. (2001) find a curvilinear relationship. Initially, the influence of scientifically skilled employees on firm performance is negative, but it turns positive at higher levels of human capital (i.e., a U-shaped effect).

Similarly, according to the literature, the availability of financial capital, such as equity, debt, and retained earnings, is one of the most important determinants of start-ups' success (Martin and Justis 1993). In highly innovative industries, access to financial resources would help newborn firms to build capabilities, be exempted from financial constraints, and enhance their chances to survive (e.g., Bates 1990; Coleman et al. 2013; Cooper et al. 1994). Firms generally prioritize internal finance over external finance when they conduct new investment (Myers and Majluf 1984). Accordingly, internal financial resources exhibit a crucial influence on firms' growth and survival (Carpenter and Petersen 2002). Empirical findings have confirmed that internal funds can prolong the duration of firms' survival since these can serve as a buffer to overcome (un)expected losses or financial constraints that may lead to closure (e.g., Bates 1990; Bridges and Guariglia 2008). Holtz-Eakin et al. (1994) also witness that enterprises that have substantial internal finance will be more likely to survive than those that do not.

The potential of the internal resources "R&D resources," "scientifically skilled employees," and "financial resources" to contribute to firm performance and survival has been researched extensively in the past (Bates 1990; Esteve-Perez and Manez-Castillejo 2008; Geroski et al. 2010; Mata and Portugal 2002). Few would refute the crucial role of these resources in determining the survival chances of the technological start-ups. However, a major question that remains is to what extent a combination of these internal resources can explain variances in the survival of high-tech start-ups (Black and Boal 1994; Dutta et al. 1999; Galbreath 2005; Hult and Ketchen 2001).

2.2 Combined use of resources and the survival of high-tech start-ups

Resources or capabilities play a considerable role in a firm's development and survival, but it is argued that they seldom affect a technological firm's performance separately, and need to be considered as combinations, as interconnected internal resources that have an effect on firm survival. In the RBV, a firm can be viewed as a bundle of resources (Grant 1991), and the individual resources would not contribute to a sustainable competitive advantage unless they operate in concert (Grant 2010:127; Peteraf 1993). Thus, internal resources used in combinations are likely to be more valuable than when they are used in isolation (Denrell et al. 2003). By analyzing a sample of RBV-based empirical articles, Newbert (2007) confirmed that, compared with isolated resources, resource combinations seem to have a higher explanatory power of the variances of performance across firms. Hult and Ketchen (2001) found that the effect of market orientation on firm performance is embedded in a web of interrelated resources. By examining the technological and competitive history of the global typesetter industry over 100 years, Tripsas (1997) argues that the combined use of technological capabilities and specialized complementary assets can shelter incumbents from creative destruction and help them to occupy new markets. For firms competing in high-technology industries, Dutta et al. (1999) report a strong effect of the interaction between a firm's marketing and R&D activities on this firm's performance. In other words, the competitive advantage of the firm depends on the complex relationships of resources.

A possible explanation for the positive effect of a combined use of internal resources on firm performance resides in the nature of the interconnections of firm resources. Firstly, the synergy among firms' resources may lead to creating a unique asset, which is expected to strengthen the competitive position of the firm. Hult and Ketchen (2001) found that firms' capabilities, i.e., market orientation, entrepreneurship, innovativeness, and organizational learning, collectively contribute to their positional advantage. This positional advantage has significant positive effects on these firms' performance. Secondly, the interconnectedness of assets makes the process of resource accumulation more unique and inimitable. As Dierickx and Cool (1989) propose, the accumulation of a current asset may depend on the levels of other stocks. For example, to meet new demands, it may be more difficult to develop and sell new products for firms who have rich R&D resources but do not have related marketing capabilities (Dierickx and Cool 1989; see also Dutta et al. 1999). Thirdly, the positive effects of an existing resource can be enhanced by the implementation of a related one. Firms with two related resources will outperform those with only one of them. Using a Spanish dataset, which comprises 210 innovative firms, Belso-Martinez et al. (2013) find that a firm founder's accumulated experience amplifies the effect of organizational resources on firm performance. Therefore, the synergetic effect will arise from the confluence of two or more internal resources. This effect leads to unique assets, increasing the barrier of imitation, or enhancing the positive influence of the related resources. The resources creating such a synergetic effect are widely recognized as complementary resources (Teece 1986). High-tech companies accordingly benefit from innovations while reducing the threat of imitation of their products by competing enterprises. If a firm possesses these complementary resources, the combined value will be higher than the deployment of isolated resources (Amit and Schoemaker 1993), especially for firms that are confronted with radical technological changes (Rothaermel 2001; Tripsas 1997). This synergy means that the effect of a specific internal resource is embedded in the specific internal resource set of the firm (Amit and Schoemaker 1993; Hult and Ketchen 2001). The combinations of resources can therefore also be viewed as the strategically relevant resources of the firm (Hult and Ketchen 2001), and our focus should shift from exploring the effects of individual resources to examining the synergy between internal resources (Galbreath 2005; Hult and Ketchen 2001), or investigating whether and how firm performance is contingent on the portfolios of resources (Black and Boal 1994; Lee et al. 2001). This leads to hypothesis 1.

> *Hypothesis 1 (H1): The survival chances of high-tech start-ups will benefit from the combined use of complementary internal resources.*

Both the mixed results of the effect of R&D on firm survival and the interdependence of resources lead us to consider whether the effect of R&D on survival depends on or is moderated by the presence of another resource. Substantial R&D resources of a high-tech start-up mark the ability and ambition of scientific discovery and science-based technology development. Although investment in R&D is a key determinant for "specific assets" (Cohen and Levinthal 1990; Esteve-Perez and Manez-Castillejo 2008; Freeman 1991; Lee et al. 2001), R&D expenditure itself does not necessarily prolong the survival chances of technological start-ups (Hult and Ketchen 2001; Ugur et al. 2016). High R&D investments are usually associated with a high-risk strategy, especially in technology-based industries. If successful, the R&D activities will introduce competitive products into the market and prolong the survival of firms, but in case of failure, it will lead to a higher exit risk. Additionally, when a firm devotes a further increasing amount of its resources to R&D activities, it will tend to limit its investments in other complementary activities, such as market development, and hence may impair its survival. Accordingly, a negative relationship between excessive investment in R&D (which limits investments in complementary resources) and firm survival can be expected (e.g., Zhang and Mohnen 2013; Ugur et al. 2016). To mitigate the uncertainty of R&D investments, a high-tech firm needs related resources to complement and enhance the function of R&D resources (Dierickx and Cool 1989; Hult and Ketchen 2001). As discussed, the ability to seize opportunities and to commercialize technologies ahead of competitors largely depends on the firm's human capital (Teece 1986). A firm's knowledge, which leads to superior performance, is embodied in individuals or in the organizational routines and processes that guide those individuals (Teece 1998). Empirical evidence has also stressed the determinant role of scientifically skilled employees in the operations of technological start-ups, by means of obtaining and applying new knowledge, developing specific resources, enhancing firms' innovative abilities, and exploiting advanced technologies (Autor et al. 1998; Hitt et al. 2001; Ranft and Lord 2002; Subramaniam and Youndt 2005). Furthermore, employees' scientific skills and expertise also may provide the ability of a quick response to changing market and technology conditions (Cooper et al. 1994; Gimmon and Levie 2010). If a technological firm seeks for success with an ambitious innovation strategy or investment plan, it should recruit and maintain scientifically skilled employees that are capable of dealing with cutting edge technologies, as these employees can efficiently transform scientific and technological knowledge into prospective products and services. The above reasoning demonstrates that *R&D resources* and *scientifically skilled employees* can complement each other and can be seen as "cospecialized" resources (Newbert 2007; Teece 1986; Tripsas 1997). The combined use of these two resources will reduce resource deficiencies and exhibit positive effects on the survival chances of high-tech start-ups (Teece et al. 1997). This leads to hypothesis 1a.

> *Hypothesis 1a (H1a): The combined use of the R&D resources and scientifically skilled employees exerts a positive effect on the survival chances of high-tech start-ups.*

High-tech start-ups expect to obtain a return from the market by introducing new products. However, new high-tech firms are often confronted with difficulties in accumulating internal funds during initial business years (Carpenter and Petersen 2002). Accordingly, generating internal financial resources is important for firm growth. More specifically, internal financial resources are a main driver of developing new products and a critical determinant to secure R&D decisions (Ughetto 2008). Internal funds send the signal that the technology-based firm is able to commercialize new technologies, create its own specific capabilities, build a business reputation, and extend its resources for further development (Lee et al. 2001). Furthermore, the generation of internal funds, in terms of turnover and profit, provides positive feedback and a powerful incentive for subsequent technology development and reinforces future decisions to invest in technological innovation (Vogt 1994; Lee et al. 2001; Carpenter and Petersen 2002). In line with Myers and Majluf's (1984), Pecking Order Theory (POT), which proposes that to support new investments in technological innovation, companies often prefer using their retained earnings to debt and equity to support new investments, this implies that firms prioritize internal finance over external finance when they invest in technology. Accordingly, internal funds provide substantial support for new product development of start-ups. Moreover, funds generated by a firm itself often enable its operations, such as research and development, to be more effective, efficient, and productive (Teece et al. 1997). The enhanced R&D expenses will in turn facilitate a firm's development of technologies and new products and the firm's improvement of performance (Teece et al. 1997; Ughetto 2008). Previous research points in that direction. For example, Mitchell (1992) argues that the joint use of technological resources and marketing capabilities contributes to competitive advantage. On the relationship between complementary resources and innovative survival of firms, Ugur et al. (2016) find that at the same level of R&D, firms with higher profits (indicated by market concentration) will enjoy higher survival duration than those with lower levels of profits. Building on the above, we contend that internal finance and R&D resources may complement each other, i.e., internal finance may amplify the effects of R&D resources on firm development and growth. Based on the above reasoning, we introduce hypothesis 1b.

> *Hypothesis 1b (H1b): The combined use of the R&D resources and internal financial resources exerts a positive effect on the survival chances of high-tech start-ups.*

Empirically, both positive and negative effects of scientifically skilled employees on firm survival have been presented in previous studies (e.g., Geroski et al. 2010; Hitt et al. 2001; Mata and Portugal 2002). To untangle these mixed findings, a contingent view, i.e., the interdependence of resources, would be a helpful and suitable lens. According to the RBV, the function of scientifically skilled employees is embedded in interconnections of firm resources (Amit and Schoemaker 1993; Barney 1991; Grant 1991; Hult and Ketchen 2001). Therefore, the effect of scientifically skilled employees may depend on the presence of another interconnected resource (e.g., internal finance). Firms tend to accumulate internal finance through their own marketing activities and usually prioritize the internal funds over external finance when they invest due to the transaction cost arising from information asymmetry between the high-tech firm and the outside stakeholders providing finance

(Myers 1984; Myers and Majluf 1984). Accordingly, internal funds not only reflect the abilities of firms to successfully develop market-required products themselves but also provide substantial support or investment for recruiting more skilled and experienced employees (i.e., talented scientists and engineers). High-skilled, scientifically trained employees play an essential role in high-tech product innovation and development. In turn, high-tech start-ups should pay them with equivalent value. The higher the levels of expertise, knowledge, and skills the employees are perceived to have, the higher the salary and benefits that they will expect in return. The costs of high-tech start-ups will increase as the need for scientifically skilled employees is increasing. Therefore, a survival crisis would emerge if firms' earnings cannot offset such costly investments in human capital (Hitt et al. 2001; Schwab 1993). Substantial internal finance would help to cover this cost and risk and support product-developing strategies of high-tech start-ups. In addition, the up-to-date knowledge and skills the newly hired will bring, in turn, enhance the start-ups' abilities for product development and marketing and thus increase the firms' performance. Empirically, Belso-Martinez et al. (2013) confirm that the combination of highly skilled human capital and internal investment contributes significantly to firms' performance. Hiring skilled scientists and engineers would enhance the positive effect of financial resources on firms' development and growth. This results in hypothesis 1c.

> *Hypothesis 1c (H1c): The combined use of scientifically skilled employees and the internal financial resources exerts a positive effect on high-tech start-ups' survival chances.*

We have argued that the bilateral interconnections between R&D resources, scientifically skilled employees, and internal financial resources will positively influence the survival rates of high-tech start-ups. Following from the above, the R&D resources, scientifically skilled employees, and internal financial resources may also be trilaterally complementary for firms in technology-based industries. As key resources for high-tech start-ups, R&D resources play an important role in building a stock of knowledge (Hall 1987). Scientifically skilled employees not only translate prospective ideas into new products and services but also introduce new knowledge and market opportunities. Internal financial resources can cover risks of uncertain innovation plans and support the potential of these plans to generate future turnover and profits (which can be used to further invest in technological innovation). In the RBV, high-tech start-ups can be viewed as entities that consist of bundles of resources (Barney 1991; Grant 1991), in which R&D resources, scientifically skilled employees, and internal financial resources are key components. Their interactions would contribute to the development of specific assets and a unique competitive advantage (Amit and Schoemaker 1993; Tripsas 1997). Logically, based on the relationships that are hypothesized in the above (H1a, b and c), we further expect that the three mentioned resources complement each other and together will stimulate start-ups' survival chances, leading to hypothesis 1d.

> *Hypothesis 1d (H1d): The combined use of R&D resources, scientifically skilled employees, and internal financial resources exerts a positive effect on the survival chances of high-tech start-ups.*

3 Data, variables, and methods

3.1 Empirical setting/data

After 30 years of rapid development, economic growth in China has slowed down since the force of the traditionally export-oriented, low-cost, and low-tech manufacturing-based economic model is weakening. As the world's second-biggest economy, China is opting for a transition towards a more market-dominated, innovation-oriented, and technology-initiated economy (Vinig and Bossink 2015). To achieve this end, the Chinese central government has issued and implemented a series of policies targeting to support a sound environment for incubating technological renewal and improvement for entrepreneurship and innovation in small- and medium-sized enterprises (SMEs), e.g., the *Massive Entrepreneurship and Innovation Policy* in 2015. The SMEs in transitional China can be characterized by several traits. Firstly, the number of SMEs in China is increasing. In 2013, the number of SMEs in China grew to about 12 million, which accounted for 77% of all firms. In Beijing, one of the most innovative areas in China, 85% of its firms can be classified as SME, and approximately one third of these SMEs can be characterized as technology driven and R&D

induced. Secondly, the Chinese high-tech start-ups among Chinese SMEs are often not dependent on external venture capital, debt, and equity. Internal finance (e.g., owner's capital) is usually these firms first choice (Tan et al. 2013). Thirdly, at various levels of the Chinese government, incentives are provided to support entrepreneurship and innovation in SMEs. For example, Premier Li Keqiang proposed a *Twin Engines Strategy* in 2015 (*Report on the Work of the Government 2015*), and in this strategy, *Entrepreneurship and Innovation* is marked as a crucial engine. By implementing these policies, the central government intends to motivate Chinese SMEs to learn from opportunities and mitigate the uncertainties of institutions and markets, which arise from the gradual economic reform (He and Yang 2016). Under the support of local and central policies, a conductive environment of entrepreneurship is envisioned to emerge, in which establishment and growth of SMEs are fostered. Clearly, SMEs, especially high-tech SMEs, are seen as crucial in driving China's economic transition. The empirical research of this article is situated in this context.

In China, there is a growing need to understand the mechanisms that drive the development and success of high-tech SMEs. Two important questions that originate here are: What are the survival patterns of Chinese high-tech SMEs? Which combinations of resources influence these patterns, particularly in a transitional economy like China? Answering these questions will be beneficial to international scholars, as well as Chinese managers and policy makers. To scholars, it provides an insight in the effects of combined resources on high-tech SMEs survival in China and can stimulate sort-like research in other countries. To managers and policy makers in China, this study can provide insights into the dynamics and effects of investing in combinations of resources in Chinese high-tech SMEs, which can function as an input for management and policy decisions.

The data that is used in this article are derived from the annual statistical information database in which the high-tech firms of the Zhongguancun Science Park (Z-Park) in Beijing are stored. Some unique characteristics of this dataset make it particularly suitable for this study. Firstly, the dataset comprises the entire population of technological firms of Z-Park, which is useful for avoiding sampling bias. Since the mid-1990s, high-tech firms are required to report annual information on revenues, employees, profitability, and R&D activities to the management committee of Z-park, resulting in a 100% response rate. Secondly, the information in the dataset is updated annually, which allows us to identify patterns in time. Each firm is identified by a particular number, by which we can trace the updated information. Consequently, all measures of the data are of a longitudinal nature. Thirdly, records on firms' internal resources in the database help us to untangle the relationship between the internal resource combinations (i.e., combinations of R&D resources, scientifically skilled employees, and internal finance) and firm survival. In order to control for the effects of firms' mortality in the cohort, we work with the complete cohort of 2595 firms, which were established in 2006 and followed up until 2011. In total, 1464 of these firms have exited by 2011, resulting in 11,516 firm-year observations (see Table 1).

3.2 Variables

Dependent variable The dependent variable, *firm survival*, is a dummy indicator, which takes value 0 if the firm is active during the observation period, and 1 otherwise. The time of exit is the year when a firm discontinued to report. To avoid a false identification of an exit firm, it is required that the firm that is identified as "exit" should be unrecorded in our dataset for at least two consecutive years (Geroski et al. 2010). Unexpected issues like a firm not reporting its data on time, or information being omitted when the file was being coded, can lead to absence of a firm. Thus, the data of 2012 is used for checking the presence of the firm in 2011.

Independent variables The *R&D resources* variable is defined as R&D investment. R&D investment is not only a unique resource of a firm but also an indicator of building a stock of knowledge (Harrison et al. 1993;

Table 1 Summary statistics for exit rates by year

Year	Observations at beginning of the year	Number of exit firms	Exit percentage (%)	Cumulative exit rate (%)
2006	2595	176	6.78	6.78
2007	2419	315	12.14	18.92
2008	2104	416	16.03	34.95
2009	1688	254	9.79	44.74
2010	1434	158	6.09	50.83
2011	1276	145	5.59	56.42
Total	11,516	1464	56.42	

Hall 1987). Most of previous research measures R&D resources by the ratio of R&D expenses to sales (e.g., Audretsch and Mahmood 1994; Dzhumashev et al. 2016). We measure the variable as the amount of annual total R&D investment. The rationale is that many newly established firms with R&D investments have no or little revenue. The variable of *scientifically skilled employees* is indicated by the number of employed scientists and engineers. Geroski et al. (2010) use the share of college graduates as a proxy for human capital and find that these scientifically skilled employees contribute to the survival chances of firms. In terms of technology-based start-ups, previous studies have empirically confirmed that high levels of education and technological skills are associated with higher survival rates (Marvel and Lumpkin 2007). Based on previous studies, scientists and academically trained engineers in high-tech firms represent the scientifically skilled employees variable in our study. The *internal financial resources* variable is defined as the profitability of a start-up (Bridges and Guariglia 2008; Guariglia 2008). This variable takes value 1 if a firm generates profit from the market, and 0 otherwise. We then define the *combined use of internal resources* as a dummy variable that takes value 1 if a firm possesses two or more of the mentioned internal resources at the same time, and 0 if otherwise. To explore the combined effects of internal resources in detail, we construct the *resource combinations* by generating interaction terms among *R&D resources*, *internal financial resources*, and *scientifically skilled employees*, that is, the *internal financial resources* × *scientifically skilled employees*, *R&D resources* × *internal financial resources*, *R&D resources* × *scientifically skilled employees*, and the *R&D resources* × *scientifically skilled employees* × *internal financial resources*.

Control variables To obtain unbiased estimates, we control for the effects arising from firm characteristics (i.e., *size*, *age*, *ownership*, and *support for innovation activities*), industry-level factors (i.e., *number of firms* in the industry, *industry revenue growth*, and *technology areas*), and economic environment (i.e., *location*).

As numerous previous studies confirm, the firm's size does matter for firms' subsequent performance and survival (Geroski et al. 2010; Mata and Portugal 2002; Schoenecker and Cooper 1998). We define firm *size* as the annual number of a firm's employees and include the *squared size* to control the non-linear impact of the size on a firm's exit rate (Cefis and Marsili 2011; Geroski et al. 2010). While aging, the high-tech start-ups will accumulate and update their knowledge on innovation, marketing, and products, which will have a significant influence on a firm's exit rate (Giovannetti et al. 2011; Hannah 1998). Therefore, we control for the direct and non-linear effects of time on firm survival by including the firm *age* and *squared age* (Evans 1987). The *ownership*, which is defined as the people who provide financial support and control the new company, also plays a crucial role in firms' behavior, such as strategies, market activities, and performance (Mata and Portugal 2002; Taymaz and Özler 2007). We control for the effects of ownership by considering six types of firms, i.e., *state-owned*, *Hongkong-Taiwan-Macao*, *foreign*, *Sino-foreign joint*, *private*, and *joint-equity* ventures in our model. Each firm receives value 1, if it belongs to a category of ownership, and 0 otherwise; the *state-owned enterprise* is our reference group. *Services for innovation activities*, which is defined as the support services for the R&D activities in the firm, is a unique indicator in the Z-Park dataset. The dataset recorded information about the spending for services that support a firm's innovation activities, such as patent applications, technology searching, technology management, and information collection. In addition, we also include the *squared R&D resources* and *squared scientifically skilled employees* into our model to control the potential non-linear effects (Hitt et al. 2001; Ugur et al. 2016).

For the effects arising from industry (Audretsch 1995; Mata and Portugal 2002), we control for the linear and quadratic influence of competitive density by considering the number of firms, which is measured as the number of annual active firms in the industry, and the squared number of firms (e.g., Franco et al. 2009). To control for the influence of industry change and environmental turbulence on technological firm survival, we add *industry revenue growth* as the indicator of a changing industry environment into the model. The *industry revenue growth* is represented by the growth rate of the total revenue of the industry (e.g., Franco et al. 2009). Finally, we also control for the effects from several technology areas (Giovannetti et al. 2011). According to the technology classification system of the Z-Park, we classified firms into seven technology areas, as follows: *electronic and information technology*, *advanced manufacturing equipment*, *environmental and sustainable technology*, *biological engineering and biomedical technology*, *new material technology*, *new* *energy technology*, and *others*. Each firm is assigned a code of 1 if it is in these areas, and 0 otherwise. In our model, we set the *electronic and information technology* as the reference group.

Established in 1988, Z-Park is regarded as the first and most competitive high-tech park in China and is often referred to as the Silicon Valley of China. It is composed of 16 sub-parks. Among these sub-parks, the Haidian Park, which is located in the most innovative area of China—Beijing's Haidian District—is viewed as the core area and knowledge center of Z-Park. The Haidian Park is abundant in innovation resources, such as famous universities and research institutes (e.g., Tsinghua university, Peking university, and the Chinese Academy of Science), research headquarters of several multinational high-tech firms (e.g., Microsoft, Google, Intel, and Samsung), and a large number of venture capital investors. In contrast, the other 15 sub-parks that are scattered all over Beijing are further away from these resources. It is easier to gain access to technological spillovers and high-quality employees in Haidian. To control for the effects of the distance from innovation resources (Fotopoulos and Louri 2000; Guo et al. 2016), we define the *location* as a dummy variable that sets value 1 if a firm is located in Haidian, and 0 if otherwise.

To avoid the effects of the value magnitude, we apply logarithm transformation of variables. In addition, to alleviate the collinearity problems in our models, we center all continuous variables by subtracting their means before modeling (Aiken and West 1991). The results of the variance inflation factor (VIF) test show that all VIF values of variables are below 5.0 (see Table 2), which indicates that the multicollinearity is acceptable in our models. The description statistics, correlations, and VIFs of our variables are presented in Tables 2 and 3.

3.3 Methodology

We use the Complementary Log-Log Model (*cloglog*) to examine the effects of the internal resources upon high-tech start-ups' mortality rates. Our data was only updated yearly; we use firm-year as a unit of observation. We thus can only figure out whether a firm is active during the survey year, whereas the exact date of exit cannot be captured. We focus on discrete-time survival data. In terms of such yearly measured data, the discrete survival model, in particular, the *cloglog*—known as the discrete version of the

Table 2 Description statistics, correlations, and multicollinearity test

Variables	Mean	S.D.	Min.	Max.	1	2	3	4	5	6	7	8	9	10	11	12	VIF
1. R&D resources	906.7	9542	0	585,867													1.47
2. Scientifically skilled employees	9.43	56.25	0	2933	.53*	1											2.02
3. Internal finance	.379	.485	0	1	.07*	.09*	1										1.08
4. Size	27.93	115.0	1	3472	.43*	.62*	.12*	1									1.79
5. Age	3.075	1.658	1	6	.06*	.06*	.22*	.09*	1								1.26
6. Ownership	4.967	1.208	1	6	−.06*	−.07*	.1*	−.08*	.00	1							1.03
7. Location	0.735	0.441	0	1	.003	.004	−.03*	−.05*	−.05*	−.05*	1						1.03
8. Support for innovation	906.2	13,867	0	994,159	.09*	.39*	.04*	.4*	.03*	−.02*	−.01	1					1.28
9. Technological areas	2.174	1.914	1	7	.02*	.01	.02*	.02	.003	.08*	−.09*	.02	1				3.85
10. Industry growth rate	0.204	0.141	0.04	0.904	.003	−.01	−.01	−.02	−.27*	.03*	−.04*	−.01	.49*	1			1.47
11. Number of firms in the industry	7027	4291	520	11,048	−.02	.004	−.07*	−.01	−.15*	−.09*	.14*	−.01	−.84*	−.41*	1		3.79
12. Exit	.1236	.3292	0	1	−.03*	−.04*	−.14*	−.07*	.05*	−.004	.07*	−.02*	.002	−.02*	.01	1	

N (firm-year observations) = 11,438; dependent variable: exit $^{*}P < .05$

Table 3 The description statistics for combination and survival groups

Variables	Combination = 0		Combination = 1		Exiters		Survivors	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1. R&D resources (log)	.12	.89	4.8[1]	2.85	.82[1]	2.06	2.12[1]	3.06
2. Scientifically skilled employees (log)	.43[1]	.86	2.15[1]	1.10	.76[1]	1.0	1.51[2]	1.31
3. Internal finance	.22	.42	.63	.48	.22	.42	.41	.49
4. Size (log)	1.91	1.11	2.81[1]	1.20	1.39[1]	.91	2.38[1]	1.22
5. Age	3.07	1.74	3.05	1.52	3.23	1.46	3.04	1.68
6. Ownership	4.93	1.20	5.02	1.22	4.96	1.15	4.97	1.22
7. Location	.72	.45	.74	.44	.79	.41	.72	.45
8. Support for innovation (log)	.34	.73	.95[1]	1.00	.18[1]	.56	0.64[1]	.92
9. Technological areas	2.20	1.95	2.14	1.85	2.20	1.97	2.17	1.91
10. Industry growth rate	.20	.14	.21	.14	.20	.16	.21	.14
11. Number of firms in the industry (log)	8.47	1.04	8.48	1.04	8.49	1.04	8.47	1.04
12. Combined using of internal resources					.20	.40	.43	.49
Observations	[1] 6940; Others: 6944		[1] 4498; Others: 4572		[1] 1414; Others: 1464		[1] 10,028; [2] 10,024; Others: 10,052	

proportional hazard model (e.g., Cox model) —is suitable for our analysis (Box-Steffensmeier and Jones 2004:69–79; Tsoukas 2011). The baseline hazard model of *cloglog* is as follows:

$$h(j, X_{ij}) = 1 - \exp\left[-\exp\left(\alpha(j) + X_{ij}\beta_i\right)\right], \quad (1)$$

where $h(j, X_{ij})$ represents the interval hazard rate of a new firm i for the observation period between the beginning and the end of the jth year after the firm's entry. $\alpha(j)$ is the baseline hazard function, X_{ij} represents the covariate vector between time $j-1$ and time j, and β parameters represent the effects of explanatory and control variables of the vector X_{ij} on firms' exit rates.

4 Results

The descriptive statistics and correlations between the variables in our models are presented in Table 2. The variance inflation factors show no severe multicollinearity. Specifically, Table 3 shows a statistical overview of variables for high-tech start-ups with and without a combined use of internal resources and for exit firms and survivors. Table 4 presents the estimated results of the effects of current resources upon the survival chances of high-tech start-ups. *Model 1* includes control variables and examines the isolated effects of current resources on survival events; *Models 2–6* analyze the combined effects of internal resources. Tables 5–8 present the results of robustness checks.

We first scrutinize the individual effects of internal resources on technology-based start-ups' survival. In *Model 1* in Table 4, we can read that all the current internal resources—*R&D resources* ($\beta = -0.372$, $p < 0.001$), *scientifically skilled employees* ($\beta = .732$, $P < 0.001$), and *internal financial resources* ($\beta = -0.449$, $P < 0.001$)—exert significant effects on high-tech start-ups' survival prospects at a 0.1% significance level. The analysis results of our dataset confirm previous findings about the individual effects of internal resources on firm survival (e.g., Cefis and Marsili 2005; Dzhumashev et al. 2016; Esteve-Perez and Manez-Castillejo 2008; Hitt et al. 2001; Holtz-Eakin et al. 1994).

4.1 The combined effects of internal resources

Models 2–6 in Table 4 present the estimates of the combined effects of current internal resources upon new high-tech start-up firms' survival. The high-tech start-ups that use internal resources collectively will have a survival probability much higher than its counterpart ($\beta = -0.794$, $P < 0.001$, Model 2). Hypothesis 1 is clearly corroborated. As illustrated, the combined use of internal resources will increase high-tech start-ups' chances to survive. However, *Model 2* does not provide

Table 4 Discrete-time estimate results of high-tech start-ups exit and internal resources

Variables	Model1	Model2	Model3	Model4	Model5	Model6
Combined using of internal resources (1 Yes and 0 No)		−0.794*** (0.187)				
R&D resources × scientifically skilled employees			−0.042*** (0.013)			−0.030* (0.017)
R&D resources × internal financial resources				−0.007 (0.025)		0.0551 (0.038)
Internal financial resource × scientifically skilled employees					−0.133** (0.055)	−0.187** (0.078)
R&D resources × scientifically skilled employees × internal financial resources						−0.008 (0.022)
R&D resources	−0.372*** (0.027)	−0.219*** (0.046)	−0.352*** (0.027)	−0.370*** (0.028)	−0.364*** (0.027)	−0.359*** (0.030)
Squared R&D resources	0.036*** (0.008)	0.018** (0.009)	0.044*** (0.007)	0.0366*** (0.008)	0.037*** (0.008)	0.041*** (0.007)
Internal financial resources	−0.449*** (0.072)	−0.322*** (0.077)	−0.448*** (0.072)	−0.454*** (0.075)	−0.508*** (0.077)	−0.474*** (0.099)
Scientifically skilled employees	0.732*** (0.035)	0.764*** (0.036)	0.660*** (0.041)	0.732*** (0.035)	0.749*** (0.036)	0.702*** (0.047)
Squared scientifically skilled employees	−0.240*** (0.025)	−0.250*** (0.025)	−0.208*** (0.026)	−0.240*** (0.025)	−0.233*** (0.025)	−0.205*** (0.026)
Size	−0.513*** (0.032)	−0.519*** (0.032)	−0.508*** (0.032)	−0.513*** (0.032)	−0.515*** (0.032)	−0.512*** (0.032)
Squared size	0.114*** (0.017)	0.118*** (0.017)	0.112*** (0.017)	0.115*** (0.017)	0.117*** (0.017)	0.112*** (0.017)
Support for innovation activities	−0.342*** (0.021)	−0.323*** (0.0208)	−0.347*** (0.0205)	−0.343*** (0.0206)	−0.335*** (0.0207)	−0.336*** (0.0210)
Age	0.808*** (0.106)	0.809*** (0.107)	0.809*** (0.106)	0.807*** (0.106)	0.804*** (0.106)	0.810*** (0.106)
Squared age	−1.012*** (0.147)	−1.038*** (0.148)	−1.018*** (0.148)	−1.012*** (0.147)	−1.016*** (0.147)	−1.023*** (0.148)
Ownership						
Hongkong-Taiwan-Macao	−0.342 (0.208)	−0.360* (0.209)	−0.356* (0.209)	−0.344* (0.208)	−0.361* (0.209)	−0.368* (0.209)
Foreigner	−0.102 (0.297)	−0.121 (0.298)	−0.133 (0.299)	−0.102 (0.297)	−0.125 (0.298)	−0.154 (0.299)
Sino-foreign joint venture	−0.025 (0.239)	−0.032 (0.240)	−0.034 (0.240)	−0.026 (0.239)	−0.032 (0.240)	−0.033 (0.240)
Private	−0.254 (0.183)	−0.270 (0.183)	−0.264 (0.183)	−0.254 (0.183)	−0.263 (0.183)	−0.270 (0.183)
Joint-equity	−0.264 (0.186)	−0.279 (0.186)	−0.276 (0.186)	−0.264 (0.186)	−0.269 (0.186)	−0.278 (0.187)
Industry growth rate	−1.374*** (0.260)	−1.425*** (0.262)	−1.380*** (0.260)	−1.373*** (0.260)	−1.379*** (0.260)	−1.396*** (0.261)
Number of firms in the industry	1.329** (0.561)	1.255** (0.562)	1.356** (0.560)	1.328** (0.561)	1.298** (0.561)	1.327** (0.561)
Squared number of firms in the industry	0.085 (0.150)	0.096 (0.150)	0.091 (0.150)	0.085 (0.150)	0.085 (0.150)	0.093 (0.150)
Technological areas						
Advanced equipment manufacturing	2.244*** (0.869)	2.131** (0.871)	2.285*** (0.868)	2.243*** (0.869)	2.199** (0.869)	2.243*** (0.869)

Table 4 (continued)

Variables	Model1	Model2	Model3	Model4	Model5	Model6
Environment and sustainable technology	3.372** (1.688)	3.123* (1.693)	3.437** (1.688)	3.371** (1.688)	3.293* (1.689)	3.349** (1.690)
Biological engineering and biomedical technology	2.621** (1.131)	2.469** (1.134)	2.674** (1.131)	2.619** (1.131)	2.559** (1.131)	2.613** (1.132)
New material technology	2.974** (1.252)	2.801** (1.255)	3.030** (1.252)	2.973** (1.252)	2.910** (1.253)	2.965** (1.253)
New energy technology	3.344** (1.450)	3.155** (1.453)	3.402** (1.449)	3.342** (1.450)	3.274** (1.450)	3.332** (1.450)
The others	3.184** (1.243)	3.017** (1.245)	3.244*** (1.243)	3.181** (1.243)	3.115** (1.243)	3.178** (1.244)
Location	0.413*** (0.071)	0.417*** (0.071)	0.415*** (0.071)	0.414*** (0.071)	0.416*** (0.071)	0.415*** (0.071)
Constant	−2.511*** (0.521)	−1.990*** (0.537)	−2.542*** (0.521)	−2.511*** (0.521)	−2.488*** (0.521)	−2.520*** (0.523)
Average VIF	2.93	3.46	3.01	2.94	2.93	3.41
Observations	11,438	11,438	11,438	11,438	11,438	11,438
Chi-square test statistics	2069.09	2089.11	2078.56	2069.17	2074.99	2084.73
Log likelihood	−3244.2039	−3234.195	−3239.468	−3244.1665	−3241.2553	−3236.3864

Standard errors in parentheses ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

a detailed elaboration. It is necessary to further explore which and how resource combinations influence the survival of high-tech start-ups. Hypothesis 1a posits that the combination of *R&D resources* and *scientifically skilled employees* will exert a positive influence on the survival rate of new high-tech start-ups. As shown in *Model 3*, the interaction term of these two resources presents a significant and negative coefficient ($\beta = -0.042$, $P < 0.001$). This result suggests that a joint input of both resources is associated with a higher survival probability, as *H1a* predicts. Although the estimate of the combination of *R&D resources* and *internal financial resources* presents a negative sign as expected ($\beta = -0.007$, Model 4), the huge P value ($P = 0.785$) illustrates that *H1b* is not supported. Moreover, the interaction between *scientifically skilled employees* and *internal financial resources* exerts a significantly negative impact on firm survival risk ($\beta = -0.133$, $P < 0.05$, Model 5), which supports the hypothesis that the input of this resource combination will increase a new high-tech start-up firms' possibility to survive (*H1c*). To get and interpret the true three-way interaction, we include all the two-way interactions along with the three-way interaction in *Model 6*, as Aiken and West (1991) suggest. The average VIF of *Model 6* is 3.41. The insignificant coefficient of the triple-interaction term in *Model 6* ($\beta = -0.008$, $P > 0.10$) indicates *H1d*, which predicts a positive effect of the combined use of all three internal resources on survival chances, is rejected. Till now, in terms of the proposed combined effects, Hypothesis *1* has been supported; more specifically, *H1a* and *1c* have been fully supported, whereas *H1b* and *H1d* have been rejected.

To capture detailed insights of how the combined use of internal resources impacts high-tech start-ups' survival chances, a further graphic analysis of these interaction effects needs to be presented. Figure 1, which presents the support for Hypothesis 1, shows that firms with the combined use of internal resources have much higher survival rates than those without resource combinations, and the difference between them becomes larger as time passes.

Figures 2 and 3 display the *Average Marginal Effects* (*AME*) of *scientifically skilled employees* on firms' survival risk for firms that are at levels of *R&D resources* (*H1a*) and *internal financial resources* (*H1c*) respectively. The AME here shows how the probability of firm survival risk changes at the given levels of the mentioned resources as one more unit of the *scientifically skilled employees* increases. In each case, we expect a decrease in slope or marginal probability to reveal positive marginal effects on survival probability. As expected, Fig. 2

Table 5 Robustness: checking model stability by including the founding effect of resources

Variables	Model1	Model2	Model3	Model4	Model5	Model6
Combined using of internal resources (1 yes and 0 no)		−0.790*** (0.187)				
R&D resources × scientifically skilled employees			−0.039*** (0.013)			−0.027 (0.017)
R&D resources × internal financial resources				−0.004 (0.025)		0.060 (0.038)
Internal financial resources × scientifically skilled employees					−0.126** (0.055)	−0.188** (0.078)
R&D resources × scientifically skilled employees ×internal financial resources						−0.011 (0.023)
R&D resources	−0.373*** (0.027)	−0.220*** (0.046)	−0.354*** (0.027)	−0.372*** (0.028)	−0.365*** (0.027)	−0.363*** (0.030)
Squared R&D resources	0.036*** (0.008)	0.018* (0.009)	0.044*** (0.007)	0.036*** (0.008)	0.037*** (0.008)	0.041*** (0.008)
Internal financial resources	−0.418*** (0.074)	−0.290*** (0.079)	−0.417*** (0.075)	−0.421*** (0.077)	−0.475*** (0.079)	−0.433*** (0.101)
Scientifically skilled employees	0.714*** (0.035)	0.746*** (0.036)	0.646*** (0.041)	0.714*** (0.035)	0.731*** (0.036)	0.690*** (0.048)
Squared scientifically skilled employees	−0.240*** (0.024)	−0.250*** (0.025)	−0.211*** (0.025)	−0.240*** (0.024)	−0.234*** (0.024)	−0.208*** (0.026)
Internal resources at the founding year						
Internal financial resources	−0.103 (0.064)	−0.105 (0.064)	−0.101 (0.064)	−0.103 (0.064)	−0.10 (0.064)	−0.099 (0.064)
Scientifically skilled employees	0.042** (0.021)	0.042** (0.021)	0.042** (0.021)	0.042** (0.021)	0.042** (0.021)	0.042** (0.021)
R&D resources	0.026** (0.011)	0.025** (0.011)	0.025** (0.011)	0.026** (0.011)	0.025** (0.011)	0.025** (0.011)
Size	−0.518*** (0.032)	−0.523*** (0.032)	−0.512*** (0.032)	−0.518*** (0.032)	−0.519*** (0.032)	−0.516*** (0.032)
Squared size	0.115*** (0.018)	0.119*** (0.017)	0.113*** (0.017)	0.115*** (0.018)	0.118*** (0.017)	0.113*** (0.017)
Support for innovation activities	−0.342*** (0.021)	−0.322*** (0.021)	−0.346*** (0.021)	−0.342*** (0.021)	−0.335*** (0.021)	−0.335*** (0.021)
Age	0.754*** (0.108)	0.755*** (0.109)	0.755*** (0.108)	0.753*** (0.108)	0.751*** (0.108)	0.756*** (0.108)
Squared age	−1.006*** (0.148)	−1.031*** (0.148)	−1.011*** (0.148)	−1.006*** (0.148)	−1.009*** (0.148)	−1.016*** (0.148)
Ownership						
Hongkong-Taiwan-Macao	−0.390* (0.209)	−0.407* (0.210)	−0.405* (0.210)	−0.391* (0.209)	−0.407* (0.209)	−0.415** (0.210)
Foreigner	−0.171 (0.297)	−0.191 (0.298)	−0.204 (0.299)	−0.172 (0.297)	−0.192 (0.298)	−0.224 (0.299)
Sino-foreign joint venture	−0.077 (0.240)	−0.082 (0.240)	−0.086 (0.240)	−0.077 (0.240)	−0.082 (0.240)	−0.083 (0.241)
Private	−0.276 (0.183)	−0.290 (0.184)	−0.288 (0.184)	−0.277 (0.183)	−0.283 (0.184)	−0.291 (0.184)
Joint-equity	−0.306 (0.186)	−0.319* (0.187)	−0.318* (0.187)	−0.306 (0.186)	−0.309* (0.187)	−0.318* (0.187)
Industry growth rate	−1.349*** (0.260)	−1.397*** (0.261)	−1.354*** (0.260)	−1.348*** (0.260)	−1.353*** (0.260)	−1.369*** (0.260)

Table 5 (continued)

Variables	Model1	Model2	Model3	Model4	Model5	Model6
Number of firms in the industry	1.442** (0.562)	1.370** (0.564)	1.469*** (0.562)	1.441** (0.562)	1.416** (0.563)	1.444** (0.563)
Squared number of firms in the industry	0.105 (0.151)	0.115 (0.151)	0.109 (0.151)	0.104 (0.151)	0.104 (0.151)	0.111 (0.151)
Technological areas						
Advanced equipment manufacturing	2.423*** (0.871)	2.311*** (0.873)	2.464*** (0.871)	2.422*** (0.871)	2.386*** (0.872)	2.429*** (0.872)
Environment and sustainable technology	3.657** (1.692)	3.416** (1.696)	3.726** (1.692)	3.657** (1.692)	3.595** (1.692)	3.650** (1.693)
Biological engineering and biomedical technology	2.828** (1.134)	2.678** (1.137)	2.882** (1.134)	2.828** (1.134)	2.777** (1.135)	2.828** (1.135)
New material technology	3.200** (1.255)	3.033** (1.258)	3.258*** (1.255)	3.200** (1.255)	3.148** (1.256)	3.202** (1.256)
New energy technology	3.572** (1.453)	3.389** (1.456)	3.634** (1.453)	3.572** (1.453)	3.517** (1.453)	3.575** (1.454)
The others	3.426*** (1.247)	3.263*** (1.249)	3.487*** (1.247)	3.425*** (1.247)	3.370*** (1.248)	3.431*** (1.248)
Location	0.408*** (0.072)	0.412*** (0.073)	0.409*** (0.073)	0.408*** (0.072)	0.410*** (0.073)	0.410*** (0.073)
Constant	−2.649*** (0.524)	−2.132*** (0.540)	−2.678*** (0.524)	−2.649*** (0.524)	−2.631*** (0.525)	−2.664*** (0.526)
Chi-square test statistics	2081.02	2100.89	2089.39	2081.05	2086.31	2095.44
Log likelihood	−3216.4985	−3206.5649	−3212.3139	−3216.4862	−3213.8534	−3209.2913
Observations	11,392	11,392	11,392	11,392	11,392	11,392

Standard errors in parentheses

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

demonstrates that accumulation of *scientifically skilled employees* would increase the marginal probability of survival at levels of *R&D resources* (one standard deviation below (−1 S.D) and above (+1 S.D) the mean of R&D resources), and the more *R&D* spending the higher the *AME* would be (up to about +2 SD of *scientifically skilled employees*). This is in line with *H1a*. Similarly, Fig. 3 clearly

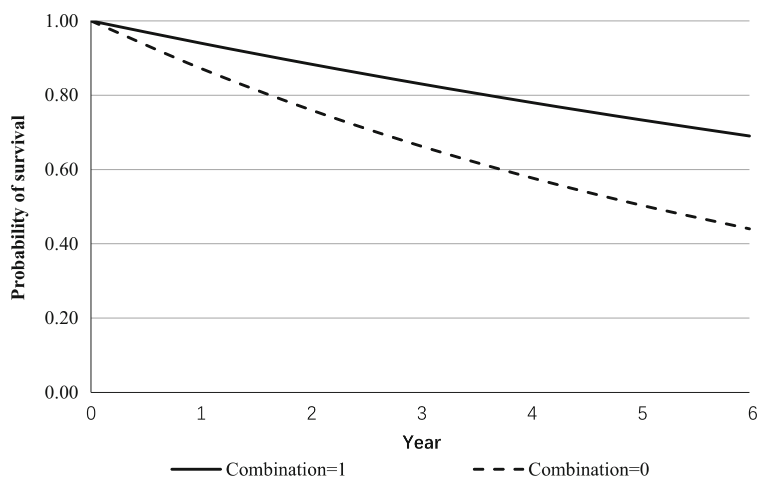

Fig. 1 The survival chance of firms with and without combining internal resources

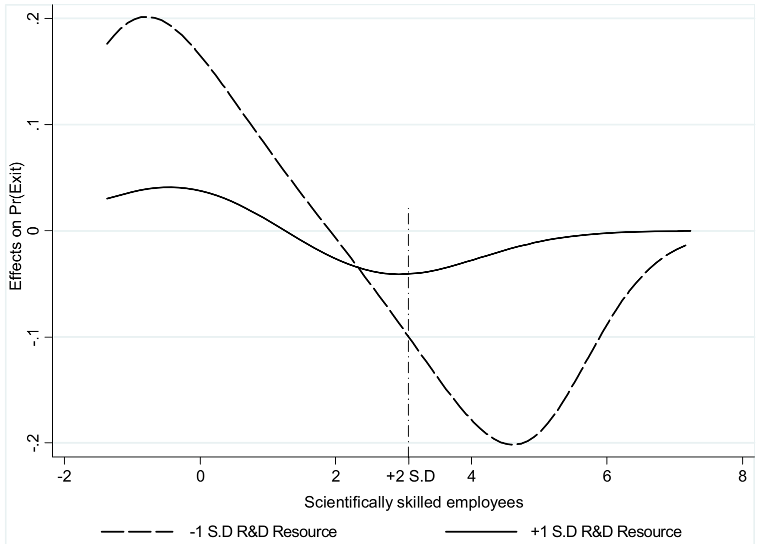

Fig. 2 Average marginal effects of scientifically skilled employees on high-tech start-ups' survival risk at lower and higher level of R&D resources

indicates the prediction of Hypothesis 1c. The decreasing slope of the curve suggests that the portfolio of internal finance and scientifically skilled employees positively impacts the survival probabilities of emerging technological ventures. Specifically, although both Figs. 2 and 3 present a slightly upward shift of the right curve (beyond +2 SD of *scientifically skilled employees*), the marginal probabilities of survival risk are below zero, which indicates that the aforementioned resource combinations still help new high-tech start-ups to prolong their survival durations at higher levels of scientifically skilled employees.

4.2 Robustness tests

We carry out four kinds of tests to check the robustness of our empirical results. Firstly, we add new effects—the effects of founding resources on subsequent survival events—into our given model (Geroski et al. 2010). To achieve this goal, we extend the Eq. 1 to $h(j, X_{ij}) = 1 - \exp[-\exp(\alpha(j) + X_{ij}\beta_i + \log(j)X_{i0}\eta_i)]$. The term $\log(j)X_{i0}\eta_i$ represents the influence of founding resources at time j, X_{i0} is the vector of the mentioned resources (i.e., R&D resources, scientifically skilled employees, and internal financial resources) at the founding year, and η_i denotes the parameters that need

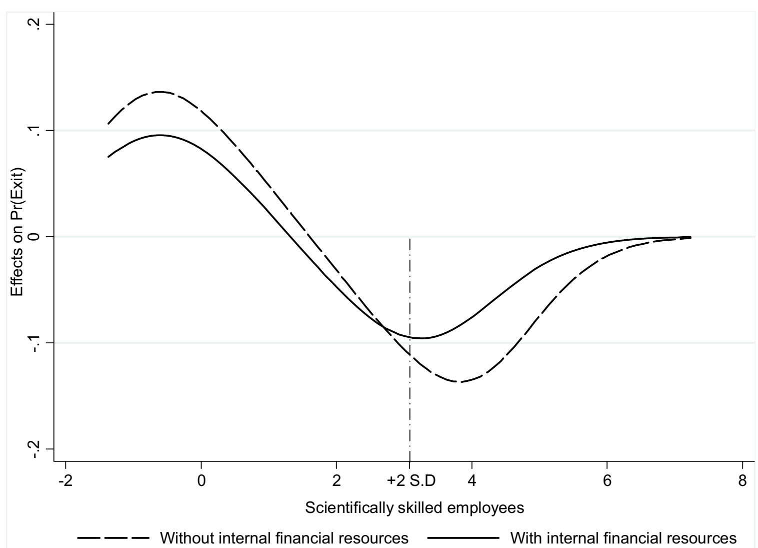

Fig. 3 Average marginal effects of scientifically skilled employees on start-ups' survival risk at levels of with or without internal financial resources

Table 6 Robustness: checking the effects of outliers by excluding the huge firms (more than 100 employees at the founding year)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Combined using of internal resources (1 yes and 0 no)		−0.766*** (0.188)				
R&D resources × scientifically skilled employees			−0.046*** (0.013)			−0.030* (0.017)
R&D resources × internal financial resources				−0.011 (0.026)		0.064* (0.0387)
Internal financial resources × scientifically skilled employees					−0.146*** (0.056)	−0.209*** (0.078)
R&D resources × scientifically skilled employees ×internal financial resources						−0.017 (0.023)
R&D resources	−0.387*** (0.028)	−0.236*** (0.047)	−0.364*** (0.029)	−0.384*** (0.029)	−0.378*** (0.029)	−0.374*** (0.031)
Squared R&D resources	0.039*** (0.008)	0.021** (0.009)	0.047*** (0.008)	0.039*** (0.008)	0.039*** (0.008)	0.044*** (0.008)
Internal financial resources	−0.450*** (0.073)	−0.326*** (0.078)	−0.449*** (0.073)	−0.457*** (0.075)	−0.509*** (0.077)	−0.451*** (0.099)
Scientifically skilled employees	0.763*** (0.037)	0.795*** (0.038)	0.684*** (0.042)	0.763*** (0.037)	0.781*** (0.037)	0.735*** (0.048)
Squared scientifically skilled employees	−0.244*** (0.026)	−0.254*** (0.026)	−0.209*** (0.027)	−0.244*** (0.026)	−0.237*** (0.025)	−0.205*** (0.027)
Size	−0.523*** (0.033)	−0.530*** (0.033)	−0.517*** (0.032)	−0.524*** (0.033)	−0.526*** (0.032)	−0.521*** (0.032)
Squared size	0.122*** (0.018)	0.125*** (0.018)	0.120*** (0.018)	0.123*** (0.018)	0.125*** (0.018)	0.120*** (0.018)
Support for innovation activities	−0.351*** (0.021)	−0.332*** (0.021)	−0.356*** (0.021)	−0.351*** (0.021)	−0.343*** (0.021)	−0.345*** (0.021)
Age	0.805*** (0.106)	0.807*** (0.107)	0.807*** (0.106)	0.804*** (0.106)	0.802*** (0.106)	0.809*** (0.107)
Squared age	−1.023*** (0.148)	−1.047*** (0.149)	−1.029*** (0.148)	−1.022*** (0.148)	−1.026*** (0.148)	−1.033*** (0.149)
Ownership						
Hongkong-Taiwan-Macao	−0.421** (0.211)	−0.442** (0.211)	−0.434** (0.211)	−0.423** (0.211)	−0.442** (0.211)	−0.445** (0.211)
Foreigner	−0.147 (0.298)	−0.168 (0.299)	−0.180 (0.299)	−0.148 (0.298)	−0.174 (0.299)	−0.201 (0.300)
Sino-foreign joint venture	−0.084 (0.241)	−0.094 (0.242)	−0.093 (0.242)	−0.085 (0.241)	−0.092 (0.242)	−0.089 (0.242)
Private	−0.295 (0.183)	−0.314* (0.184)	−0.305* (0.184)	−0.296 (0.183)	−0.306* (0.184)	−0.308* (0.184)
Joint-equity	−0.312* (0.187)	−0.330* (0.187)	−0.323* (0.187)	−0.312* (0.187)	−0.319* (0.187)	−0.321* (0.188)
Industry growth rate	−1.375*** (0.262)	−1.423*** (0.264)	−1.377*** (0.262)	−1.372*** (0.262)	−1.379*** (0.262)	−1.390*** (0.263)
Number of firms in the industry	1.341** (0.565)	1.268** (0.566)	1.377** (0.565)	1.339** (0.565)	1.307** (0.565)	1.350** (0.565)
Squared number of firms in the industry	0.094 (0.151)	0.104 (0.151)	0.103 (0.151)	0.093 (0.151)	0.094 (0.151)	0.107 (0.151)
Technological areas						
Advanced equipment manufacturing	2.257*** (0.875)	2.144** (0.877)	2.310*** (0.875)	2.254*** (0.875)	2.206** (0.875)	2.270*** (0.876)

Table 6 (continued)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Environment and sustainable technology	3.414** (1.700)	3.170* (1.704)	3.490** (1.700)	3.412** (1.700)	3.326* (1.701)	3.400** (1.701)
Biological engineering and biomedical technology	2.632** (1.139)	2.481** (1.142)	2.700** (1.139)	2.629** (1.139)	2.563** (1.140)	2.640** (1.140)
New material technology	2.991** (1.261)	2.820** (1.264)	3.061** (1.261)	2.988** (1.261)	2.919** (1.262)	2.996** (1.262)
New energy technology	3.353** (1.460)	3.167** (1.463)	3.423** (1.460)	3.350** (1.460)	3.274** (1.460)	3.353** (1.461)
The others	3.185** (1.253)	3.020** (1.255)	3.259*** (1.252)	3.181** (1.253)	3.108** (1.253)	3.193** (1.253)
Location	0.432*** (0.072)	0.437*** (0.073)	0.434*** (0.073)	0.433*** (0.072)	0.435*** (0.073)	0.436*** (0.073)
Constant	−2.471*** (0.524)	−1.974*** (0.539)	−2.514*** (0.524)	−2.470*** (0.524)	−2.446*** (0.524)	−2.507*** (0.526)
Chi-square test statistics	2035.66	2054.11	2046.49	2035.84	2042.59	2054.03
Log likelihood	−3181.4995	−3172.2784	−3176.0886	−3181.4133	−3178.0348	−3172.3152
Observations	11,105	11,105	11,105	11,105	11,105	11,105

Standard errors in parentheses $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

to be estimated. Secondly, we check whether the results are unduly influenced by outliers—start-ups with a huge number of employees. We therefore identify start-ups with more than 100 employees at 2006 and then filter them from our dataset (2.7% cases deletion). Thirdly, we examine the relationship between high-tech start-ups' survival and internal resources by an alternative discrete survival method, the *logit model*. All these checks (results are given in Tables 5, 6, and 7 respectively) produce unchanged conclusions to those we have presented in Table 4. Finally, we check unobserved heterogeneity by analyzing a random-effects panel regression. Due to the limitation of the dataset, there may be covariates affecting firm survival that are unmeasured or are not observed. If these factors that correlate to the predicted variable are excluded from the model, we obtain biased statistical inferences. To check this unobserved heterogeneity, we rewrite the Eq. 1 to $h(j, X_{ij}) = 1 - \exp[-\exp(\alpha(j) + X_{ij}\beta_i + \mu_i)]$. μ_i is the random term unrelated with X_{ij} denotes the unobserved heterogeneity, and we assume that μ_i is distributed normally with mean zero (Box-Steffensmeier and Jones 2004: 141–154). By running the model with an *xtcloglog* procedure of the Stata13.0, we find that all results are maintained, and the unobserved heterogeneity in our model is negligible (H_0 : rho = 0 ; $P > 0.05$) (Table 8). Therefore, it can be concluded here that our findings are not driven by unobserved heterogeneity and that all findings are robust.

5 Discussion and conclusion

Our results illustrate that combinations of internal resources of high-tech start-ups affect these firms' survival. The research findings not only reconfirm the direct effects of internal resources on firm survival (e.g., Audretsch and Mahmood 1994; Hitt et al. 2001; Lee et al. 2001; Zhang and Mohnen 2013; Ugur et al. 2016), but also go further; they provide fresh evidence on the effects of combinations of internal resources on the survival chance of high-tech start-ups.

This study is among the first to confirm that synergetic effects arising from the characteristics of the interconnectedness of internal resources significantly prolong the survival time of Chinese high-tech start-ups. In the theoretical framework of the RBV, the influence of internal resources on firm performance is embedded in a web of interconnected resources (e.g., Denrell et al. 2003; Galbreath 2005; Hitt et al. 2001; Subramaniam and Youndt 2005). The results in this study provide empirical evidence that supports this assumed *combined effect*: Resource combinations are also strategically relevant resources and positively affect the survival of high-tech

Table 7 Robustness: logit estimation as the alternative method

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Combined using of internal resources (1 yes and 0 no)		−0.928*** (0.208)				
R&D resources × scientifically skilled employees			−0.061*** (0.014)			−0.054*** (0.019)
R&D resources × internal financial resources				−0.002 (0.027)		0.065 (0.041)
Internal financial resources × scientifically skilled employees					−0.141** (0.060)	−0.215** (0.084)
R&D resources × scientifically skilled employees ×internal financial resources						−4.99e-05 (0.023)
R&D resources	−0.416*** (0.032)	−0.243*** (0.051)	−0.392*** (0.032)	−0.416*** (0.033)	−0.408*** (0.032)	−0.398*** (0.034)
Squared R&D resources	0.038*** (0.008)	0.017* (0.010)	0.049*** (0.008)	0.038*** (0.008)	0.038*** (0.008)	0.045*** (0.008)
Internal financial resources	−0.507*** (0.080)	−0.366*** (0.085)	−0.508*** (0.080)	−0.508*** (0.081)	−0.566*** (0.084)	−0.562*** (0.108)
Scientifically skilled employees	0.845*** (0.049)	0.891*** (0.050)	0.761*** (0.051)	0.845*** (0.049)	0.868*** (0.050)	0.808*** (0.057)
Squared scientifically skilled employees	−0.252*** (0.030)	−0.264*** (0.030)	−0.194*** (0.032)	−0.252*** (0.030)	−0.243*** (0.030)	−0.184*** (0.033)
Size	−0.591*** (0.035)	−0.599*** (0.035)	−0.592*** (0.036)	−0.591*** (0.035)	−0.594*** (0.035)	−0.596*** (0.036)
Squared size	0.137*** (0.019)	0.141*** (0.019)	0.129*** (0.019)	0.137*** (0.019)	0.139*** (0.019)	0.129*** (0.019)
Support for innovation activities	−0.377*** (0.024)	−0.356*** (0.024)	−0.391*** (0.024)	−0.377*** (0.024)	−0.370*** (0.024)	−0.379*** (0.025)
Age	0.994*** (0.125)	0.995*** (0.125)	1.001*** (0.125)	0.994*** (0.125)	0.989*** (0.125)	1.002*** (0.125)
Squared age	−1.131*** (0.174)	−1.170*** (0.175)	−1.141*** (0.174)	−1.131*** (0.174)	−1.136*** (0.174)	−1.151*** (0.175)
Ownership						
Hongkong-Taiwan-Macao	−0.340 (0.247)	−0.354 (0.247)	−0.348 (0.247)	−0.340 (0.247)	−0.359 (0.247)	−0.355 (0.247)
Foreigner	−0.132 (0.350)	−0.162 (0.350)	−0.157 (0.353)	−0.132 (0.350)	−0.157 (0.350)	−0.180 (0.353)
Sino-foreign joint venture	0.015 (0.285)	0.010 (0.285)	0.002 (0.285)	0.015 (0.285)	0.010 (0.285)	0.006 (0.285)
Private	−0.308 (0.217)	−0.322 (0.217)	−0.321 (0.218)	−0.308 (0.217)	−0.313 (0.217)	−0.324 (0.218)
Joint-equity	−0.322 (0.221)	−0.335 (0.221)	−0.337 (0.221)	−0.322 (0.221)	−0.324 (0.221)	−0.337 (0.221)
Industry growth rate	−1.689*** (0.299)	−1.725*** (0.300)	−1.684*** (0.300)	−1.689*** (0.299)	−1.686*** (0.299)	−1.693*** (0.300)
Number of firms in the industry	1.580** (0.664)	1.499** (0.665)	1.618** (0.664)	1.580** (0.664)	1.547** (0.664)	1.581** (0.664)
Squared number of firms in the industry	0.119 (0.175)	0.128 (0.176)	0.115 (0.175)	0.119 (0.175)	0.118 (0.175)	0.116 (0.175)
Technological areas						
Advanced equipment manufacturing	2.682*** (1.027)	2.553** (1.029)	2.739*** (1.027)	2.682*** (1.027)	2.633** (1.027)	2.684*** (1.028)

Table 7 (continued)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Environment and sustainable technology	3.940** (1.987)	3.678* (1.991)	4.072** (1.987)	3.940** (1.987)	3.857* (1.986)	3.965** (1.988)
Biological engineering and biomedical technology	3.097** (1.335)	2.927** (1.338)	3.183** (1.335)	3.096** (1.335)	3.028** (1.335)	3.104** (1.336)
New material technology	3.519** (1.478)	3.330** (1.481)	3.615** (1.478)	3.519** (1.478)	3.448** (1.478)	3.532** (1.479)
New energy technology	3.952** (1.709)	3.746** (1.712)	4.056** (1.709)	3.951** (1.709)	3.875** (1.708)	3.969** (1.710)
The others	3.787*** (1.470)	3.602** (1.472)	3.882*** (1.469)	3.786** (1.470)	3.711** (1.469)	3.800*** (1.470)
Location	0.480*** (0.081)	0.483*** (0.081)	0.484*** (0.081)	0.480*** (0.081)	0.481*** (0.081)	0.483*** (0.081)
Constant	−2.549*** (0.616)	−1.951*** (0.632)	−2.599*** (0.617)	−2.549*** (0.616)	−2.526*** (0.616)	−2.565*** (0.617)
Chi-square test statistics	2031.87	2053.34	2047.38	2031.87	2037.49	2054.52
Log likelihood	−3262.8162	−3252.0791	−3255.0577	−3262.8144	−3260.0066	−3251.4913
Observations	11,438	11,438	11,438	11,438	11,438	11,438

Standard errors in parentheses ***$p < 0.01$; **$p < 0.05$; * $p < 0.1$

start-ups. In terms of these combined effects, we find that the complementarity between *R&D resources* and *scientifically skilled employees* and between the *internal financial resources* and *scientifically skilled employees* helps high-tech start-ups to overcome constraints, such as liability of newness (Freeman et al. 1983) and liability of adolescence (Fichman and Levinthal 1991), and improve their chances to survive. Obviously, the attraction of scientifically skilled employees will amplify the positive effects of the R&D resources and the positive effects of the internal financial resources. In addition to the amplifying effects, R&D resources and scientifically skilled employees combined will give rise to a unique capability and reinforce the barrier of imitation from competitors and so does the resource bundle of scientifically skilled employees and internal financial resources. The findings not only respond to, but also confirm the arguments of Galbreath (2005) and Hult and Ketchen (2001), who state that interconnections of internal resources will influence firm performance. Therefore, to obtain a full and deepened understanding of the effects of internal resources upon firm survival, the role of individual resources as well as of the synergy between them have to be considered (Hitt et al. 2001; Subramaniam and Youndt 2005).

Our results reveal another interesting phenomenon. The complementary effects of scientifically skilled employees on R&D resources and internal financial resources may decrease. As shown in Fig. 2, as the scientifically skilled employees increase beyond +2 SD, the amplifying effect of scientifically skilled employees is higher for firms that have lower R&D resources than those who have higher R&D resources. The same applies to Fig. 3. A possible explanation for this is that the effect of R&D resources or internal financial resources may be suppressed by scientifically skilled employees when the accumulation of scientifically skilled employees exceeds to an optimal level (Black and Boal 1994). Under certain conditions, the presence of scientifically skilled employees will diminish the influence of R&D resources or internal financial resources. Thus, when the accumulation of scientifically skilled employees exceeds an optimal level, the interaction of scientifically skilled employees and R&D resources or the interaction of scientifically skilled employees and internal financial resources may lead to diminishing marginal survival rates of high-tech start-ups. Also, the non-linear nature of the interaction between R&D resources and scientifically skilled employees will make the pattern of combined effects curvilinear. These results demonstrate that the synergetic effects will arise from a proper combination of the internal resources.

Table 8 Robustness: checking for the unobserved heterogeneity of the discrete time duration model

Variables	Mode1	Model2	Model3	Model4	Model5	Model6
Combined using of internal resources (1 yes and 0 no)		−0.814*** (0.191)				
R&D resources × scientifically skilled employees			−0.042*** (0.013)			−0.031* (0.017)
R&D resources × internal financial resources				−0.007 (0.025)		0.057 (0.038)
Internal financial resources × scientifically skilled employees					−0.134** (0.056)	−0.192** (0.079)
R&D resources × scientifically skilled employees ×internal financial resources						−0.007 (0.023)
R&D resources	−0.373*** (0.028)	−0.218*** (0.046)	−0.353*** (0.028)	−0.371*** (0.028)	−0.365*** (0.028)	−0.361*** (0.030)
Squared R&D resources	0.036*** (0.008)	0.017* (0.009)	0.044*** (0.007)	0.037*** (0.008)	0.037*** (0.008)	0.041*** (0.008)
Internal financial resources	−0.452*** (0.073)	−0.324*** (0.078)	−0.453*** (0.074)	−0.456*** (0.075)	−0.512*** (0.078)	−0.483*** (0.101)
Scientifically skilled employees	0.735*** (0.037)	0.774*** (0.040)	0.664*** (0.042)	0.735*** (0.037)	0.754*** (0.038)	0.709*** (0.049)
Squared scientifically skilled employees	−0.241*** (0.025)	−0.252*** (0.026)	−0.208*** (0.026)	−0.240*** (0.025)	−0.234*** (0.025)	−0.205*** (0.026)
Size	−0.520*** (0.038)	−0.535*** (0.038)	−0.518*** (0.038)	−0.520*** (0.038)	−0.523*** (0.038)	−0.526*** (0.038)
Squared size	0.116*** (0.018)	0.121*** (0.018)	0.114*** (0.018)	0.116*** (0.018)	0.119*** (0.018)	0.115*** (0.018)
Support for innovation activities	−0.343*** (0.021)	−0.324*** (0.021)	−0.348*** (0.021)	−0.343*** (0.021)	−0.335*** (0.021)	−0.337*** (0.021)
Age	0.832*** (0.132)	0.867*** (0.133)	0.847*** (0.133)	0.831*** (0.132)	0.834*** (0.132)	0.862*** (0.134)
Squared age	−1.006*** (0.150)	−1.026*** (0.151)	−1.008*** (0.150)	−1.006*** (0.150)	−1.008*** (0.150)	−1.011*** (0.151)
Ownership						
Hongkong-Taiwan-Macao	−0.345 (0.212)	−0.367* (0.217)	−0.361* (0.214)	−0.346 (0.212)	−0.364* (0.213)	−0.374* (0.217)
Foreigner	−0.109 (0.303)	−0.139 (0.309)	−0.146 (0.307)	−0.110 (0.302)	−0.134 (0.304)	−0.173 (0.310)
Sino-foreign joint venture	−0.0150 (0.246)	−0.00822 (0.252)	−0.0191 (0.248)	−0.0159 (0.246)	−0.0192 (0.247)	−0.0128 (0.251)
Private	−0.256 (0.186)	−0.276 (0.191)	−0.269 (0.188)	−0.256 (0.186)	−0.265 (0.187)	−0.276 (0.190)
Joint-equity	−0.266 (0.189)	−0.285 (0.194)	−0.280 (0.191)	−0.266 (0.189)	−0.271 (0.190)	−0.283 (0.193)
Industry growth rate	−1.380*** (0.261)	−1.438*** (0.264)	−1.388*** (0.262)	−1.378*** (0.261)	−1.386*** (0.262)	−1.406*** (0.263)
Number of firms in the industry	1.342** (0.566)	1.281** (0.573)	1.378** (0.569)	1.340** (0.566)	1.313** (0.567)	1.355** (0.572)
Squared number of firms in the industry	0.084 (0.151)	0.094 (0.152)	0.089 (0.151)	0.084 (0.151)	0.084 (0.151)	0.090 (0.152)
Technological areas						
Advanced equipment manufacturing	2.265*** (0.878)	2.174** (0.888)	2.321*** (0.882)	2.263*** (0.878)	2.224** (0.880)	2.289*** (0.886)

Table 8 (continued)

Variables	Mode1	Model2	Model3	Model4	Model5	Model6
Environment and sustainable technology	3.408** (1.705)	3.197* (1.725)	3.499** (1.713)	3.406** (1.704)	3.336* (1.708)	3.429** (1.720)
Biological engineering and biomedical technology	2.645** (1.142)	2.516** (1.156)	2.716** (1.148)	2.643** (1.142)	2.587** (1.144)	2.666** (1.153)
New material technology	3.007** (1.266)	2.869** (1.281)	3.086** (1.272)	3.004** (1.266)	2.949** (1.269)	3.037** (1.278)
New energy technology	3.378** (1.465)	3.226** (1.482)	3.461** (1.471)	3.375** (1.464)	3.316** (1.467)	3.409** (1.478)
The others	3.216** (1.257)	3.082** (1.271)	3.298*** (1.263)	3.212** (1.257)	3.153** (1.259)	3.248** (1.268)
Location	0.421*** (0.076)	0.436*** (0.077)	0.428*** (0.077)	0.421*** (0.076)	0.426*** (0.077)	0.433*** (0.077)
Constant	−2.534*** (0.531)	−2.029*** (0.551)	−2.580*** (0.534)	−2.533*** (0.531)	−2.516*** (0.532)	−2.570*** (0.538)
Lnsig2u	−3.468 (3.215)	−2.589 (1.389)	−3.002 (2.078)	−3.501 (3.325)	−3.254 (2.627)	−2.694 (1.558)
sigma_u	.177 (.284)	.274 (.190)	.223 (.232)	.174 (.289)	.197 (.258)	.26 (.203)
Rho	.019 (.059)	.044 (.058)	.029 (.059)	.018 (.059)	.023 (.059)	.0395 (.059)
Likelihood-ratio test of rho = 0	0.376	0.224	0.310	0.380	0.348	0.251
Observations	11,438	11,438	11,438	11,438	11,438	11,438
Number of ID	2578	2578	2578	2578	2578	2578

Standard errors in parentheses

***$p < 0.01$; **$p < 0.05$; * $p < 0.1$

Surprisingly, the combination of R&D resources and internal financial resources does not significantly amplify the survival chances of Chinese high-tech start-ups. This finding contradicts the empirical results of Dutta et al. (1999), who indicate that the interaction of R&D capability and the ability to commercialize innovation are the most important bundle of resources for high-tech firms. Our findings also conflict with Ugur et al. (2016), who state that, at the same level of R&D, higher profits will lead to higher survival rates. The combination of the three resources does not significantly improve high-tech start-ups' survival as well. These findings imply that the complementarity of internal resources may not be a sufficient condition for improving the survival rate of high-tech start-ups (Harrison et al. 2001). In addition to these complementary resources, high-tech start-ups seem to also need other capabilities to integrate them and to create unique opportunities and value, or the complementary effects of resources may depend on other factors (Black and Boal 1994; Harrison et al. 2001). Alternatively, the synergetic effects of internal resources can be rooted in the specific nature of the synergy of resources, which is open for further exploration in future research.

In addition to the scholarly value of this study, it is also of value to Chinese entrepreneurs and policy makers. Our study implies that entrepreneurial strategies should be tailored to take advantage of the complementarity of internal resources of high-tech start-up firms. Considering the contingent nature of the effects of these firms' internal resources, as supported in this study, an efficient and practical way to improve the survival chances of technology-based start-ups in China is to generate synergic effects by properly combining resources, observing the effects of the chosen combinations carefully, and changing these combinations when their observed effects are disappointing. Our study shows that utilizing resources in an isolated way will limit their potential effects. It implies that managers in Chinese high-tech start-ups also need to identify the synergy of their existing resources and then take advantage of this to create unique opportunities and specific value. In the Chinese setting, current innovation policies could pay more attention to the relationship between policies, which may lead to a synergic implementation of firm-specific assets. For example, in addition to an R&D subsidies policy, a related and coordinated talent-attracting policy could be helpful. This means that an isolated measure is usually insufficient to achieve policy goals. Policy makers in China can focus on the synergy between various policies, such as R&D, tax, talent, and social-economic environmental cultivation, to design a coordinated policy system that is needed to stimulate the use of portfolios of internal resources.

Some limitations of this study may lead to further explorations and research. To obtain detailed estimations of the combined effects, we firstly expect to scrutinize the synergy between more internal resources of high-tech start-ups, such as the pre-entry experience of the management team (e.g., Gimmon and Levie 2010), the entrepreneur's social capital (Coleman et al. 2013), the quality of scientifically skilled employees, and the accumulation of employees' professional experience. Subsequently, how resource combinations affect the exit modes of high-tech start-ups (e.g., "death" or merger) (Fontana and Nesta 2009) also needs further exploration. Our data are lacking such records. In addition, the extent of market competition and resource accessibility is spatially unevenly distributed in China (Guo et al. 2016), which may imply that firms adopt varying resource combinations. Consequently, the question whether the effects of combined resources vary across social-economic settings also awaits further examination. Finally, as already stated, this study is based on data in the most advanced technology park in Beijing. Generalizing these findings to less advanced regions in China and other countries is problematic. This study can be considered as a first attempt to gain insight, which now deserves further testing in other areas. Overall, this study found that Chinese high-tech start-ups that use internal resources jointly may benefit from this: Evidence shows that they are likely to survive longer than those that do not. In conclusion, our research stresses the importance of considering the potentially positive effect of combinations of internal resources on the survival of high-tech start-up firms. Future research is needed to gain a deeper insight into why and how resource combinations do, and do not, positively influence the survival chance of high-tech start-up firms, in China as well as in other countries.

References

Agarwal, R., Echambadi, R., Franco, A. M., & Sarkar, M. B. (2004). Knowledge transfer through inheritance: spin-out generation, development, and survival. *Academy of Management Journal, 47*(4), 501–522. doi:10.2307/20159599.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: testing and interpreting interactions*. Newbury Park: Sage.

Amit, R., & Schoemaker, P. J. H. (1993). Strategic assets and organizational rent. *Strategic Management Journal, 14*(1), 33–46. doi:10.1002/smj.4250140105.

Audretsch, D. B. (1995). Innovation, growth and survival. *International Journal of Industrial Organization, 13*(4), 441–457. doi:10.1016/0167-7187(95)00499-8.

Audretsch, D. B., & Mahmood, T. (1994). The rate of hazard confronting new firms and plants in U.S. manufacturing. *Review of Industrial Organization, 9*(1), 41–56. doi:10.1007/BF01024218.

Autor, D. H., Katz, L. F., & Krueger, A. B. (1998). Computing inequality: have computers changed the labor market? *The Quarterly Journal of Economics, 113*(4), 1169–1213. doi:10.1162/003355398555874.

Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120. doi:10.1177/014920639101700108.

Barney, J. B., & Arikan, A. M. (2001). The resource-based view: origins and implications. In M. A. Hitt, R. Edward Freeman, & J. S. Harrison (Eds.), *The Blackwell handbook of strategic management* (pp. 124–188). MA: Blackwell Publishing.

Bates, T. (1990). Entrepreneur human capital inputs and small business longevity. *The Review of Economics and Statistics, 72*(4), 551–559. doi:10.2307/2109594.

Belso-Martinez, J. A., Molina-Morales, F. X., & Mas-Verdu, F. (2013). Combining effects of internal resources, entrepreneur characteristics and KIS on new firms. *Journal of Business Research, 66*(10), 2079–2089. doi:10.1016/j.jbusres.2013.02.034.

Black, J. A., & Boal, K. B. (1994). Strategic resources: traits, configurations and paths to sustainable competitive advantage. *Strategic Management Journal, 15*(S2), 131–148. doi:10.1002/smj.4250151009.

Box-Steffensmeier, J. M., & Jones, B. S. (2004). *Event history modeling: a guide for social scientists*. New York: Cambridge University Press.

Boyer, T., & Blazy, R. (2014). Born to be alive? The survival of innovative and non-innovative French micro-start-ups. *Small Business Economics, 42*(4), 669–683. doi:10.1007/s11187-013-9522-8.

Bridges, S., & Guariglia, A. (2008). Financial constraints, global engagement, and firm survival in the United Kingdom: evidence from micro data. *Scottish Journal of Political Economy, 55*(4), 444–464. doi:10.1111/j.1467-9485.2008.00461.x.

Bruno, A. V., Liedecker, J. K., & Harder, J. W. (1986). Patterns of failure among Silicon Valley high technology firms. In J. W. Rodstadt, J. A. Hornaday, R. Peterson, & K. H. Vesper (Eds.), *Frontiers of entrepreneurship research* (pp. 677–694). Wellesley: Babson College.

Buddelmeyer, H., Jensen, P. H., & Webster, E. (2010). Innovation and the determinants of company survival. *Oxford Economic Papers, 62*(2), 261–285. doi:10.1093/oep/gpp012.

Carpenter, R. E., & Petersen, B. C. (2002). Is the growth of small firms constrained by internal finance? *The Review of Economics and Statistics, 84*(2), 298–309. doi:10.1162/003465302317411541.

Cefis, E., & Marsili, O. (2005). A matter of life and death: innovation and firm survival. *Industrial and Corporate Change, 14*(6), 1167–1192. doi:10.1093/icc/dth081.

Cefis, E., & Marsili, O. (2011). Born to flip. exit decisions of entrepreneurial firms in high-tech and low-tech industries. *Journal of Evolutionary Economics, 21*(3), 473–498. doi:10.1007/s00191-010-0210-4.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128–152. doi:10.2307/2393553.

Coleman, S., Cotei, C., & Farhat, J. (2013). A resource-based view of new firm survival: new perspectives on the role of industry and exit route. *Journal of Developmental Entrepreneurship, 18*(1), 1350002. doi:10.1142/S1084946713500027.

Cooper, A. C., Gimeno-Gascon, F. J., & Woo, C. Y. (1994). Initial human and financial capital as predictors of new venture performance. *Journal of Business Venturing, 9*(5), 371–395. doi:10.1016/0883-9026(94)90013-2.

Criaco, G., Minola, T., Migliorini, P., & Serarols-Tarrés, C. (2014). "To have and have not": founders' human capital and university start-up survival. *The Journal of Technology Transfer, 39*(4), 567–593. doi:10.1007/s10961-013-9312-0.

Denrell, J., Fang, C., & Winter, S. G. (2003). The economics of strategic opportunity. *Strategic Management Journal, 24*(10), 977–990. doi:10.1002/smj.341.

Dierickx, I., & Cool, K. (1989). Asset stock accumulation and sustainability of competitive advantage. *Management Science, 35*(12), 1504–1511. doi:10.1287/mnsc.35.12.1504.

Dutta, S., Narasimhan, O., & Rajiv, S. (1999). Success in high-technology markets: is marketing capability critical? *Marketing Science, 18*(4), 547–568. doi:10.1287/mksc.18.4.547.

Dzhumashev, R., Mishra, V., & Smyth, R. (2016). Exporting, R&D investment and firm survival in the Indian IT sector. *Journal of Asian Economics, 42*, 1–19. doi:10.1016/j.asieco.2015.10.002.

Esteve-Perez, S., & Manez-Castillejo, J. A. (2008). The resource-based theory of the firm and firm survival. *Small Business Economics, 30*(3), 231–249. doi:10.1007/s11187-006-9011-4.

Esteve-Perez, S., Sanchis-Llopis, A., & Sanchis-Llopis, J. A. (2004). The determinants of survival of Spanish manufacturing firms. *Review of Industrial Organization, 25*(3), 251–273. doi:10.1007/s11151-004-1972-3.

Evans, D. S. (1987). The relationship between firm growth, size, and age: estimates for 100 manufacturing industries. *The Journal of Industrial Economics, 35*(4), 567–581. doi:10.2307/2098588.

Fichman, M., & Levinthal, D. A. (1991). Honeymoons and the liability of adolescence: a new perspective on duration dependence in social and organizational relationships. *Academy of Management Review, 16*(2), 442–468. doi:10.5465/AMR.1991.4278962.

Fontana, R., & Nesta, L. (2009). Product innovation and survival in a high-tech industry. *Review of Industrial Organization, 34*(4), 287–306. doi:10.1007/s11151-009-9210-7.

Fotopoulos, G., & Louri, H. (2000). Location and survival of new entry. *Small Business Economics, 14*(4), 311–321. doi:10.1023/A:1008180522759.

Franco, A. M., Sarkar, M. B., Agarwal, R., & Echambadi, R. (2009). Swift and smart: the moderating effects of technological capabilities on the market pioneering-firm survival relationship. *Management Science, 55*(11), 1842–1860. doi:10.1287/mnsc.1090.1061.

Freeman, C. (1991). Networks of innovators: a synthesis of research issues. *Research Policy, 20*(5), 499–514. doi:10.1016/0048-7333(91)90072-X.

Freeman, J., Carroll, G. R., & Hannan, M. T. (1983). The liability of newness: age dependence in organizational death rates. *American Sociological Review, 48*(5), 692–710. doi:10.2307/2094928.

Galbreath, J. (2005). Which resources matter the most to firm success? An exploratory study of resource-based theory. *Technovation, 25*(9), 979–987. doi:10.1016/j.technovation.2004.02.008.

Geroski, P. A. (1995). What do we know about entry? *International Journal of Industrial Organization, 13*(4), 421–440. doi:10.1016/0167-7187(95)00498-X.

Geroski, P. A., Mata, J., & Portugal, P. (2010). Founding conditions and the survival of new firms. *Strategic Management Journal, 31*(5), 510–529. doi:10.1002/smj.823.

Gimmon, E., & Levie, J. (2010). Founder's human capital, external investment, and the survival of new high-technology ventures. *Research Policy, 39*(9), 1214–1226. doi:10.1016/j.respol.2010.05.017.

Giovannetti, G., Ricchiuti, G., & Velucchi, M. (2011). Size, innovation and internationalization: a survival analysis of Italian firms. *Applied Economics, 43*(12), 1511–1520. doi:10.1080/00036840802600566.

Grant, R. M. (1991). The resource-based theory of competitive advantage: implications for strategy formulation. *California Management Review, 33*(3), 114–135. doi:10.2307/41166664.

Grant, R. M. (2010). *Contemporary strategy analysis* (7th ed.). Chichester: Wiley.

Guariglia, A. (2008). Internal financial constraints, external financial constraints, and investment choice: evidence from a panel of UK firms. *Journal of Banking & Finance, 32*(9), 1795–1809. doi:10.1016/j.jbankfin.2007.12.008.

Guo, Q., He, C., & Li, D. (2016). Entrepreneurship in China: the role of localisation and urbanisation economies. *Urban Studies, 53*(12), 2584–2606. doi:10.1177/0042098015595598.

Hall, B. (1987). The relationship between firm size and firm growth in the US manufacturing sector. *The Journal of Industrial Economics, 35*(4), 583–606. doi:10.2307/2098589.

Hannah, M. T. (1998). Rethinking age dependence in organizational mortality: logical formalizations. *American Journal of Sociology, 104*(1), 126–164. doi:10.1086/210004.

Harrison, J. S., Hall, E. H., & Nargundkar, R. (1993). Resource allocation as an outcropping of strategic consistency: performance implications. *Academy of Management Journal, 36*(5), 1026–1051. doi:10.2307/256644.

Harrison, J. S., Hitt, M. A., Hoskisson, R. E., & Ireland, R. D. (2001). Resource complementarity in business combinations: extending the logic to organizational alliances. *Journal of Management, 27*(6), 679–690. doi:10.1177/014920630102700605.

He, C., & Yang, R. (2016). Determinants of firm failure: empirical evidence from China. *Growth and Change, 47*(1), 72–92. doi:10.1111/grow.12116.

Hitt, M. A., Biermant, L., Shimizu, K., & Kochhar, R. (2001). Direct and moderating effects of human capital on strategy and performance in professional service firms: a resource based perspective. *Academy of Management Journal, 44*(1), 13–28. doi:10.2307/3069334.

Holtz-Eakin, D., Joulfaian, D., & Rosen, H. S. (1994). Sticking it out: entrepreneurial survival and liquidity constraints. *Journal of Political Economy, 102*(1), 53–75. doi:10.1086/261921.

Howell, A. (2015). 'Indigenous' innovation with heterogeneous risk and new firm survival in a transitioning Chinese economy. *Research Policy, 44*(10), 1866–1876. doi:10.1016/j.respol.2015.06.012.

Hult, G. T. M., & Ketchen, D. J. (2001). Does market orientation matter? A test of the relationship between positional advantage and performance. *Strategic Management Journal, 22*(9), 899–906. doi:10.1002/smj.197.

Koch, A., Späth, J., & Strotmann, H. (2013). The role of employees for post-entry firm growth. *Small Business Economics, 41*(3), 733–755. doi:10.1007/s11187-012-9456-6.

Lee, C., Lee, K., & Pennings, J. M. (2001). Internal capabilities, external networks and performance: a study on technology-based ventures. *Strategic Management Journal, 22*(6–7), 615–640. doi:10.1002/smj.181.

Martin, R. E., & Justis, R. T. (1993). Franchising, liquidity constraints and entry. *Applied Economics, 25*(9), 1269–1277. doi:10.1080/00036849300000188.

Marvel, M., & Lumpkin, G. (2007). Technology entrepreneurs' human capital and its effects on innovation radicalness. *Entrepreneurship Theory and Practice, 31*(6), 807–828. doi:10.1111/j.1540-6520.2007.00209.x.

Mata, J., & Portugal, P. (2002). The survival of new domestic and foreign-owned firms. *Strategic Management Journal, 23*(4), 323–343. doi:10.1002/smj.217.

Mitchell, W. (1992). Are more good things better, or will technical and market capabilities conflict when a firm expands? *Industrial and Corporate Change, 1*(2), 327–346. doi:10.1093/icc/1.2.327.

Myers, S. C. (1984). The capital structure puzzle. *The Journal of Finance, 39*(3), 575–592. doi:10.1111/j.1540-6261.1984.tb03646.x.

Myers, S. C., & Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics, 13*(2), 187–221. doi:10.1016/0304-405X(84)90023-0.

Newbert, S. L. (2007). Empirical research on the resource-based view of the firm: an assessment and suggestions for future research. *Strategic Management Journal, 28*(2), 121–146. doi:10.1002/smj.573.

Peteraf, M. A. (1993). The cornerstones of competitive advantage: a resource-based view. *Strategic Management Journal, 14*(3), 179–191. doi:10.1002/smj.4250140303.

Ranft, A. L., & Lord, M. D. (2002). Acquiring new technologies and capabilities: a grounded model of acquisition implementation. *Organization Science, 13*(4), 420–441. doi:10.1287/orsc.13.4.420.2952.

Rauch, A., Frese, M., & Utsch, A. (2005). Effects of human capital and long-term human resources development and utilization on employment growth of small-scale businesses: a causal analysis. *Entrepreneurship Theory and Practice, 29*(6), 681–698. doi:10.1111/j.1540-6520.2005.00103.x.

Robins, J., & Wiersema, M. F. (1995). A resource-based approach to the multibusiness firm: empirical analysis of portfolio interrelationships and corporate financial performance. *Strategic Management Journal, 16*(4), 277–299. doi:10.1002/smj.4250160403.

Rothaermel, F. T. (2001). Complementary assets, strategic alliances, and the incumbent's advantage: an empirical study of industry and firm effects in the biopharmaceutical industry. *Research Policy, 30*(8), 1235–1251. doi:10.1016/S0048-7333(00)00142-6.

Schoenecker, T. S., & Cooper, A. C. (1998). The role of firm resources and organizational attributes in determining entry timing: a cross-industry study. *Strategic Management Journal, 19*(12), 1127–1143. doi:10.1002/(SICI)1097-0266(1998120)19:12<1127::AID-SMJ7>3.0.CO;2-4.

Schwab, S. J. (1993). Life-cycle justice: accommodating just cause and employment at will. *Michigan Law Review, 92*(1), 8–62. doi:10.2307/1289641.

Shrader, R., & Siegel, D. S. (2007). Assessing the relationship between human capital and firm performance: evidence from technology-based new ventures. *Entrepreneurship Theory and Practice, 31*(6), 893–908. doi:10.1111/j.1540-6520.2007.00206.x.

Silverman, B. S. (1999). Technological resources and the direction of corporate diversification: toward an integration of the resource-based view and transaction cost economics. *Management Science, 45*(8), 1109–1124. doi:10.1287/mnsc.45.8.1109.

Stuart, T. E. (2000). Interorganizational alliances and the performance of firms: a study of growth and innovation rates in a high-technology industry. *Strategic Management Journal, 21*(8), 791–811. doi:10.1002/1097-0266(200008)21:8<791::AID-SMJ121>3.0.CO;2-K.

Subramaniam, M., & Youndt, M. A. (2005). The influence of intellectual capital on the types of innovative capabilities. *Academy of Management Journal, 48*(3), 450–463. doi:10.5465/AMJ.2005.17407911.

Tan, Y., Huang, H., & Lu, H. (2013). The effect of venture capital investment—evidence from China's small and medium-sized enterprises board. *Journal of Small Business Management, 51*(1), 138–157. doi:10.1111/j.1540-627X.2012.00379.x.

Taymaz, E., & Özler, S. (2007). Foreign ownership, competition, and survival dynamics. *Review of Industrial Organization, 31*(1), 23–42. doi:10.1007/s11151-007-9144-x.

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy, 15*(6), 285–305. doi:10.1016/0048-7333(86)90027-2.

Teece, D. J. (1998). Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets. *California Management Review, 40*(3), 55–79. doi:10.2307/41165943.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509–533. doi:10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z.

Tripsas, M. (1997). Unraveling the process of creative destruction: complementary assets and incumbent survival in the typesetter industry. *Strategic Management Journal, 18*, 119–142. doi:10.1002/(SICI)1097-0266(199707)18:1+<119::AID-SMJ921>3.0.CO;2-0.

Tsoukas, S. (2011). Firm survival and financial development: evidence from a panel of emerging Asian economies. *Journal of Banking & Finance, 35*(7), 1736–1752. doi:10.1016/j.jbankfin.2010.12.008.

Ughetto, E. (2008). Does internal finance matter for R&D? New evidence from a panel of Italian firms. *Cambridge Journal of Economics, 32*(6), 907–925. doi:10.1093/cje/ben015.

Ugur, M., Trushin, E., & Solomon, E. (2016). Inverted-U relationship between R&D intensity and survival: evidence on scale and complementarity effects in UK data. *Research Policy, 45*(7), 1474–1492. doi:10.1016/j.respol.2016.04.007.

Vinig, T., & Bossink, B. (2015). China's indigenous innovation approach: the emergence of Chinese innovation theory? *Technology Analysis and Strategic Management, 27*(6), 621–627. doi:10.1080/09537325.2015.1036537.

Vogt, S. C. (1994). The role of internal financial sources in firm financing and investment decisions. *Review of Financial Economics, 4*(1), 1–24. doi:10.1016/1058-3300(94)90002-7.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal, 5*(2), 171–180. doi:10.1002/smj.4250050207.

Youndt, M. A., Snell, S. A., Dean, J. W., & Lepak, D. P. (1996). Human resource management, manufacturing strategy, and firm performance. *Academy of Management Journal, 39*(4), 836–866. doi:10.2307/256714.

Zhang M., & Mohnen, P. *Innovation and survival of new firms in Chinese manufacturing, 2000–2006*. UNU-MERIT Working Paper Series 057; 2013.