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Performance of Technological Startups: The Interaction of R&D and Founding Team Human Capital

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Cover Page Footnote

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Introduction

The impacts of R&D investments and activities on performance have been of great interest to both scholars and practitioners for a long time. In the past decade, a number of theoretical arguments propose a direct positive association between R&D and firm performance. R&D is usually seen as an important indicator of innovation, one of the most crucial means through which new firms bring crush blows to larger incumbents and grow. On the other hand, R&D is also perceived as a form of insurance that established firms take to compete and against failure. Theoretically, R&D directly causes superior firm performance for new startup firms because it leads to innovativeness in raw materials, process, organizing, products, and market that enhances their power of 'creative destruction' to entry into the market (Schumpeter, 1934). For incumbent firms, R&D leads to superior performance because: 1) it drives innovativeness that helps differentiate firms from their competitors (Porter, 1980); 2) through R&D, firms are able to obtain rare, valuable, in-imitative, and non-substitutable resources for sustainable competitive advantage (Barney, 1991); and 3) internal R&D investments in building stock of knowledge can help firms to obtain large R&D capacity so that they will be better able to recognize and evaluate external resources for better innovative performance (Berchicci, 2013). There are extensive empirical findings supporting that R&D activities are directly related to survival (Cefis and Marsili, 2006; Lee, Kelley, Lee, and Lee, 2012), positive employment effect (Karhunen and Huovari, 2015), productivity and/or output (Hall, Mairesse, and Mohnen, 2010; Doraszelski and Jaumandreu, 2013; Solomon, Ugur, Guidi, and Trushin, 2015), and growth (Demirel and Mazzucato, 2012; Piras, Postiglione, and Aroca, 2012) etc..

Although previous research has extensively explored the impact of R&D on firm performance, the existing literature mainly focuses on the impacts of R&D on firm survival, productivity, or growth. Very few studies examine R&D and revenue relationship. Revenue is one of the most important indicators of firm performance. It is particularly important for new startup firms because startups typically struggle to break even or increase sales. Revenue in the initial business development period starts from the first sale, which has been congruently considered as a crucial indicator of the successful creation of an entrepreneurial startup although there are tremendous variations in the startup processes (Carter, Gartner, and Reynolds, 1996; Delmar and Shane, 2003; Lichtenstein, Carter, Dooley, and Gartner, 2007). Accumulated initial sales generate revenue in subsequent months and years, which not only shows that the startup starts obtaining income from its initial business activities, but also provides healthy cash flow that is vital for the startup to move forward. A healthy revenue record improves the legitimacy of the startup in the marketplace, and it can be useful information for VCs to make next round

investment decisions. A healthy R&D and revenue relation is an ex ante condition of survival, productivity, and growth; therefore, a better understanding of R&D and revenue relation helps to better understand the influence of R&D on startup performance. It also has practical implementations that help solve entrepreneurs' strategic decision-making dilemma: Whether or not invest in R&D at initial startup stage when having strong resource constraints?

A common practice of the available empirical literature on R&D and startup performance is using data on incumbents or established young firms but not startups at the initial stages of business development. In addition, most empirical studies use patents / trademarks as indicators of R&D investments and activities. The existing approaches have two types of selection bias: a survivorship bias of firms and a survivorship bias of ideas (Hyytinen, Pajarinen, and Rouvinen, 2015). Incumbent firms are survivors of startups in the marketplace. Positive association of R&D and performance among incumbent firms is hardly generated to the whole startup population due to the survivorship bias of firms. In the similar vein, although it is uncertain about the results of commercializing patents and/or trademarks into market, patents and trademarks do indicate the first level success of prior R&D investments/activities. There is a large number of unsuccessful R&D projects failed to achieve any patent or trademark. Using patents/trademarks as a measure of R&D is under the risk of survivorship bias of ideas. Therefore, even though a positive relation between patents/trademarks and performance was found by previous studies, this relationship does not fully represent the actual relationship of R&D and startup performance. Moreover, if entrepreneurs start their business by licensing existing patents or trademarks of third parties, owning patents / trademarks or not does not provide information on whether or not the startup engage in R&D investments/activities at initial startup stage.

To address the above issues, the current study examines the link between R&D and revenue by investigating the moderating role of founding team human capital, using a longitudinal panel data from the Kauffman Firm Survey (KFS). This study has a few contributions to the existing empirical literature. 1) It fills in a gap in the literature by investigating the relation of R&D and technology-based startup's revenue, and adding empirical evidence to R&D and startup performance. 2) It contributes to the startup founding team literature by examining the role of founding team human capital on the relationship between R&D and startup performance. 3) Instead of having incumbent firms as the sample, this study sheds light on startup firms at initial stage of business development. The sample includes 1369 technology-based startups established in year 2004 and a total of 286 founding teams. These startups were surveyed during the first year right after the firm was established, which reduces the survivorship bias of firms. 4) The current study uses longitudinal data that better investigates the influences of R&D on business development overtime. It is often found that R&D and/or innovation activities will

affect firm performance only with a certain time lag (Lachenmaier and Rottmann, 2011; Falk, 2012). This study uses 2-year time lag for the impact of R&D on revenue, so revenue is captured in the following third year after the business starts. 5) R&D is measured by startup's actual engagement in R&D investments and activities that better mirrors the uncertainty of R&D projects and reduces the risk of bias of survivorship of ideas. 6) Results of this study also has important practical implementation for entrepreneurs, decision makers, and policy makers as an added reference of the impacts of R&D on technology-based startup performance.

This remainder of the paper is organized as follows. The first section includes literature review and hypotheses development. The second part presents methodology, data analysis, and empirical results. Discussion and conclusion are included in the end.

R&D and Startup Firm Performance

Startups are firms in gestation or at initial stage of business development right after the firm is established. Technology-based startups play a key role in the area of product and service innovation as they operate in high technology sectors recognized to be responsible of innovations that lead a country's future economic growth. When these startups established, they all have extreme uncertainty of the future. However, new-born technology-based firms exhibit enormous differences in firm performance and this greatly increases the variance of economic performance in samples of startups versus incumbent firms (Gilbert, McDougall, and Audretsch, 2006). Some nascent startups evolve into large firms and spawn whole new industries but some others cease to exist while in infancy.

A number of theories have suggested numerous factors explaining the heterogeneity of technology-based startup performance. A prevailing view in the literature appears to be that R&D and /or innovativeness is the central determinant for the success of technology-based startups. R&D directly leads to innovativeness in raw materials, process, organizing, products, and market that enhances startups' power of 'creative destruction' to entry into the market (Schumpeter, 1934). Once a startup enters into a marketplace, keeping pursuing R&D helps differentiate the firm from their competitors (Porter, 1980). Through R&D, startups are able to obtain rare, valuable, in-imitative, and non-substitutable resources for sustainable competitive advantage over other firms (Maidique and Patch, 1982; Barney, 1991; Ng, Pearson, and Ball, 1992). R&D increases the chances of technology-based startups' survival by providing successful niche strategies in the market (Cefis and Marsili, 2006). R&D investments in building stock of knowledge can help technology-based startup firms have large R&D capacity so that they will be better able to recognize and evaluate external resources for better innovative performance (Berchicci, 2013). Thus, R&D and/or innovativeness represents the most relevant

factor that allows technology-based startups to cope with liability of newness and achieve success (Eisenhardt and Schoonhoven, 1990).

Previous literature shows that technology-based small-medium enterprises have higher survival rates (Agarwal, 1998) and higher growth rate of employment and sales than non-tech small-medium enterprises (Jones-Evans and Westhead, 1996). Extensive empirical studies have supported that R&D is a primary factor explaining outperformance of technology-based enterprises. For example, R&D was found to directly relates to survival (Cefis and Marsili, 2006; Lee et al., 2012), positive employment effect (Karhunen and Huovari, 2015), productivity and/or output (Hall et al., 2010; Doraszelski and Jaumandreu, 2013; Solomon et al., 2015), and growth (Demirel and Mazzucato, 2012; Piras et al., 2012) etc..

However, although previous studies support positive influences of R&D on entrepreneurial enterprises, the current empirical literature is still unclear about the role of R&D plays in the performance of startups— firms that are in business gestation or at the very early stage of business development. For example, Rosenbusch, Brinckmann, and Bausch (2011) conducted a detailed meta-analysis of innovation and performance relationship and they found that the positive relationship between R&D expenditures / experiences is stronger in younger firms than in older firms. In Rosenbusch et al.'s study, they used an average age of 12 years as a cut-off point between young and mature firms. Firms at age of 12 are more likely to be incumbent firms than startups. Hyytinen et al. (2015) intended to better understand the influences of innovation on infant startup firms, so their study used a sample of startups from KFS dataset in which firms were surveyed in the first few months after being established. Surprisingly, they found that innovation is negatively associated with a startup's subsequent survival. However, the focus of their study was no technology-based startups, and they did not control resources, initial asset and revenue streams in the study. Although findings of these previous studies made big contributions to the R&D and firm performance literature, whether R&D would have positive or negative impacts on early years' startup performance is still an open question.

According to the data of The Bureau of Labor Statistics and Business Dynamics Statistics of Census Bureau, 69% businesses survive 2 years or more (Regmi, Ahmed, and Quinn, 2015) and 49% small businesses survive 5 years or more (Robb and Farhat, 2013). Put in another way, about 31% startups are out of business in the third year, and 51% are out in the fifth years. Year 3-5 is a vital stage which startups must develop through. In this regard, what role R&D plays in this vital period becomes a very crucial question for entrepreneurs as they need to decide whether or not conduct R&D investments and activities while their businesses are struggling for survival.

Revenue is the income that a business has from its normal business activities, usually from the sale of goods and services to customers. Revenue is the

'life blood' that provides necessary cash flow for any business to move forward. Unlike other vital capital that startups obtain from investors, VCs, bank loans, or personal savings, revenue is direct capital from the market that provides information about the market demand. Revenue serves as a 'testing stone' for a startup about whether or not: 1) its initial business activities and products are accepted by the market; 2) it has right brand, product, and price positions; 3) its product/service is competitive; and 4) it is earning increasing legitimacy in the marketplace etc. Without healthy increasing revenue records in the first 5 years, it is hard for startups to further survive and grow.

After reviewing previous literature, there are various ways through which R&D stimulates technology-based startups' revenue. First, R&D impacts technology-based startups revenue through its effects on Technology Appropriability and Technology Spillover. Most R&D activities are conducted in the sectors labeled as 'high-tech industries' that aim for introduction of new technology and product/service development. Successful R&D brings benefit of 'technology appropriability' to startups (Malerba, Heimler and Peretto 1993, Malerba, 2004), which have a direct benefit to their revenue with 'a set of economic benefits obtained through new technology thanks to the sale of new products' (Guarini, 2013, 200). These set of economic benefits means streams of revenue that includes higher profits and higher market share in both domestic and international market (Guarini, 2013). New technology or product development resulted from R&D can also generate 'technology spillover' that can stimulates a network among firms. Technology-based startups stay in this network of technological knowledge, with two kind of strengthened capability by R&D: 1) the capability of creating a cumulative process of technological development within the same sector (vertical spillovers) and/or among different sectors; and 2) the capability of developing productive and technological significant complementarity (Guarini, 2013). Thus, resulted from R&D, either technology appropriability or technology spillover brings more revenue to startups.

Second, R&D impacts technology-based startups' revenue by shortening new product development, or cycle time. Product cycle time is a critical competitive variable, particularly for technology-based startup firms (Ali, Krapfel, and LaBahn, 1995). Using a sample of seventy-three small technology-based firms, Abdul Ali, Robert Krapfel, Jr., and Douglas LaBahn investigated the relative impact of product innovation and entry strategy on cycle time and initial market performance of small firms. They found that faster product development is associated with shorter break-even time. Their results indicate that technology-based firms are achieving shorter cycle time not by sacrificing product quality, but by keeping the technical content of the product simple. Shorter break-even time indicates that startups earn more revenue from market within shorter time period. From Ali et al. (1995) study shows that technology-based startups better conduct R&D as a way to find a right simple

technical solution and fasten new product development cycle to earn more revenue while maintain product quality and innovativeness.

Third, R&D stimulates technology-based startups' revenue by increasing productivity. Productivity is defined as the ratio of employment to value added (Karhunen and Huovari, 2015). Given the same input of resources, high productivity means high value-added output to the market, resulting in more generated revenue. From incubating a business idea to establishing a successful startup, starting a new firm is a time-consuming process full of complexity and uncertainty. Startups need to improve productivity that transforms resource-based venturing activities to the maximum of value created. Conducing R&D investments and activities in gestation period helps startups quickly build up necessary stock of knowledge that enlarges firm R&D capacity and enhances absorptive capacity. These firms are able to recognize external resources, evaluate environmental dynamics, and learn about advances in the leading edge, leading to increasing productivity (Hall et al., 2010). A growing number of empirical studies examined R&D effects on firm productivity. Results support that high R&D expenditure represents high knowledge stock that has a significant impact on a firm's productivity (Ortega-Argilés, Piva, and Vivarelli, 2015). Moreover, R&D stimulates innovation and productivity growth directly at the industry-level (Griffith, Redding, and Van Reenen, 2004).

Fourth, R&D helps generate more technology-based startup revenue through improving firm legitimacy with expanding partnership network. As discussed before, R&D can stimulate a network among technology-based firms. When startups are in gestation, the network among other technology-based firms facilitates partnership and strategic alliances, which can act as endorsements to the startup firm. These endorsements help technology-based startups cope with liability of newness, smallness, and innovativeness. Because of staying in the high-tech network, technology-based startups are easier to establish partnership and alliances with other firms; have more chances to acquire technological know-how from their collaborators; build public confidence in startups' products and services; and thereby facilitate the firms' efforts into new market niches (Kogut, 1988); enter new market segments to serve new customers (Mitchell and Singh, 1992), and attract customers and other corporate partners (Stuart, 2000). When a technology-based startups obtains large legitimacy, the revenue potential is likely to be significant. Stuart (2000) presented a model of sales growth and innovation rates in a large sample of semiconductor producers, and results showed that technology-based firms with large and innovative alliance partners have higher rate of sales growth (revenue) than otherwise comparable firms that lack such partners. Without pursuing R&D investments and activities, it is hard for technology-based startups to catch up the advanced technological know-how; benefit and/or being benefited

by other technology-based firms; thereby will be little by little excluded from the network.

Last, R&D assists technology-based startups to gain more revenue through its impacts on establishing and adjusting business model with optimized customer interface in the market. Customer interface includes three elements of customer interface: target customer, fulfillment and support, and pricing model. Fulfillment and support describes the way a firm's product and service reaches its customers. It also refers to the channels a company uses and what level of customer support it provides. When startups are establishing its business model in gestation, R&D helps them to better understand customer interests and preferences, their competitive advantages in terms of customer offerings, price, and missed customer needs etc.. R&D facilitates the product development team to use 'the voice of customer' (Griffin and Hauser, 1993) to create a successful new product, which bring large revenue potential to the firm.

Drawing on the above discussion, it can be hypothesized that:

H1: For technology-based startups in initial stages of business development, high R&D expenditures and activities are more likely associated with high revenue of following years.

Founding Team Human Capital and Startup Performance

Technology-based startups are created because of various reasons. It could because founders intend to exploit their talents for self-realization (BarNir, 2012), or because they pursue opportunities basing on specific technological advances (Zahra, 1996). Decisions made at the venture gestation stage include when and what business to start, how to specify product/service, customer and technology; what resources are needed and how those resources will be obtained (Chrisman, Bauerschmidt, and Hofer, 1998), and how to compete in a marketplace (Abell, 1980). Once decisions are made, entrepreneurs engage in developing product and/or service, seeking technology endorsement, obtaining resources, establishing social network, and creating the business boundary etc. (Brush, Manolova, and Edelman, 2007). Early venturing decisions and activities will dramatically lock the pattern of resource employment.

Startup decisions and activities are mostly made by founders, an individual or a team (Katz and Gartner, 2004). To make right decisions, entrepreneurs must evaluate the value of an opportunity, estimate the likelihood of success, and take risks when employing limited resources to capture potential gains. To cope with uncertainty during the venture gestation, they need to acquire and employ relevant knowledge that is often tacit and experience-based (Kor, Mahoney, and Michael, 2007). When a group of entrepreneurs start a business together, they compose a

startup founding team. Founding team members shares various individual skills, knowledge, life experiences, social and personality attributes, and backgrounds, which build up an important stock of knowledge and ability available to the team—founding team human capital (Becker, 1964).

Founding team human capital has been perceived as an intangible asset of startups. It influences startups' accesses to information and choices of venturing strategies, resulting in various paths of venture creation and associated performance (Sandberg and Hofer, 1987; Dess, Lumpkin, and Covin, 1997; Shane, 2000; Lu and Beamish, 2001). Founding team human capital affects a startup's ability to attract venture capital, and influences whether or not the startup can successfully complete its initial public offering (Beckman, Burton, and O'Reilly, 2007). With larger knowledge stock and stronger abilities, founding teams appear more successful than those founded by solo entrepreneurs (Chandler and Hanks, 1998). Extensive empirical studies support the important role of founding team human capital played in strengthening firm performance (Cooper, Gimeno-Gascon, and Woo, 1994; Dahlqvist, Davidsson, and Wiklund, 2000; Davidsson and Honig, 2003; Wright, Hmieleski, Siegel, and Ensley, 2007; Baptista, Karaöz, and Mendonça, 2014).

Founding team human capital is reflected by different forms: education, domain knowledge, and specific knowledge. Each founder's education indicates codified knowledge he/she has, the knowledge that can be produced and transmitted through formal channels. Codified knowledge includes '*know-what*' that indicates the codified information of the relevant facts of reality; and '*know-why*' that is a scientific knowledge of the causes of phenomena analyzed (Lundvall and Johnson, 1994). Domain knowledge and specific knowledge are tacit knowledge, the knowledge that can be produced and transmitted informally from working and life experiences. Domain knowledge includes '*know-how*', the knowledge of how to act and about practical skills; and '*know-who*', that is information about who can solve specific problems in order to minimize the cost of the acquisition of new knowledge (Lundvall and Johnson, 1994). Specific knowledge is obtained through specific job or position, the knowledge that can have no effect on the productivity of the person if he/she works in other occupations (Ganotakis, 2012).

Education Level of Founding Team

Education level of founding team indicates an average level of general education of founding team members of startups. Education level is usually measured in the literature by educational qualifications such as undergraduate degree or PhD etc. General education level relates to a person's knowledge, skills, ability of problem-solving, discipline, motivation, and self-confidence (Cooper et al., 1994). High level of general education can increase an individual's communication and social abilities as well as his/her learning ability (Avermaete, Viaene, Morgan, Pitts, Crawford, and Mahon, 2004), which in turn increases the

necessary skills for entrepreneurial opportunity discovery, identification, and exploitation (Ferrante, 2005; Marvel and Lumpkin, 2007; Unger, Rauch, Frese, and Rosenbusch, 2011). Entrepreneurs' general education is an important factor for 'post-entry' firm performance such as productivity, profitability, and growth (Bates, 1985; Jo and Lee, 1996; Van der Sluis, Van Praag, and Vijverberg, 2008). A founding team is composed with high educated members will cope with problems better, therefore be more likely to success than lower educated team. A number of previous empirical studies suggest a positive connection between the educational level of founding team and firm performance. For example, based on 48 new Korean startup-firms at the early stages, Jo and Lee (1996) found that the relative profits of the startups tends to be high when founders have more education. A study conducted by Mengistae (2006) shows that the probability of business survival and growth rate both increase with the number of founders' years of education. A few studies have shown that the high educated founding teams are likely to derive more revenues to startups. For example, using a sample of UK technology-based firm, Guarini (2013) found that general education of founding teams has positive effects on export propensity and subsequent performance of the startup. Startups founded by high educated founding team are sensitive to growth opportunities that might beyond the limits of the domestic market, which derives significant revenues from foreign markets (Feeser and Willard, 1990).

> *H2a: Education level of founding team is positively associated with technology-based startups' early years of revenue.*

Domain Knowledge of Founding Team

Domain knowledge represents tacit knowledge of '*know-how*' and '*know-who*' that is specific to the industry or the line of business relevant to a startup (Cooper et al., 1994). Both knowledge of '*know-how*' and '*know-who*' are accumulated from previous experiences in the same or similar businesses. The '*know-how*' includes tacit knowledge of products, technology, or business operations etc. The '*know-who*' is very useful to reduce the search costs of new technology (Lundvall and Johnson, 1994).

Extensive empirical studies have shown that entrepreneurs' domain knowledge has significant association with startup's performance. Each founder's industry and startup experience are transited into domain knowledge stocked into the founding team. With strong domain knowledge, the founding team has strong knowledge of markets, customer problems, and ways to serve customers, therefore increases the likelihood of successful entrepreneurial opportunity recognition and implementation (Ardichvili, Cardozo, and Ray, 2003). In addition, the likelihood of successful transition from a new venture idea to a profitable business is

contingent on the breadth of the resources available within the founding team (Muñoz-Bullon, Sanchez-Bueno, and Vos-Saz, 2015). Strong domain knowledge increases founders' alertness and help them establish strong social network (Ardichvili et al., 2003), increasing the likelihood of access a breadth of resources (Kor et al., 2007). Domain knowledge also influences the team's ability to profitably establish the firm via the mobilization of resources.

Using a sample of nascent entrepreneurs in the USA, the study of Muñoz-Bullon et al. (2015) shows that founding team's domain knowledge positively moderates the impacts of resource heterogeneity on profitable firm creation. Ganotakis (2012) investigated the role of entrepreneurs' general and specific human capital on the performance of 412 UK new technology-based firms operating in both technology-based manufacturing and the services sectors. They found that high levels of founding teams' domain knowledge obtained from formal business education, commercial, managerial or same sector experience is associated with better performance. Firm performance can be improved through the combination of heterogeneous domain knowledge (Ganotakis, 2012). Using the data from the Panel Study of Entrepreneurial Dynamics, Oe and Mitsuhashi (2013) found that startups reach their break-even point faster when their founders had work experience in the same industry.

Taking together, high domain knowledge enables technology-based startup founders to develop better relationships with customers, suppliers, distributors, and stakeholders. With strong 'know-how' and 'know-who' in the industry and/or business sectors, startup founding teams have more likelihood of successful discovering, identifying, and implementing opportunities, access a breadth of resources, better serve customer need and solve problems, but spend lower costs than those teams with weak domain knowledge, therefore, generating more revenues.

> *H2b: Domain knowledge of founding team is positively associated with revenue of early years of technology-based startups.*

Specific Knowledge of Founding Team

Starting up new firms involves a dynamic process that includes various activities such as obtaining resources, developing products, hiring employees, and seeking funding (Brush et al., 2007). Carrying out these activities successfully shows the startup's capability of future development (Brush et al., 2007). During such dynamic startup process, most founders are 'learning by doing' and therefore obtaining another form of uncodified tacit knowledge – the specific knowledge related to business startups, the knowledge that can only be understood by undertaking startup activities (Duchesneau and Gartner, 1990). Evidence shows

that many entrepreneurs start a series of businesses rather than only focusing on one company. Those founders with a series startup experiences have obtained strong specific knowledge. Each founder's specific knowledge can be accumulated into the founding team.

Specific knowledge of startups contributes to the success of startups (Box, White, and Barr, 1993). It has been documented that the startup experience, namely the number of previous startup involvements and the level of the management role played in such firms, is by far the most significant factor venture capitalists have traditionally weighted in their funding decisions (Stuart and Abetti, 1990). In addition to help startups access more capital, specific knowledge of startup founding team enables startups to have more opportunities to access markets (Box et al., 1993), generating more revenues to the firm.

H2c: Specific knowledge of founding team is positively associated with revenue of early years of technology-based startups.

Moderating Role of Founding Team Human Capital on R&D & Revenue Relationship

Although R&D benefits technology-based startups as a result of introducing more novel products into marketplaces and frequently acquire more patents and copyrights (Zahra, 1996), it requires large resources endorsement. Whether or not conducting R&D activities in the initial stage of business development is a decision-making dilemma faced by every technology-based founding team. Pursuing R&D reflects startups' need to keep innovativeness to maintain product/service novelty, but not all R&D investments lead to desired outcomes. A large number of R&D projects have failed because of inefficiency of internal bureaucracy of the firm; poor selection of research projects; weak technology commercialization; and costly implementation of innovative projects (Zahra, 1996). At initial stage of business development, most of venturing decisions, startup activities, and business operations are made by founding teams, therefore, strong founding team human capital will offset the risks of failure of R&D investments and activities. Startups can strategically allocate their resources for competitive advantage, thereby enhancing performance and improve chances of survival.

Moderating Role of Education Level of Founding Team

As a form of general human capital, formal education level of founding team has been found to be most highly related to the degree of innovativeness (Marvel and Lumpkin, 2007). Higher educated entrepreneurs perceive greater opportunity costs when they decide to start a new business (Cooper and Gimeno-

Gascon, 1992). When a group of highly educated entrepreneurs who have diversified beliefs, information, and high concern about opportunity cost constitute a technology-based startup, it signals the validity of the business concept and the potential of the technological advances. When pursuing a R&D project, a highly educated founding team will select better projects in which to invest, more effectively implement the innovation strategy, and better use the competencies they control. All of these will offset the risks of failure of R&D, and facilitate positive R&D effects on generating more revenue.

H3a: High education level of founding team moderates the impact of R&D on revenue of early years of technology-based startups.

Moderating Role of Domain Knowledge of Founding Team

High-technology industries involve the use of sophisticated and complex technologies, and they typically require extensive knowledge and research in dynamic and uncertain environments (Covin, Slevin, and Heeley, 2001). In such dynamic and uncertain industrial contexts, firms in technology-based industries have to continually adapt R&D. Founding team domain knowledge provides important tacit knowledge of 'know-how' and 'know-who' of the industry and/or business sectors that are required for conducting R&D products. Strong domain knowledge of founding team should reduce uncertainty associated with innovation and dynamic environments in the industry (McMullen and Shepherd, 2006), leading to better startup performance.

In addition to offset the uncertainty associated with R&D projects, founding team domain knowledge facilitates the process of establishing legitimacy in the market. Previous literature suggests that the 'liability of newness' is the major reason for the failure of startups because these new firms do not have legitimacy during their early business lives. When technology-based startups pursue high innovation by investing in R&D and product developments, the lack of legitimacy creates problems in product distribution and commercialization. Since domain knowledge is very useful to discover and identify better opportunities and to access resources easier (Kor et al., 2007), high domain knowledge enhances startups' capability to foresee the potential value of an innovation, reducing the likelihood of choosing poor R&D projects. Domain knowledge reduces the search costs of new technology (Lundvall and Johnson, 1994). It helps startups leverage their network with prior suppliers or customers, creating and maintaining functional, personal, or social relationships in the industry. Therefore, high domain knowledge facilitates the process of establishing firm legitimacy and offsets the liability of newness or smallness. Strong domain knowledge of founding teams strengthens the positive effects and offsets the negative effects of pursuing R&D.

H3b: High domain knowledge of founding teams moderates the impact of R&D on revenue of early years of technology-based startups.

Moderating Role of Specific Knowledge of Founding Team

Technology-based startups always pursue R&D activities that are costly with little assurance of eventual payoff. Lack of continuous resources to fully develop and promote technological innovation or product improvement provides another reason for the negative financial performance of startups. Specific knowledge of startups contributes to increase the likelihood of the success of startups (Box et al., 1993). It enables startups to have more opportunities to access capital and markets (Box et al., 1993). For example, it has been documented that the startup experience, namely the number of previous startup involvements and the level of the management role played in such firms, is by far the most significant factor venture capitalists have traditionally weighted in their funding decisions (Stuart and Abetti, 1990). It has been documented that habitual entrepreneurs (those with prior business ownership experience) have broader social networks and are more effective in developing network ties to gain equity finance and management knowledge (Mosey and Wright 2007). Strong specific knowledge of startups enables startups to access broader sources of capital that are required by the resource commitment of a R&D project, thereby positively moderates the effects of R&D on performance.

H3c: High specific knowledge of startup founding teams moderates the impact of R&D on revenue of early years of technology-based startups.

Research Method

Sample

Because the focus of this study is to investigate the influences of R&D on performance of startups that are in very initial stage of business development, data for this study was collected via the Kauffman Firm Survey (KFS) conducted by the Ewing Marion Kauffman Foundation over the period 2005-2007. The description of the sample comes from the KFS documentation (Robb, Ballou, DesRoches, Potter, Zhao, Reedy, 2009). A random sample of 32,469 firms was chosen from Dun and Bradstreet's database of all new businesses started in 2004 in the United States, excluding nonprofit firms, those owned by an existing business or firms inherited from someone else; the KFS research team interviewed principals of 4,928 nascent startups between July 2005 and July 2006 (43% response rate with sampling weights).

A startup is defined as a firm right after gestation and created by a single individual or a team of individuals. The technology-based ventures were defined by KFS as high, medium or low technology using the R&D criteria established by the Bureau of Labor Statistics (BLS) that relies on an industry's percentage of R&D employment. This study uses only 1369 firms that KFS labels as high or medium technology firms. The Baseline Survey in 2005-2006 consisted of 4,928 nascent startups and 3,998 of these participated in the First Follow-Up Survey conducted between June 2006 and January 2007 with an 89 percent response rate. Respondents were paid $50 to participate. The Second Follow-Up Survey in May to December of 2007 interviewed 3,390 firms and identified 406 businesses no longer in operation. Firms no longer operating were excluded along with a small number of entrepreneurs who refused to participate.

Technology-based startups represent owner-operators who help to run the business, provide regular assistance or advice with day-to-day operations of the business, rather than providing only money or occasional operating assistance. This study excluded startups with only one entrepreneur but focused on startups with a founding team, defined as two or more owner-operators. The startups started by more than two owner-operators represent the 421 technology-based startups in our sample. This set of 421 startups encompasses 345 with two team members (82 percent of the teams) and 76 with three or more members. It is able to obtain revenue data in year 3 for 286 out of 421 teams.

Measures

Dependent Measure

Revenue in Year Three. The startup's revenue in year three is used to measure technology-based startup performance. Using firm revenue in year three allows us to examine a three-year lag model linking R&D activities and startup founding team human capital to the revenue of year 3. Respondents were asked what the total revenue was for calendar year 2006 and responses of '$500 or less' were coded as 0 for low revenues; '$501 to $25,000' = 1 for medium revenues; and '$25,001 to $1,000,001 or more' = 2 indicating high revenues. Categorical performance measures have been used in prior studies such as Cooper et al. (1994) study concerning growth, survival and profitability as well as in a follow-up study by Dahlqvist et al. (2000) for both growth and economic performance measures.

Independent variables

R&D investments and activities. R&D investments and activities is measured by a dichotomous variable for 'whether or not the startup invested in R&D in year one'. Respondents were asked, 'Did your business spend any money on research and development?' Responses were coded as 'yes' = 1 and 'no' = 0.

This measure captures the uncertainty of R&D investments/activities, and avoid the survivorship bias of ideas (Hyytinen et al., 2015).

Founding team education. Respondents reported the highest level of education, and each of the founding team members had completed his/her education level, ranging from 1 (less than 9th grade) to 10 (professional school or doctorate). The average education level of the founding team is measured by summing each individual's years of formal education divided by the total number of members of the founding team. This provided a measure of average founding team education that could be compared across technology-based startups.

Founding team domain knowledge. Founding team domain knowledge was measured by years of work experience in the industry in which the startup competes. Respondents were asked, 'how many years of working experience have you had in this industry—the one in which the business competes?' and their responses ranged from 1 to 40+ (more than 40 years). This study combined the 40+ category with the one for 40-years of experience because anything from 40 years and up represents extensive industry experience and likely exhibits the same relationships with key variables in the present study. Only six startup founding teams have more than 40 years of industry experience, so my decision likely had minimum effect on variance in the study. Average founding team domain knowledge was calculated by dividing the sum of total years of industry experience of the team by the total number of members of the team.

Founding team specific knowledge of startups. Founding team specific knowledge of startups is captured by responses to the question 'how many other new businesses have you started besides this one?' The number of other new businesses started ranged from 1 to 11+. This study combined the category 11+ with 11 because the startup experience of 11 or above indicates a substantial strong prior startup experience; additionally, only four founding teams have more than 11 startup experiences while over 50 percent of the founding teams have zero business startup experience and about 23 percent have only one other startup experience. No theoretical reason exists for assuming the effect of experiences of having more than 11 startup would differ from the effect of experiences of having 11 prior startups. The average founding team specific knowledge of startups was calculated by dividing the total number of other new businesses each member has started before by the total number of members of the founding team.

Control Variables

Type of business. Previous literature shows that the type of business impacts startup performance, so this study controlled the type of business using responses to two questions: 'Does your business provide service?' and 'Does your business provide products?' Two dummy variables were created, one for service-related

ventures (0 = not services and 1 = services) and another for product-related ventures (0 = not products, 1 = products).

Team size. Founding team size was measured as the number of owner-operators who help to run the business, provide regular assistance or advice with day-to-day operations of the business, not including individuals who provide only money or occasional operation assistance. The number of founding team members ranges from 2 to 7. Most founding teams (82 percent or 345 out of 421) have two members—the minimum required for a startup team--but this variable allows us to control for the effect of minimum versus large founding teams.

Initial firm size. The initial size of a startup is measured as initial firm asset a startup owns. The initial total assets in year one was used: 0 = small or initial assets of $500 or less; 1 = medium or initial assets of $501 to $25,000; and 2 = large or ventures with initial assets greater than $25,000. The cut-off points for each category were based on the sample distribution.

Data Analysis

Multinominal logit regression (MNL) was used to examine the direct or interaction effects of the independent variables on venture revenue (coded as 0 = low, 1 = medium, and 2 = high). MNL works well with a dependent variable that has more than two categories; when the classes of dependent variable can be ranked, ordinal logistic regression is preferred to multinomial logistic regression. However, the application of ordinal regression must satisfy the assumptions of parallel lines among the results for each category of the dependent variable and adequate cell count. The data violated these assumptions, making use of ordinal regression inappropriate and requiring MNL for testing our model. MNL has been used in prior research (Cooper et al., 1994; Dahlqvist et al., 2000). Logistic regression remains more robust to violation of the normality assumption for categorical explanatory variables, and MNL represents an extension of the common binary logit model when the dependent variable has more than two categories (Cooper et al., 1994).

Entrepreneurship researchers and entrepreneurs focus more on high startup performance, so this study used the low revenue category as the reference variable for the analysis. The models estimate parameters of the explanatory variables for the propensity of nascent ventures in making: 1) high revenues versus low revenues; and 2) medium versus low revenues. The coefficients do not represent any absolute effect on the probability of that outcome (Cooper et al., 1994). An important parameter in MNL is the odds ratio, Exp(β), that shows the factor by which the odds of a given outcome (high or medium revenue) change for a one-unit change in a continuous independent variable. When using a categorical or dichotomous independent variable, the odds ratio is interpreted compared to the

reference category. 'No R&D investments and activities' was the reference category so the odds ratio indicated the odds for R&D investments and activities.

The KFS Baseline Survey oversampled businesses in high-tech industries so we weighted the data prior to the analysis using the weighting factor provided by MPR statisticians (included in the KFS dataset); this weighting ensures that estimates reflect the true population based on the full sample frame. Our study examined outliers through the analysis of residuals but no outliers needed to be excluded.

Results

The analysis uses a lag model to examine the effects of R&D investments and activities in year one on revenue in year three, considering the moderating effect of founding team human capital. The rationale behind this lag model is that investments and activities of R&D and the influences of human capital take time to impact firm performance. They will not affect performance immediately but may have an impact after a few years.

Table 1 provides means, standard deviations, and correlation coefficients for the variables used in this study. Most variables included in this study are ordinal, interval or dichotomous variables, so Spearman correlation tests were conducted. Spearman correlations represent the most common correlation when faced with two ordinal variables or an ordinal and an interval variable. The Spearman correlations provide initial indications of strong relationships between founding team human capital, R&D investments and activities, and revenues. The correlation table shows that the maximum correlation between variables is -0.420 for the relationship among product and service types of businesses (both control variables). Most correlations were much smaller so multicollinearity does not appear to be a problem. All variance inflation factors (VIF) scores are less than 1.291, far below the commonly used cut-off value of 4, supporting the determination that multicollinearity was not an issue.

Table 1

Correlation Matrix, Year 3 (N=286)

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	VIF
1 Revenues	1.41	.85	1									
2 Service	.82	.38	.07	1								1.174
3 Product	.51	.50	.03	-.42**	1							1.291
4 Initial firm size	1.61	.54	.16*	.06	.05	1						1.051
5 R&D investment	.27	.44	.18*	-.16**	.29**	-.05	1					1.149
6 Founding team education	6.57	1.84	.25**	-.06	-.03	.02	.14**	1				1.065
7 Founding team domain knowledge	10.06	8.16	.18**	.17**	-.05	.18*	.06	.18**	1			1.082
8 Founding team specific knowledge	.96	1.20	-.05	-.06	.07	.15**	.18*	.09	.17*	1		1.041
9 Team size	2.25	.65	.09	.06	-.06	.09	.02	.02	.04	.11*	1	1.021

* p< .05, ** p < .01

Table 2 presents the multi-nominal logistic regression results. We tested separate regression models for the control variables, R&D, founding team human capital, and the full model. Effects of interactions between R&D and founding team human capital on startup revenue were also tested.

Table 2

Multinominal Logistic Regressions results for R&D, Founding Human Capital on Revenue in Year 3 (n=286)

Independent Variables	Controls		Technology Innovation		Nascent Venture Team		Full Model	
	Med. Rev.	High Rev.	Med. Rev.	High Rev.	Med. Rev.	High Rev.	Med. Rev.	High Rev.
R&D								
H_1 Technology innovation (R&D investment)			.85 (2.35)	.78* (2.19)	.		.95* (2.55)	.56 (1.76)
Founding Team Human Capital								
H2a Education					.10 (1.11)	.20** (1.22)	.07 (1.07)	.17** (1.19)
H2b Domain knowledge					-.06 (.94)	.04* (1.04)	-.06* (.94)	.04* (1.04)
H2c Specific knowledge					-.19 (.82)	-.14 (.87)	-.23 (.79)	-.14 (.87)
Service	-.84 (.43)	.45 (1.57)	-.81 (.45)	.49 (1.63)	-.89 (.41)	.50 (1.65)	-.91 (.40)	.51 (1.67)
Product	-.21 (.81)	.15 (1.16)	- .41 (.66)	-.01 (.99)	-.24 (.79)	.26 (1.30)	-.46 (.63)	.16 (1.18)
Initial firm size								
Small	.34 (1.40)	-1.29 (.28)	.30 (1.35)	-1.30 (.27)	.29 (1.34)	-.86 (.42)	.26 (1.29)	-.85 (.43)
Medium	.62 (1.85)	-.52 (.60)	.56 (1.76)	-.55* (.58)	.52 (1.67)	-.58* (.56)	.45 (1.57)	-.60* (.55)
Team size	-.16 (.85)	.25 (1.30)	-.20 (.88)	.22 1.25)	-.03 (.97)	.27 (1.32)	-.08 (.93)	.25 (1.29)
Goodness-of-fit Deviance Chi-square (p value)	34.99 (.919)		60.59 (.975)		406.29 (1.00)		401.39 (1.00)	
Model Fitting: -2LL Likelihood ratio	17.68*		21.72 **		37.39 ***		40.69 **	
Pseudo Nagelkerke R-Square	.080		.098		.163		.177	

Note: Low revenue of less than $500 as reference category.
Parameters in parentheses are odds ratio Exp (β).
* p< .10, ** p < .05, *** p<.01

Table 2. Continued

Multinominal Logistic Regressions results for R&D, Founding Human Capital on Revenue in Year 3 (n=286)

Independent Variables	Interaction Model					
	Med. Rev.	High Rev	Med. Rev.	High Rev.	Med. Rev.	High Rev.
R&D						
H_1 Technology innovation	.78	.30	1.48	1.87**	1.23	.86
(R&D investment)	(2.03)	(1.35)	(4.13)	(6.50)	(3.43)	(2.36)
Founding Team Human Capital						
H2a Education	.06	.17*	.07	.19**	.07	.18**
	(1.06)	(1.18)	(1.07)	(1.21)	(1.07)	(1.19)
H2b Domain knowledge	-.06*	.09*	-.07	.07***	-.06*	.08*
	(.94)	(1.04)	(.93)	(1.07)	(.94)	(1.04)
H2c Specific knowledge	-.23	-.14	-.24	-.18	-.19	-.18
	(.80)	(.87)	(.78)	(.84)	(.83)	(.90)
Innovation Strategy × Team Human Capital						
H3a R&D Investment × Education	.04	.04				
	(1.04)	(1.04)				
H3b R&D Investment × Domain Knowledge			-.02	-.12**		
			(.98)	(.89)		
H3c R&D Investment × Specific Knowledge					-.25	-.25
					(.78)	(.78)
Service	-.90	.52	-.99	.44	-.92	.49
	(.41)	(1.68)	(.37)	(1.55)	(.40)	(1.63)
Product	- .47	.16	-.44	.25	-.46	.17
	(.63)	(1.17)	(.64)	(1.28)	(.63)	(1.19)
Initial firm size						
Small	.24	-.87	.30	-.76	.21	-.89
	(1.27)	(.42)	(.79)	(.47)	(1.24)	(.41)
Medium	.45	-.60*	.45	-.62*	.48	-.57
	(1.57)	(.55)	(1.58)	(.54)	(1.62)	(.57)
Team size	-.07	.26	-.03	.31	-.07	.26
	(.93)	(1.30)	(.97)	(1.36)	(.93)	(1.30)
Goodness-of-fit Deviance Chi-square	401.35		394.73		400.86	
Model Fitting: -2LL Likelihood Ratio	40.72**		47.37 **		41.22 **	
Pseudo Nagelkerke R-Square	.18		.20		.18	

Note: Low revenue of less than $500 as reference category.
Parameters in parentheses are odds ratio Exp (β).
* p< .10, ** p < .05, *** p<.01

MNL goodness-of-fit test shows that the model provides an adequate fit of the data (deviance $\chi^2 = 60.59$, p=0.98). The likelihood ratio for the model is significant ($\chi^2 = 21.72$, p=.04), indicating that the R&D activity model relates significantly to startup revenue as predicted in H1. The logistic regression coefficient for R&D activity of 0.783 has an odds ratio of Exp(β)= 2.19, so that a startup's odds of

obtaining high revenue is 2.19 times the odds of obtaining low revenue when adopts R&D investment/activity versus no R&D activity. This supports H1 that predicted initial startup firms conducting R&D investment and activity would more likely exhibit high revenues. However, the regression coefficient for the relationship between R&D investment/activity and medium revenues was not significant. Overall, H1 received partial support.

The likelihood ratio of the overall model of founding team human capital was significant (X^2=37.39, p=0.002) indicating founding team human capital makes a significant difference in predicting startup revenue. The goodness-of-fit test indicates an appropriate model fit (deviance X^2=406.29, p=1.000). The effects of founding team education and domain knowledge have positive and significant impacts on the odds of obtaining high revenue. These results suggest that founding teams with strong education and domain knowledge more likely generate high revenue than low revenue, compared to founding teams with low education level and low domain knowledge, providing support for H2a and H2b. Results do not support the expected significantly different effects of founding team education and domain knowledge on the odds of obtaining medium revenue. Founding team specific knowledge of startups does not appear to impact startup revenue, indicating no support for H2c.

The interaction effects of R&D and founding team human capital was further tested. The likelihood ratio test, commonly used to examine interaction effects in MNL, tests the difference between a full model and a reduced model after dropping an interaction effect. If the model chi-square is significant, then the interaction effect contributes significantly to the full model and should be retained. Results showed that the interaction between R&D and founding team domain knowledge improves the model (p=0.033 if reduced). We conducted a series of MNL regression models to determine the independent interaction effect of each measure of founding team human capital and R&D. Interactions among R&D and founding team education and specific knowledge of startups are insignificant, providing no support for H3a and H3c. Consistent with the likelihood ratio test, the multinominal logistic coefficient in the table shows that the interaction between R&D and founding team domain knowledge is significant in predicting the odds of earning high revenues, however, the relationship is negative. From this result, founding team domain knowledge significantly moderates R&D and revenue relationship, but in the opposite direction from what was expected. It shows that when R&D investments and founding team human capital interact together, the founding teams with high domain knowledge conduct R&D investments and activities are less likely to obtain high revenue compared as obtain low revenue. The result appears surprising because R&D, founding team education, and domain knowledge appear positively impact the odds of obtaining high revenue individually. Startup firms either pursue R&D or have strong founding team

domain knowledge have more likelihood of obtaining high revenues, as compared to obtain low revenues. However, R&D investment and strong founding team domain knowledge do not appear to work well together for increasing the odds of high versus low revenues.

Discussion

Attaining positive firm performance has different implications for technology-based startups than established firms. Unlike their established counterparts, startups face the challenge of survival due to the liability of newness and smallness. Established firms intend to sustain viability, while startups struggle to obtain viability (Gilbert et al., 2006). Pursuing R&D is a prevailing way for technology-based startups to cope with liability of newness, establish legitimacy, and increase the likelihood of success. However, R&D investments require large resource endorsements but with little assurance of eventual payoff. Whether or not new-born startups invest in R&D is a debating unsolved question. The results of this study are consistent with prior theories and empirical studies that, at initial stage of business development, technology-based startups investing in R&D can significantly increases the chances of obtaining high revenue than those startups do not. However, the R&D effects are not significant for chances of obtaining medium than low revenue.

The results of this study are also consistent with the existing literature suggesting that the human capital of founding teams can significant impact upon a technology-based startup performance. More specifically in line with human capital theory of the firm, founding team's education and domain knowledge were found to significantly increase the likelihood of obtaining high revenue for a technology-based startup. The founding team specific knowledge of startups does not necessarily have a positive effect on startups' revenue as shown by the results. One reason for this result may be that high number of new businesses previously started by the founding team means that the team might be very familiar with startup processes, but the experiences from prior startups may not be able to be transited into necessary knowledge required by value generated activities in new market. Each new business has its own specific business model and venturing strategies in a given business sector. Prior successes might not be applicable into new business settings. Although founding teams have strong experiences of prior startups, the firm can still face disadvantages when pursuing novel techniques or technology advances that have not previously existed in the industry. The second reason may be that entrepreneurs are not be able to learn from their prior startup experiences and fail to turn their human capital into firm performance. Experienced entrepreneurs could be more inclined to adopt routines and decisions that have worked in the past, ignoring new information but still sourcing what have been used

previously. Or they might perceive their specific knowledge and experience of startups are sufficient for market entry and generating more revenue, while in fact it is not the case. Entrepreneurs, no matter they have prior startup experiences or not, are needed to gather information from further sources and continuously learning, improving, and adapting in the new startup business sectors/contexts or environmental changes, particularly when conducting R&D investments. Another possible reason might because the quality of specific knowledge varies across serial entrepreneurs. Future research may want to include whether or not prior startups were successful, since prior research shows that serial entrepreneurs with successful track records have a higher likelihood of succeeding with a subsequent startup than serial entrepreneurs who failed with prior startups (Gompers et al., 2006).

Whereas the available empirical literature mostly suggests positive interaction of R&D investments and founding team human capital, this study surprisingly find a negative interactive effect of R&D and domain knowledge on odds of obtaining high revenue. Neither founding team education nor specific knowledge is found to have moderating effects on R&D and revenue relationship. Although this result was unexpected, as discussed above, entrepreneurs with high domain knowledge might be very overconfident due to their skills and knowledge in the business sector or industry, which constrain them from gathering further information that can improve R&D decisions or better implement R&D projects. Strong prior knowledge and experiences of 'know-how' and 'know-who' could be disadvantages of pursuing novel techniques that have not previously existed in the industry.

The data of this study did not allow to investigate why R&D does not distinguish among medium versus low-revenue firms. It may be that R&D investments are always costly, but R&D investments have large potential to generate high rather than medium revenue. Another reason might be that startups with medium or low revenues lack consistent strategies for R&D or that they experience a gap between their intended (stated) and actual (realized) R&D implementations (Mintzberg, 1987).

Conclusion and Implications

The initial stage of business development is very critical for a startup's future development. Strategic decisions chosen in this period will lockup the future pattern of resource mobilization, and impact a startup's future paths of development. Due to the financial constraints and lack of legitimacy, the ability to enhance or exploit resources is vital to the viability of a startup, allowing some new-born firms to evolve and become extremely large while other firms go out of business.

In this paper, we examined the influences of R&D and founding team's human capital on new-born startups' firm performance. We argued that founding team human capital can offset the uncertain aspect of R&D investments and activities, thereby, increase the likelihood of success of startups. This study sheds light on the R&D and revenue relationship because most startups struggle for breakeven in initial years then for growth in later development stages. The sample of this study composes technology-based startups that were surveyed in just a few months after the firm gestation. Data of this study allows a longitudinal study that examines impacts of R&D investments from age one to age three. By using new-born startup firms and investigating time lag effect of R&D investments on revenue, the current study addresses the issue of 'survivorship bias of firms' (Hyytinen et al., 2015) which avoids a spurious positive relation between R&D and startup performance.

This study has both theoretical and practical implications. For theoretical implications, the current study has a few contributions. First, it contributes to the entrepreneurship startup performance literature by filling a gap in understanding the impacts of R&D on firm performance at the initial stage of business development. Second, this study contributes to the innovation and R&D investments/activities literature by applying human capital theory in the context of technology-based new-born startups. Consistent with previous theories and empirical studies, results show that R&D investments has a positive association with startup performance, although these startups are still at very early stage of business development. Third, this paper also contributes to the entrepreneurship team literature by highlighting the importance of founding team human capital to startup performance. The results demonstrate that the average education level of startup founding team and team's domain knowledge play important roles in achieving positive startup performance. More future research need to be done to better understand the contextual factors that influence the effects of founding team human capital.

For practical implications, results of this study suggest that, although R&D investments and activities are costly, pursuing R&D in the first year when a business is born will facilitate its market entry by generating high revenues because R&D enables it to obtain competitive advantages at very first beginning. Entrepreneurs of technology-based startups should recognize that investing in R&D will help to set their businesses apart from less successful counterparts. Results of this study also provide an important reference to investors that founding teams play essential roles in obtaining high performance of startups at the new-born stage, however, the impacts of founding teams and their human capital are contextual.

Although this paper explores the role R&D and founding team human capital play on startup performance, our understanding of the very early business life of technology-based startups remains far from drawing a conclusive

conclusion. Factors other than R&D investments and human capital likely impact startup performance as well. We hope this research provides insights and serves as a catalyst for a more detailed look at the evolvement of startup firms from the period of infancy.

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