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Founders' human capital and external knowledge sourcing: An absorptive capacity perspective for innovative start-ups

Masatoshi Kato

(School of Economics, Kwansei Gakuin University)

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SCHOOL OF ECONOMICS

KWANSEI GAKUIN UNIVERSITY

1-155 Uegahara Ichiban-cho

Nishinomiya 662-8501, Japan

Founders' human capital and external knowledge sourcing: An absorptive capacity perspective for innovative start-ups

Masatoshi Kato[†]

Abstract

This study explores the role of founders' human capital in determining the external knowledge sourcing (licensing-in and joint R&D) of a firm during the start-up period using panel data drawn from original questionnaire surveys conducted in Japan. The results of a probit model with an endogenous regressor show that firms managed by founders with a high level of specific human capital, measured as prior work experience in a related field or as technological experience, tend to engage in external knowledge sourcing because of their absorptive capacity. The findings indicate that this type of human capital also promotes R&D investment. Contrariwise, this study finds that firms managed by founders with a high level of general human capital, measured as educational attainment, tend to invest more in R&D as an absorptive capacity-building activity, which may promote external knowledge sourcing. The implications of these findings are discussed from the perspective of economic policy.

Keywords: start-up, founder, general human capital, specific human capital, R&D investment, external knowledge sourcing.
JEL Classification: M13, L26, O32.

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[†] School of Economics, Kwansei Gakuin University
Address: 1-155 Uegahara Ichiban-cho, Nishinomiya, Hyogo 662-8501, Japan
E-mail: mkato@kwansei.ac.jp

1. Introduction

It is widely held that start-ups promote competition and enhance efficiency by driving inefficient firms out of the market (Siegfried and Evans 1994; Geroski 1995; Ito and Kato 2016). In particular, innovative start-ups can help boost regional development and growth through knowledge spillovers (Fritsch and Mueller 2004; Audretsch et al. 2008; Bos and Stam 2014). However, because start-ups typically have limited resources and experience, it is often difficult for them to innovate successfully. Therefore, relying on knowledge sources from external organizations, including other firms and universities, may be an important strategy for helping small start-ups obtain complementary resources and share costs and risks for innovative activities, which will improve innovative performance (Rothwell and Dodgson 1991; Shan et al. 1994; Deeds and Hill 1996; Decarolis and Deeds 1999; Laursen and Salter 2004; Wu 2007). Nevertheless, few studies have attempted to explain which firms rely more on external knowledge sources among start-ups, as the literature has tended to investigate this topic with a focus on established firms (Pisano 1990; Veugelers 1997; Nakamura and Odagiri 2005). The benefits of collaborating for innovation have been assumed to be particularly important to small firms (de Jong and Freel 2010). Therefore, understanding the factors that promote innovation strategies, such as external knowledge sourcing, for young firms suffering the liability of smallness and newness may provide clues for future innovation policies, including the creation and improvement of innovative opportunities through inter-organizational networks.

Entrepreneurship research studies have indicated that founders' human capital plays a critical role in the post-entry performance of firms, partly because it can compensate for a lack of resources and experience. For example, Colombo and Grilli (2005) found that individuals with greater human capital were likely to have better entrepreneurial judgment and that human capital level had a positive effect on the growth of high-tech start-ups.[1] Marvel and Lumpkin (2007) examined how the human capital of entrepreneurs involved in university-affiliated incubators affected innovation radicalness, finding that previous knowledge played a significant role in innovation outcomes. However, as pointed out by Unger et al. (2011), human capital may not affect performance directly. Rather, human capital may affect strategy, which may in turn affect performance over time. However, little is known about the mechanism affecting the innovation performance of start-ups (Debrulle et al. 2014).

Since the pioneering work of Cohen and Levinthal (1989, 1990), it has been widely accepted that the ability of a firm to recognize the value of new external information, assimilate it, and apply it to commercial ends (known as “absorptive capacity”) is critical to innovative capabilities. According to Cohen and Levinthal (1990), this ability is a function of the level of prior related knowledge, including basic skills and a shared language, as well as scientific or technological developments in a given field. They also pointed out that an organization’s absorptive capacity depends on the absorptive capacities of its members. This suggests that founders’ absorptive capacity plays an important role in external knowledge sourcing among start-ups, which typically face an internal lack of expertise. For example, founders’ work experience in a related field or technological experience may be related to their ability to recognize the value of new external knowledge and utilize it for commercialization because of their accumulated knowledge base.

This study examines whether and how founders’ human capital plays a key role in external knowledge sourcing for innovative start-ups using panel data taken from questionnaire surveys conducted in Japan from 2008 to 2011. The study distinguishes between two types of human capital (i.e., specific vs. general) and sheds light on which type promotes external knowledge sourcing via

[1] Other studies that have found that founders’ human capital played an important role in firm performance include Bates (1990), Cressy (1996), Colombo and Grilli (2010), Rauch and Rijsdijk (2013), and Criaco et al. (2014). See Unger et al. (2011) and Marvel et al. (2016) for reviews of the evidence.

founders' absorptive capacity and enhances the firm's R&D investment as an absorptive capacity-building activity. This study contributes to the literature by investigating the underexplored question of how founders' human capital influences a firm's innovation strategies during the start-up period from the absorptive capacity perspective.

The remainder of this paper is organized as follows. Section 2 discusses the theoretical background of the study's issues and presents the hypotheses. Section 3 describes the data and model used in the analysis. Section 4 explains the determinants of external knowledge sourcing. Section 5 discusses the descriptive statistics of the sample used, then presents the estimation results and several robustness checks. Finally, Section 6 discusses the implications and limitations of this study, and then concludes the paper.

2. Theory and hypotheses

2.1. Theoretical backgrounds

Managing external knowledge flows is important for achieving innovation outcomes efficiently because it is difficult for firms to develop all technologies by themselves in an environment where technologies are becoming more science-based and complex and competition is intensifying (Tether 2002; Nakamura and Odagiri 2005; Escribano et al. 2009). The Organisation for Economic Co-operation and Development (2015, p. 143) shows that about 60% of R&D-active firms in Japan engage in collaboration for innovation. Few firms are able to innovate alone (de Jong and Freel 2010). By developing joint collaborations or by buying R&D in the market, firms can access a greater knowledge pool than is available in-house (Mata and Woerter 2013). In addition, firms are increasingly using open innovation strategies due to the combination of two factors: the rising costs of technology development and shorter product lives in the market (Chesbrough 2003). As pointed out by Muscio (2007), innovative firms must seek and recombine multiple knowledge inputs originating from various sources. Nooteboom (1994) argued that acquiring knowledge through external networks is an important way for small business to compensate for an internal lack of expertise. Acquiring new knowledge to serve as a complementary resource from outside, including from other firms and universities, is a key to success, especially for small start-ups with few resources and a short business history (Rothwell and Dodgson 1991).

Reliance on external knowledge sources has been examined in a rich stream of literature as an issue concerning firms' R&D boundaries. One traditional approach to this issue is the transaction cost theory developed by Williamson (1975).[2] This theory suggests that internal transactions are preferable in a situation with bounded rationality, uncertainty and complexity, opportunism, and information impactedness, which all lead to transaction costs. The boundaries of the firm are determined by the trade-off between the transaction costs of using the market and the organizational costs of using hierarchies (Pisano 1990, p. 160). Regarding R&D activities, internal R&D is preferable when there are substantial transaction costs for external knowledge acquisition, such as the costs of searching for partners. The R&D boundaries of the firm have also been addressed in studies based on the resource-based view of the firm (Wernerfelt 1984; Barney 1991).[3] These highlight that resources are heterogeneous across firms and are essential as sources of sustained competitive advantage. However, because accumulating resources and enhancing capabilities through investment and learning both take time and are costly, firms may decide to use outside resources if this is cheaper than developing resources and capabilities by themselves. Decisions on firm boundaries (i.e., what to do in-house and what to obtain from outside the firm) thus depend on the relative levels of available internal and external capabilities (Nakamura and Odagiri 2005).

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[2] For a further discussion of transaction cost theory, see Shelanski and Klein (1995).

[3] The resource-based view was developed into dynamic capabilities theory, which emphasizes the path-dependence of firms' resources and capabilities (Teece and Pisano 1994; Teece et al. 1997; Eisenhardt and Martin 2000).

Meanwhile, absorptive capacity is widely recognized as an important notion in explaining whether firms rely on external knowledge sources. According to Cohen and Levinthal (1990), the notion of absorptive capacity is premised on the argument that an organization needs prior related knowledge in order to assimilate and use new knowledge; this is supported by research in cognitive science suggesting that prior knowledge increases the ability to put new knowledge into memory and to recall and use it. Cohen and Levinthal (1989) pointed out that R&D has two faces: R&D generates new knowledge and also enhances the firm's innovative capacity to assimilate and exploit existing knowledge. Thus, a firm's absorptive capacity is typically generated by conducting internal R&D. Several empirical studies have examined the role of absorptive capacity in external knowledge sourcing. For example, Arora and Gambardella (1990) found that large firms with high internal knowledge were more likely to have external linkages in the biotechnology industry. Muscio (2007) examined whether firms' absorptive capacity, measured as R&D employment and human resource elements, affected their knowledge sourcing using a sample of 276 manufacturing SMEs in Italy. He found that absorptive capacity enhanced the probability of external knowledge sourcing regardless of partner type. De Jong and Freel (2010) highlighted the role absorptive capacity plays in collaboration, especially in the context of SMEs. However, little evidence has been provided concerning the role of absorptive capacity in external knowledge sourcing for start-ups. Start-ups without a business history tend to face difficulties in searching for external knowledge sources because they lack the prior related knowledge required to assimilate and use new knowledge. As mentioned, a firm's absorptive capacity depends on that of its individual members (Cohen and Levinthal 1990), and start-ups are dependent on the knowledge sources provided by entrepreneurs (Debrulle et al. 2014). Thus, the founders' absorptive capacity is important for start-ups in that it compensates for a lack of prior related knowledge at the firm level. This study highlights the role of founders' human capital in explaining firms' external knowledge sourcing during the start-up period from the perspective of absorptive capacity.

2.2. Founders' human capital and external knowledge acquisition

It is widely recognized that start-ups make a substantial contribution to the creation of new knowledge in an economy (Acs and Audretsch 1990). As mentioned, however, start-ups struggle to innovate because of their scarce resources and experience (Honjo et al. 2014). While many firms rely on external knowledge sources to compensate for their lack of resources or to obtain complementary assets, start-ups may face difficulties acquiring external technologies, partly because of a lack of the absorptive capacity needed to assimilate and use new knowledge (Okamuro et al. 2011). In this context, founders' human capital associated with absorptive capacity may play an important role in firms' innovation strategies, including external knowledge sourcing, since start-ups (unlike established firms) are dependent on the knowledge sources of their founders.[4]

The role of founders' human capital in start-ups has been discussed in a rich stream of literature. Based on the competence-based view, Colombo and Grilli (2005) argued that new technology-based firms (NTBFs) established by individuals with greater human capital should outperform other NTBFs because of their unique capabilities. They emphasized that the capability effect of founders' human capital has a positive impact on the performance of NTBFs—meaning that the founders' human capital is a valuable resource for start-ups and plays a critical role in their performance. The firm's performance reflects management strategy, and the founders of start-ups have more influence on firm strategies, including innovation strategies, than do the top managers of established firms (Okamuro et al. 2011). With the exception of Colombo et al. (2006) and Okamuro et al. (2011), however, the role of

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[4] Several studies have examined the effects of founders' human capital on innovation performance, distinguishing between generic and specific human capital. For example, Marvel and Lumpkin (2007) use a sample of 145 technology entrepreneurs operating within university-affiliated incubators to find that both specific and general human capital affect innovation radicalness. Kato et al. (2015) also found that innovation-specific human capital such as prior innovation experience was directly associated with innovation outcomes, whereas generic human capital such as educational attainment affected innovation outcomes indirectly through R&D investment.

the founder's human capital in innovation strategies has been ignored in the literature. Founders' human capital is reflected in how their capabilities affect their start-ups' strategies. Rothwell (1992) argued that acquiring knowledge from external sources of scientific and technological know-how is effective only when the organization exhibits a willingness to take on external ideas. Allen (1986) emphasized that key individuals called "technological gatekeepers" are necessary for external knowledge acquisition. Veugelers (1997) concluded that the ability to access external know-how is conditioned by its in-house employment of qualified technical specialists, scientists, and engineers; Muscio (2007) empirically supported this observation. Therefore, founders with high levels of human capital appear more likely to have a superior ability to assimilate and use external knowledge.

Many studies (e.g., Cooper et al. 1994; Gimeno et al. 1997; Unger et al. 2011) recognize that human capital is composed of specific and general human capital, which may play different roles in external knowledge sourcing.[5] On one hand, a certain type of human capital may be of a specified nature and applicable only in specific settings. This type of human capital is called "specific human capital," since it is directly related to a task in a newly created firm. On the other hand, some skills and learning may be easily applied in many settings and therefore transferable. This type of human capital is called "general human capital," since it is not directly related to a task in a newly created firm. Stucki (2016) differentiated between specific and general human capital in his study on the role of human capital in the export activities of start-ups. He further argued that while specific human capital was categorized into field-specific and export-specific types, general human capital is formed through education and experience. Following this stream of research, this study classifies types of human capital for innovative activities as shown in Figure 1.

Specific human capital is generally formed through specific occupational experience, such as

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[5] Regardless of the type of human capital, as pointed out by Cassar (2006), human capital allows individuals to achieve tasks more productively and successfully.

innovation-specific or context-specific experience. It may be directly related to the ability to assimilate and use new knowledge, because of the accumulation of knowledge in a specific field. As suggested by Cohen and Levinthal (1989, 1990), external knowledge acquisition requires a certain level of absorptive capacity. While the literature on established firms tends to regard the R&D stock as a measure of absorptive capacity, absorptive capacity for start-ups without an R&D history can be regarded as consisting primarily of the founder's technological experience. In addition, Cassar (2014) argued that experience in similar settings reduces the number of unknowns and assumptions and provides entrepreneurs with more relevant and accurate information about their environment. This suggests that firms managed by founders with a high level of specific human capital may have an advantage because of their accumulated related knowledge gained by acquiring new knowledge from external sources.

While founders with a high level of specific human capital have accumulated related knowledge, they may have to enhance the absorptive capacity of their firms in order to explore new opportunities and assimilate new knowledge. Cohen and Levinthal (1989) argued that the firm can enhance the absorptive capacity needed to exploit external knowledge efficiently. As argued by Mowery and Rosenberg (1989), external knowledge is, alone, insufficient; the development of sufficient expertise within firms is needed to utilize the results of externally performed research. Nakamura and Odagiri (2005) also pointed out that a more R&D-intensive firm will be more alert to outside R&D opportunities and will have more knowledge of potential alliance partners and the technologies to license. These arguments suggest that firms managed by founders with a high level of specific human capital may also conduct internal R&D that will enhance the firm's absorptive capacity and engage it in external knowledge sourcing. These considerations lead to the following hypotheses:

Hypothesis 1a: Firms managed by founders with a high level of specific human capital are more likely to engage in external knowledge sourcing.

Hypothesis 1b: Firms managed by founders with a high level of specific human capital are more likely to invest in R&D, which promotes external knowledge sourcing.

General human capital does not consist of capabilities that are directly applied to a task in a newly created firm. This type of human capital includes analytical and problem-solving skills that are applied in many settings and are therefore transferable to other fields. Backes-Gellner and Werner (2007) argued that narrow occupational skills become obsolete very quickly, while the ability to reason, analyze, communicate, and cross-check information is of more enduring value. They emphasized that such skills are especially useful in rapidly changing environments characterized by uncertainty. As pointed out by Colombo and Grilli (2005), general human capital is related to the general knowledge acquired by entrepreneurs through both formal education and professional experience. Davidsson and Honig (2003) argued that nascent entrepreneurs with higher levels of education are more likely to identify opportunities. Ucbasaran et al. (2008) pointed out that more highly educated entrepreneurs may be better able to deal with complex problems and may also leverage their knowledge and the social contracts generated through the educational system to acquire resources by which they can identify and exploit business opportunities. Honjo et al. (2014) argued that founders with high levels of general human capital, such as highly educated ones, are more likely to have a superior ability to identify better opportunities and conduct large-scale projects with risks and uncertainty; they also found that such founders tend to invest more in R&D. Ucbasaran et al. (2008) pointed out that work experience assists the integration and accumulation of new knowledge and enables individuals to adapt to new situations. Given that R&D is typically associated with uncertainty (Czarnitzki and Toole 2013), founders with work experience may invest more in R&D than other founders because of their superior capabilities.

On the contrary, general human capital, unlike specific human capital, lacks the ability to assimilate and exploit new knowledge from outside. Debrulle et al. (2014) found that, while a founder's specific human capital is positively related to the absorptive capacity of the firm, general human capital is not related to absorptive capacity. Applying the resource-based view of the firm, Debrulle et al. (2014) pointed out that, while general human capital such as formal education can assist in the development of explicit knowledge based on facts and data that can be codified into written documents, general human capital does not help foster the competitive advantage obtained through organizational absorptive capacity's use of valuable, rare, inimitable, and non-substitutable resources. Therefore, a firm that lacks absorptive capacity may invest in R&D as an absorptive capacity-building activity, which could promote search activities (Fabrizio 2009; Spithoven et al. 2011). Taking these considerations into account, the following hypothesis is postulated:

> **Hypothesis 2**: Firms managed by founders with a high level of generic human capital tend to invest more in R&D, which promotes external knowledge sourcing.

The above hypotheses are summarized with the predicted signs in Figure 2. They suggest that, while founders' specific human capital directly and positively affects external knowledge sourcing, general human capital boosts R&D investment as an absorptive capacity-building activity, which may promote external knowledge sourcing. The following section explains the methodology, including the data and model, employed to test these hypotheses.

3. Methodology

3.1. Data and sample

To the best of the author's knowledge, no publicly available dataset provides firm-level data on start-up firms in Japan. While the *Establishment and Enterprise Census* compiled by the government covers all establishments and firms in Japan, it does not include information on founder-specific characteristics. In addition, it is difficult to obtain information on firms' innovation activities during the start-up period. Therefore, this study is based on original questionnaire surveys on start-up firms in

Japan conducted in the four years from 2008 to 2011 (four surveys in total). The first survey was sent in November 2008 to 13,582 manufacturing and software firms incorporated between January 2007 and August 2008. Target firms were selected based on information obtained from Tokyo Shoko Research (TSR), a major Japanese credit reporting company. In the questionnaire, the founder of the firm was asked to answer questions on firm-specific characteristics, such as the firm's finances, employment, and innovation activities, as well as on the founder's personal characteristics, such as his/her education and experience.[6]

For the first (2008) survey, the number of effective responses was 1,514 firms (for a response rate of approximately 11%). The response rate may be excused by the fact that this study targeted small start-up firms that included paper companies, inactive firms, and firms whose founders had no time to spare. With regard to industry distribution, the respondents were not significantly different from the target firms as a whole, although software firms are over-represented (relative to manufacturing firms). In addition, the major characteristics of our sample firms, except for R&D-related variables, do not differ significantly from those of the target firms as a whole.

In the second and third surveys, the questionnaires were sent to the respondents of the first survey (i.e., 1,514 firms). The numbers of effective responses in the second and third surveys were 899 (59% response rate) and 727 (48%). The questionnaires were then sent to those firms that had participated in the third survey, and effective responses were obtained from 508 firms (70% response rate). Overall, then, one-third of the respondents of the first survey participated in each survey round.

From among the respondents of the first survey, 1,060 start-up firms established in 2007 or 2008 were identified. The database compiled by TSR contains newly incorporated firms but also includes

[6] Some sample firms have multiple founders. In these cases, the survey asked about the personal characteristics of the president of the firm.

firms that had already been established as sole proprietorships before incorporation. The questionnaires indicated that one-third of responding firms had been established before December 2006. These were excluded from the sample since they were not “real” start-up firms. Meanwhile, because this study focuses on firms undertaking R&D activities, R&D-oriented start-up firms were identified based on whether their founders conducted R&D or whether the firm employed R&D personnel at the time of start-up or afterward. A total of 672 such firms were identified in the first survey. Dropping firms with missing values left an unbalanced panel of 424 R&D-oriented start-ups (794 observations) for the period from 2008 to 2011.

3.2. Model specification

The key question for this study is whether founders’ human capital affects external knowledge sourcing for start-ups. Therefore, a baseline probit model determining the probability of external knowledge sourcing is first considered:

$$EXT^* = \beta' X + \varepsilon, \; EXT = 1 \text{ if } EXT^* > 0, \; 0 \text{ otherwise}, \quad (1)$$

where EXT^* is a latent variable that is not observed. Instead, only EXT is observed. In this paper, EXT is a dummy variable set to 1 if the firm engages in external knowledge sourcing and 0 otherwise. X is a vector of independent variables consisting of founder- , firm- , industry- , and year-specific characteristics, β is a vector of the estimated parameters, and ε is an error term.

The dependent variable is a binary variable representing whether a firm had engaged in external knowledge sourcing (*EXT*). Consistent with previous studies (Nakamura and Odagiri 2005; Mata and Woerter 2013), *EXT* is a dummy variable taking a value of 1 if the firm has a contract for licensing-in or joint R&D projects. This variable is observed annually from 2008 to 2011; therefore, the values for each firm can change over time.

As a factor affecting external knowledge sourcing, the amount of the firm's R&D investment (*RD_INV*) is fairly important because firms that invest more in R&D are more likely to build their ability to assimilate and exploit new knowledge (i.e., absorptive capacity), thus promoting external knowledge sourcing (Cohen and Levinthal 1989, 1990).[7] As mentioned, the firm's R&D investment is likely to be affected by founders' human capital, since some founders tend to have related knowledge at start-up. Therefore, R&D investment is apparently endogenous in the model determining external knowledge sourcing. To deal with the potential endogeneity bias, an instrumental variable (IV) probit model is most desirable as an estimation model (Wooldridge 2002). Equation (1) can be rewritten as follows:

$$EXT^* = \beta \cdot RD\_INV + \gamma' X_1 + u_1, \;\; EXT = 1 \text{ if } EXT^* > 0, \;\; 0 \text{ otherwise}, \qquad (2)$$

$$RD\_INV = \lambda' X_1 + \varphi' X_2 + v_2, \qquad (3)$$

$$\mathrm{Corr}(u_1, v_2) = \rho, \qquad (4)$$

where (u_1, v_2) is independent of X_1 and X_2 and distributed as bivariate normal with a mean of zero, EXT^* is the latent variable that is not observed, RD_INV is an endogenous variable, X_1 is a vector of exogenous variables, β and γ are the estimated parameters, and u_1 is an error term in Equation (2); while X_2 is a vector of instrumental variables, λ and φ are the estimated parameters, and v_2 is an error term in Equation (3). There is an endogeneity problem if $\rho \neq 0$ in Equation (4); therefore, the IV probit model is used instead of the baseline probit model.

4. Determinants of external knowledge sourcing

A range of independent variables (X_1) capturing founder- , firm- , industry- , and year-specific characteristics are employed as the determinants of external knowledge sourcing. The role of

[7] In this study, the ratio of R&D expenditures to total employment and the ratio of R&D personnel to total employment as alternative measures representing R&D capacity were used. The results changed little.

founder-specific characteristics is considered according to the type of human capital (i.e., specific vs. general). Specific human capital for innovative activities in start-ups is composed of technological experience, which is *innovation-specific* human capital, as well as industry-specific work experience and managerial experience, which is *context-specific* human capital. Technological experience (*TECHEXP*), a dummy variable set to 1 if the founder achieved innovation outcomes (product/process innovations or patent applications) prior to start-up, is used as a measure of specific human capital, consistent with previous studies (Shrader and Siegel 2007; Honjo et al. 2014). Also in line with earlier studies (Marvel 2013; Rauch and Rijsdijk 2013), industry-specific work experience is used as another measure of specific human capital, measured as previous work experience in a related field before start-up (*REL_W*). *REL_W* is a dummy variable taking a value of 1 if the founder had work experience in a related field before start-up. Managerial experience (*MEXP*) is used to measure specific human capital, which captures differences in knowledge of and skill in managing a firm (Rauch and Rijsdijk 2013; Debrulle et al. 2014). *MEXP* is a dummy variable taking a value of 1 if the founder gained managerial experience at another firm before start-up.

With regards to general human capital, consistent with previous studies (Bates 1990; Åstebro and Bernherdt 2005; Ucbasaran et al. 2008), educational attainment at the undergraduate and graduate levels is used as a measure of general human capital, capturing analytical and problem-solving skills. Education also increases the founder’s general stocks of information and skills, including those needed to identify opportunities (Marvel 2013). These are dummy variables taking a value of 1 if the founder had university education at the undergraduate or graduate level (*U_EDU* and *G_EDU*), respectively. In addition to educational attainment, a dummy variable for founders’ work experience as a regular employee (*REG_W*) in any field---not only a related field---is also used as a measure of general human capital, in line with previous studies (Bosma et al. 2004; Unger et al. 2011; Rauch and Rijsdijk 2013). Following Bosma et al. (2004), founder’s age (*FO_AGE*) at start-up is included to control for the founder’s general investment in human capital related to age, which cannot be distinguished between specific and general human capital.

A number of variables reflecting firm-specific characteristics are included in the model. The first variable for firm-specific characteristics is the amount of internal funding (*IF*). The cost of internal funding tends to be lower than that of external financing, so that firms typically use external financing only after their internal funding has been exhausted (Fazzari et al. 1988; Berger and Udell 1998). Therefore, founders that have more personal capital as a source of internal funding are less likely to be financially constrained than are other founders. Including this variable in the model makes it possible to assess the effects of human capital while controlling for the wealth effect, measured as the amount of internal funding by founders (Åstebro and Bernhardt 2003; Colombo and Grilli 2005). In the questionnaire, founders were asked about the amount of funding obtained at start-up from various sources such as the founders themselves, their family, and friends. Here, the amount of internal funding is defined as the initial funding provided by the founders themselves and their family and friends. The second such variable is firm age (*FI_AGE*), measured in terms of the number of months since the establishment of the firm. The variable is included to take into account the duration of operation since start-up. Third, the number of workers (*SIZE*) is used to control for size differences between firms. Fourth, a dummy variable for independent firms (*IND*), as compared to subsidiaries or affiliated firms, is used as an independent variable. The fifth variable is a dummy for firms established by more than one founder (*MFO*) to take into account the possibility that such firms differ in terms of network and/or resources from those founded by a single individual.

In addition to these variables for firm-specific characteristics, three industry-specific variables are included in the model as control variables. A variable representing perceived competitive pressure (*COMP*) is used to examine the effects of competition surrounding start-ups, measured on a 5-point Likert scale. To control for differences in technological conditions between industries, the degree of the appropriability of innovation outcomes (*APPRO*) and technological opportunities (*TECHOP*) are used, respectively. *APPRO* is defined as the extent to which innovative outcomes can be appropriated by the innovators themselves, and *TECHOP* denotes the availability of useful information for innovation. These two variables are constructed based on Okamuro (2009). Finally, three year dummies (the reference year is 2008) are included to account for differences in macroeconomic conditions during the observation period.

As for the instrumental variables (X_2), initial public offering (IPO) intention (*IPO*) and the required amount of R&D expenditures (*REQ_RD*) are considered in the model. The IPO intention variable reflects the founder's growth aspirations and intention to access capital markets (Carpenter and Petersen 2002; Honjo et al. 2014). It is considered that a founder with an IPO intention is more likely to raise financing for R&D investment, while IPO intention is not necessarily related to external technology sourcing. The required amount of R&D expenditures (*REQ_RD*) is employed as another instrumental variable. In the questionnaire, the founders were asked about how much R&D investment their start-ups required for one year in order to achieve sufficient innovation output. This value captures the demand for R&D investment, reflecting investment opportunities for R&D. By contrast, it is assumed that the demand for R&D investment is not directly associated with external knowledge sourcing, which is affected by actual R&D, not the required R&D, which does not enhance absorptive capacity. Definitions of these variables are shown in Table 1.

5. Results

5.1. Descriptive statistics

Summary statistics and a correlation matrix for the dependent and independent variables are presented in Table 2. Starting with the dependent variable, Table 2 indicates that 45% of firms are engaged in external knowledge sourcing (licensing-in or/and joint R&D). Concerning R&D investment (*RD_INV*) as an endogenous variable, the mean value is 3.177 (equivalent to about 5.2 million yen). Of the firm-year observations, 61% have a positive value. Conditional on a positive value, the mean value is 5.179 (equivalent to about 8.5 million yen).

Regarding the independent variables, 41% of the founders had a record of technological experience (product/process innovations or patent applications) prior to starting their firm (*TECHEXP*), 89% had work experience in a related field (*REL_W*), and 33% had managerial experience at another firm (*MEXP*). Furthermore, 53% and 11% of the founders had university education at the undergraduate (*U_EDU*) and graduate levels (*G_EDU*), respectively. In addition, 93% of the founders had work experience as a regular employee (*REG_W*). The mean value of the logarithm of founders' age at start-up (*FO_AGE*) is 3.810 (equivalent to about 47 years of age). The mean value of the variable for internal funding at start-up (*I*F) is 5.425 (equivalent to about 5.9 million yen). The mean value of the logarithm of firm age measured in number of months (*FI_AGE*) is 2.940 (about 23 months). The average of the logarithm of the number of workers (*SIZ*E) is 1.187 (fewer than eight persons). Of the sample firms, 87% were founded as independent firms (*IND*) and 13% as subsidiary or affiliated firms. Meanwhile, 49% of the firms were established by multiple founders (*MFO*). The mean score of perceived competitive pressure is 3.176. With respect to industry-specific characteristics, the mean values for the degree of appropriability (*APPRO*) and technological opportunities (*TECHO*) are 1.212 and 0.913, respectively.

The number of observations and the frequency of external knowledge sourcing by industry are shown in Table 3. Looking at industries with at least 10 observations, the share of firms engaging in external knowledge sourcing through either licensing-in or joint R&D tends to be high in some industries, such as precision machinery (74.2%) and plastic products (63.6%), but below-average (45.0%) in other industries, such as fabricated metal products (36.4%) and information services (37.9%).

Next, Table 4 compares the means of the independent variables for firms engaged in external knowledge sourcing (*EXT* = 1) and those that are not (*EXT* = 0). Regarding R&D investment (*RD_INV*), the mean value is significantly higher among firms engaged in external knowledge sourcing (*EXT* = 1) than among those that are not (*EXT* = 0). It also indicates that firms that engage in external knowledge sourcing have significantly higher means of *TECHEXP*, *REL_W*, *G_EDU*, and *FO_AGE*, than firms that do not. The means of the variables for firm age and size (*FI_AGE* and *SIZE*) are significantly higher for firms that engage in external knowledge sourcing, suggesting that older and larger firms are more likely to engage in external knowledge acquisition than are younger and smaller ones. The mean of the dummy variable for independent start-ups (*IND*) is significantly lower for firms that engage in external knowledge sourcing than for those that do not, indicating that independent start-ups are (relative to subsidiaries or affiliated firms) less likely to engage in external knowledge sourcing. A dummy variable for firms with multiple founders (*MFO*) has a higher mean for firms that engage in external knowledge sourcing.

With respect to industry-specific characteristics, firms that face a less competitive environment (*COMP*) are more likely to engage in external knowledge sourcing. The variable for the degree of appropriability (*APPRO*) has a higher mean among firms that engage in external knowledge sourcing, but there is no significant difference in the samples concerning the degree of technological opportunity (*TECHOP*).

5.2. Estimation results

The estimation results using the probit model with an endogenous regressor are shown in Table 5. In the second stage, the dependent variable is the probability of external knowledge sourcing (*EXT*) and the endogenous variable is R&D investment (*RD_INV*). The result of this stage is shown in column (i) of Table 5. In the first stage, the dependent variable is R&D investment (*RD_INV*). The result of this stage is shown in column (ii). As shown in this column, both the IPO intension (*IPO*) and the amount of required R&D investment (*REQ_RD*) included as instrumental variables are positive and significant at the 1% level. As shown in the bottom of Table 5, the Wald test of exogeneity (χ^2) shows $\rho \neq 0$ and suggests the endogeneity of *RD_INV* in Equation (2).

As shown in Column (i) of Table 5, *RD_INV* has a positive and significant effect on *EXT*, which is consistent with the argument of absorptive capacity (Cohen and Levinthal 1989, 1990) as well as with previous studies (Pisano 1990; Nakamura and Odagiri 2005), suggesting that firms investing more in R&D are more likely to engage in external knowledge sourcing.

With respect to specific human capital, as shown in columns (i) and (ii) of Table 5, founders' technological experience prior to start-up (*TECHEXP*) has a positive and significant effect on both *EXT* and *RD_INV*, indicating that firms managed by founders with specific human capital, as measured by technological experience, play a significant role in both external knowledge sourcing and R&D investment. This suggests that a founder's specific human capital tends to act as the absorptive capacity of the firm in identifying, assimilating, and exploiting external knowledge, while also promoting R&D investment as an absorptive capacity-building activity affecting subsequent external knowledge sourcing. The effect of work experience in a related field (*REL_W*) is positive and statistically significant in only the second stage, determining external knowledge sourcing in column (i) of Table 5. This indicates that firms managed by founders with a high level of specific human capital, as measured by their work experience in a related field prior to start-up, are more likely to engage in external knowledge sourcing. However, its effect on R&D investment (*RD_INV*) is not significant in column (ii) of Table 5. Nor is the effect of managerial experience (*MEXP*) significant in either the first or second stages in Table 5. In these respects, Hypotheses 1a and 1b are generally supported.

With respect to the role of general human capital, while the effects of educational attainment (*U_EDU* and *G_EDU*) on external knowledge sourcing are positive but statistically insignificant in column (i) of Table 5, they have significantly positive effects on R&D investment (*RD_INV*) in column (ii). These results indicate that firms managed by founders with a high level of general human capital, as measured by educational attainment, are more likely to invest in R&D than are other founders. By contrast, general human capital does not necessarily significantly affect external knowledge sourcing (*EXT*). This suggests that founders' general human capital promotes R&D investment as an absorptive capacity-building activity because of skills in dealing with risky and uncertain projects but does not play a significant role in external knowledge sourcing because of a lack of absorptive capacity. Therefore, these findings support Hypothesis 2. However, work experience as a regular employee (*REG_W*), representing general human capital, does not appear to have a significant impact on either *EXT* or *RD_INV*, and founder's age (*FO_AGE*) has no significant effect on *EXT* or *RD_INV*.

Looking at the other variables, internal funding (*IF*), which, as mentioned, was included to control for wealth effects, has an insignificant impact on both *EXT* and *RD_INV*. The effect of firm age (*FI_AGE*) is insignificant. Firm size (*SIZE*) has a positive and significant effect on *RD_INV*, indicating that larger firms are likely to invest more in R&D than smaller ones. The dummy for independent start-ups (*IND*) has a negative and significant effect on *RD_INV*, indicating that subsidiaries or affiliated firms tend to invest more in R&D. On the other hand, the coefficient on the dummy for firms established by multiple founders (*MFO*) is insignificant in both columns (i) and (ii). Finally, the coefficient on the variable for perceived competitive pressure (*COMP*) is negative and significant only in column (i), suggesting that less competitive conditions favor external knowledge sourcing.

5.3. Robustness checks

Using a probit model with endogenous regressors, this study has examined the role of founders' human capital in determining firms' external knowledge sourcing (licensing-in and joint R&D) during the start-up period. In this model, the dependent variable is the probability of external knowledge sourcing, and R&D investment is used as the endogenous variable. It has been found that, while specific human capital plays a significant role in external knowledge sourcing and R&D investment, general human capital boosts R&D investment, which may promote external knowledge sourcing. In this subsection, several alternative models are considered to ensure the robustness of the findings.

First, a recursive bivariate probit model is estimated as an alternative model. While R&D investment was considered as an endogenous variable in the probit model with endogenous regressors, a decision of whether firms invest in R&D might be different from that of how much firms invest in R&D (Kumar and Saqib 1996; Bhattacharya and Bloch 2004). Therefore, a probability of a firm investing in R&D (*D_RD*) is used as an endogenous variable in the recursive bivariate probit model. The estimation results are shown in Table 6. The effects of specific and general human capital are generally consistent with those in Table 5. Second, the same model as Table 5 is estimated using the probit model with endogenous regressors after dropping subsidiaries and affiliated firms from the sample, to check whether the role of founders' human capital differs between independent start-ups and subsidiaries/affiliated firms. The estimation results are shown in columns (i) and (ii) of Table 7. The results are generally same as those of Table 5. Third, since there are survivorship biases in the repeated surveys, the same model as Table 5 is estimated based only on data from the first survey. The estimation results using the probit model with endogenous regressors are shown in columns (iii) and (iv) of Table 7. Although the significance levels for some human capital variables are reduced, the overall results are generally consistent with Table 5. These checks confirm that the findings of Table 5 are generally robust.

6. Discussion and conclusions

This study explored the role of founders' human capital in determining external knowledge sourcing (licensing-in and joint R&D) of firms during the start-up period using panel data taken from original questionnaire surveys conducted in Japan. Estimating a probit model with an endogenous regressor, the analysis provided evidence that firms managed by founders with a high level of specific human capital, measured as work experience in a related field or technological experience, are more likely to engage in external knowledge sourcing because of their absorptive capacity. The findings indicated that this type of human capital also promotes R&D investment. This study also found that firms managed by founders with a high level of general human capital, measured as educational attainment, tend to invest more in R&D as an absorptive capacity-building activity, which may promote external knowledge sourcing.

This study has several limitations. The first is that the analysis considered only formal R&D partnerships, namely licensing-in and joint R&D, in examining external knowledge sourcing, but external knowledge acquisition can also occur through informal networks—such as informal links to external organizations through science parks or industry clusters—that facilitate innovative activities and promote knowledge spillovers (e.g., Fukugawa 2006; Link et al. 2007). The role of such informal links was not taken into account in the analysis. Second, while this study examined the role of founders' human capital, focusing on the attributes of firm presidents, some studies argue that the characteristics of the founding team such as diverse prior affiliations are important determinants of the performance of start-up firms (e.g., Delmar and Shane 2006; Beckman et al. 2007). While this study considered the presence of co-founders by including a dummy for firms with multiple founders, it did not explicitly examine the effects of the characteristics of the founding team. Third, as highlighted in studies such as Unger et al. (2011) and Kato and Honjo (2015), the role of founders' human capital may differ depending on the industry environment. While this study controlled for differences in business environment by including sector dummies, it did not address this issue explicitly. These limitations should be addressed in future analyses.

This study has several implications for public policies. Since underinvestment in R&D may occur relative to the social optimum in the presence of R&D spillovers (i.e., positive externalities), governments can justify intervening in support of innovative start-ups. Public policies should focus more on start-ups with significant growth potential in order to boost economic growth (Santarelli and Vivarelli 2002; Shane 2009; Grilli 2014). This study suggests that governments should prioritize public support for founders with high levels of human capital as a way to achieve further innovation and thus economic growth. The findings in this study also indicate that policy makers should consider the type of human capital when selecting target firms for public support. Specifically, the findings suggest that, while firms managed by founders with high levels of specific human capital tend to engage in external knowledge sourcing, others may not be able to find suitable partners. Firms with such founders also tend to invest more in R&D. In addition, this study indicates that firms managed by founders with high general human capital levels are more likely to invest in R&D, although such firms do not necessarily tend to engage in more external knowledge sourcing. Thus, policy makers should consider more opportunities for research-matching for founders who lack specific human capital and are encountering difficulties finding external partners, especially founders with high levels of general human capital, who should have significant growth potential.

The Japanese government has enacted a support program for research-matching between organizations, called the “Industrial Cluster Project” (e.g., Nishimura and Okamuro 2011a, 2011b). If the government can provide innovative start-ups with more opportunities for research-matching by taking into account founders’ human capital, even firms without sufficient experience at start-up would enjoy the benefits of collaborative networks and thus achieve superior performance. The emergence of innovative start-ups with growth potential will strengthen national innovation systems and stimulate innovation in countries suffering from low economic growth, such as Japan.

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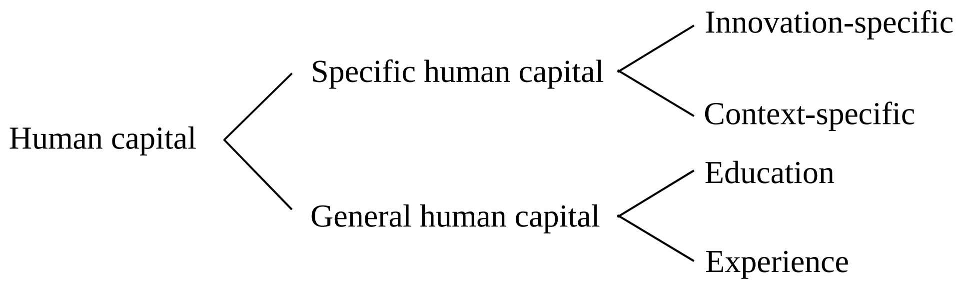

Figure 1. Types of human capital

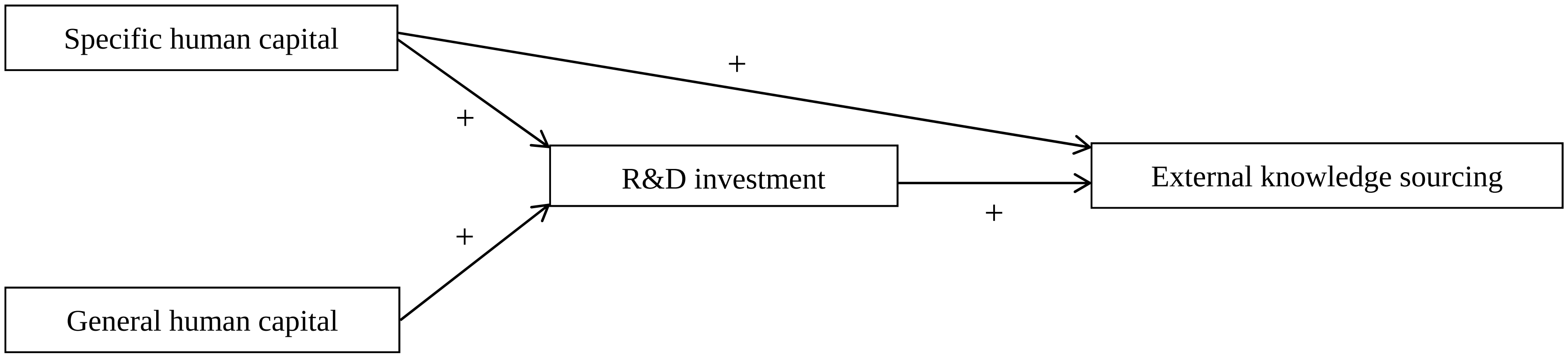

Figure 2. Analytical framework with predicted signs

Table 1. Definition of variables.

Variable	Definition
(Dependent variable)	
EXT	Dummy variable: 1 if the firm has a contract for licensing-in and/or joint R&D projects in period *t*, 0 otherwise.
(Endogenous variable)	
RD_INV	Logarithm of the amount of R&D expenditures (10 thousand yen) plus one in period *t*.
(Founder-specific characteristics)	
TECHEXP	Dummy variable: 1 if the founder has experience in product/process innovation or patent applications, 0 otherwise.
REL_W	Dummy variable: 1 if the founder has work experience in a related field, 0 otherwise.
MEXP	Dummy variable: 1 if the founder has managerial experience at another firm, 0 otherwise.
U_EDU	Dummy variable: 1 if the founder has university education at the undergraduate level, 0 otherwise.
G_EDU	Dummy variable: 1 if the founder has university education at the graduate level, 1 otherwise.
REG_W	Dummy variable: 1 if the founder has work experience as a regular employee at another firm, 0 otherwise.
FO_AGE	Natural logarithm of the founder's age at start-up.
(Firm-specific characteristics)	
IF	Logarithm of the amount of internal funding (founder's own funding plus his or her family's and friends' funding; million yen) at start-up, plus one.
FI_AGE	Natural logarithm of the number of months since the establishment of the firm in period *t*.
SIZE	Natural logarithm of the number of workers (including the manager) in period *t*.
IND	Dummy variable: 1 if the firm is founded as an independent firm, 0 otherwise (as a subsidiary or affiliated firm).
MFO	Dummy variable: 1 if the firm was established by multiple founders, 0 otherwise.
(Industry-specific characteristics)	
COMP	5-point Likert scale on the intensity of competition perceived by the firm in period t, with a range from 1 ("competition is weak") to 5 ("competition is strong").
APPRO	Degree of appropriability.
TECHOP	Degree of technological opportunities.
(Instrumental variable)	
IPO	Dummy variable: 1 if the firm has an initial public offering (IPO) intention in period *t,* 0 otherwise.
REQ_RD	Logarithm of the amount of required R&D investment (million yen) in period *t*.

Table 2. Summary statistics and correlation matrix of variables (number of observations is 794).

Variable		Mean	S.D.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
(1)	*EXT*	0.450	0.498	1.000																		
(2)	*RD_INV*	3.177	2.834	0.254	1.000																	
(3)	*TECHEXP*	0.407	0.492	0.257	0.171	1.000																
(4)	*REL_W*	0.887	0.317	0.100	0.003	-0.011	1.000															
(5)	*MEXP*	0.332	0.471	0.018	0.077	-0.029	-0.127	1.000														
(6)	*U_EDU*	0.529	0.499	0.052	0.081	0.052	0.037	0.104	1.000													
(7)	*G_EDU*	0.106	0.308	0.060	0.129	0.040	-0.006	-0.147	-0.365	1.000												
(8)	*REG_W*	0.937	0.243	0.057	-0.035	0.078	0.202	-0.158	0.119	0.039	1.000											
(9)	*FO_AGE*	3.810	0.254	0.080	0.099	0.234	-0.112	0.201	0.048	0.058	0.068	1.000										
(10)	*IF*	5.425	1.870	-0.018	0.037	0.052	0.046	0.020	0.067	-0.032	-0.047	0.049	1.000									
(11)	*FI_AGE*	2.940	0.674	0.146	0.082	0.033	0.068	-0.042	-0.015	0.017	0.038	0.025	0.061	1.000								
(12)	*SIZE*	1.187	1.000	0.136	0.204	0.020	0.002	0.153	-0.047	0.042	0.013	0.112	-0.160	0.144	1.000							
(13)	*IND*	0.869	0.338	-0.107	-0.119	-0.074	-0.009	-0.138	-0.037	0.012	-0.008	-0.090	0.434	0.091	-0.333	1.000						
(14)	*MFO*	0.490	0.500	0.077	0.095	0.035	-0.134	0.159	-0.059	0.032	-0.099	0.079	0.037	0.023	0.252	-0.127	1.000					
(15)	*COMP*	3.176	1.360	-0.073	-0.062	-0.121	0.122	-0.014	-0.048	-0.014	0.034	-0.131	-0.085	0.061	0.137	-0.035	0.100	1.000				
(16)	*APPRO*	1.212	0.212	0.071	0.013	0.040	-0.061	0.097	0.051	0.023	-0.059	0.100	-0.046	-0.011	0.073	-0.062	0.095	0.057	1.000			
(17)	*TECHOP*	0.913	0.149	-0.024	0.031	-0.079	0.136	-0.116	-0.012	0.082	0.007	-0.268	0.050	0.001	-0.117	0.103	-0.024	-0.031	0.033	1.000		
(18)	*IPO*	0.186	0.390	0.023	0.159	0.051	-0.053	0.060	-0.008	0.056	-0.129	-0.139	-0.017	-0.133	-0.033	0.090	0.061	-0.055	0.016	0.157	1.000	
(19)	*REQ_RD*	5.490	2.242	0.235	0.558	0.128	0.028	0.129	-0.005	0.152	-0.019	0.160	0.059	0.070	0.229	-0.095	0.098	-0.069	-0.023	0.077	0.158	1.000

Table 3. Summary statistics for external knowledge sourcing by industry.

Industry	*EXT*=1	(%)	*N*
Food	17	41.5	41
Beverage and food	5	38.5	13
Textiles	1	20.0	5
Apparel and textile products	14	42.4	33
Lumber and wood products	3	37.5	8
Furniture and fixtures	1	20.0	5
Pulp, paper, and paper products	4	57.1	7
Printing	1	16.7	6
Chemicals	24	57.1	42
Petroleum and coal products	0	0.0	3
Plastic products	14	63.6	22
Rubber products	0	0.0	1
Leather, leather products, and fur skins	0	0.0	3
Ceramic, stone, and clay products	6	42.9	14
Iron and steel	0	0.0	1
Non-ferrous metals and products	3	60.0	5
Fabricated metal products	12	36.4	33
General machinery	35	53.0	66
Electrical machinery	18	48.7	37
Information and communications equipment	7	58.3	12
Electronic parts and devices	19	57.6	33
Transportation machinery	6	42.9	14
Precision machinery	23	74.2	31
Miscellaneous manufacturing	30	51.7	58
Information services	114	37.9	301
Total	357	45.0	794

Table 4. Mean values of the independent variables in sub-samples: *EXT*=0 vs. *EXT*=1.

	EXT=0 (*N*=437)	*EXT*=1 (*N*=357)	Mean difference
Variable	Mean	Mean	(*p*-value)
(Endogenous variable)			
RD_INV	2.527	3.972	0.000
(Founder-specific characteristics)			
TECHEXP	0.293	0.546	0.000
REL_W	0.858	0.922	0.005
MEXP	0.325	0.342	0.618
U_EDU	0.506	0.557	0.147
G_EDU	0.089	0.126	0.094
REG_W	0.924	0.952	0.108
FO_AGE	3.792	3.833	0.025
(Firm-specific characteristics)			
IF	5.454	5.388	0.623
FI_AGE	2.852	3.049	0.000
SIZE	1.064	1.338	0.000
IND	0.902	0.829	0.003
MFO	0.455	0.532	0.031
(Industry-specific characteristics)			
COMP	3.265	3.066	0.040
APPRO	1.198	1.229	0.045
TECHOP	0.917	0.910	0.506

Note: *N* means the number of observations.

Table 5. Estimation results using probit model with endogenous regressors.

Variable	2nd stage (i) *EXT*	1st stage (ii) *RD_INV*
(Endogenous variable)		
RD_INV	0.172*** (0.032)	
(Founder-specific characteristics)		
TECHEXP	0.487*** (0.105)	0.479*** (0.177)
REL_W	0.486*** (0.162)	-0.056 (0.261)
MEXP	-0.003 (0.108)	-0.077 (0.192)
U_EDU	0.024 (0.108)	0.663*** (0.181)
G_EDU	0.029 (0.172)	0.821*** (0.315)
REG_W	0.254 (0.200)	-0.453 (0.325)
FO_AGE	-0.148 (0.200)	-0.242 (0.356)
(Firm-specific characteristics)		
IF	-0.027 (0.028)	0.053 (0.049)
FI_AGE	0.077 (0.137)	-0.058 (0.231)
SIZE	0.026 (0.057)	0.199** (0.095)
IND	-0.142 (0.170)	-0.580** (0.279)
MFO	0.154 (0.102)	0.090 (0.175)
(Industry-specific characteristics)		
COMP	-0.075** (0.036)	-0.055 (0.064)
APPRO	0.395* (0.222)	0.063 (0.382)
TECHOP	-0.397 (0.326)	-0.298 (0.580)
(Instrumental variable)		
IPO		0.611*** (0.226)
REQ_RD		0.620*** (0.034)
Constant term	-1.050 (0.992)	0.670 (1.704)
Number of observations	794	794
Log pseudolikelihood	-2251.166	
Wald test of exogeneity (χ^2)	8.670*** (*p*-value: 0.003)	

Notes: Robust standard errors are in parentheses.
*** Significance level 1%.
** Significance level 5%.
* Significance level 10%.

Table 6. Estimation results using recursive bivariate probit model.

Variable	(i) *D_RD*	(ii) *EXT*
(Endogenous variable)		
D_RD		1.110*** (0.195)
(Founder-specific characteristics)		
TECHEXP	0.316*** (0.105)	0.428*** (0.108)
REL_W	0.011 (0.160)	0.424*** (0.156)
MEXP	-0.056 (0.112)	0.010 (0.104)
U_EDU	0.320*** (0.107)	0.019 (0.106)
G_EDU	0.300* (0.172)	0.072 (0.163)
REG_W	-0.309 (0.207)	0.248 (0.190)
FO_AGE	-0.069 (0.212)	-0.111 (0.194)
(Firm-specific characteristics)		
IF	0.032 (0.028)	-0.024 (0.027)
FI_AGE	-0.045 (0.136)	0.082 (0.134)
SIZE	-0.011 (0.055)	0.069 (0.052)
IND	-0.133 (0.164)	-0.201 (0.159)
MFO	-0.074 (0.103)	0.178* (0.099)
(Industry-specific characteristics)		
COMP	-0.005 (0.038)	-0.0754** (0.035)
APPRO	-0.114 (0.225)	0.392* (0.213)
TECHOP	-0.295 (0.347)	-0.275 (0.317)
(Instrumental variable)		
IPO	0.264* (0.135)	
REQ_RD	0.236*** (0.022)	
Constant term	-0.488 (1.003)	-1.337 (0.975)
Number of observations	794	794
Log pseudolikelihood	-922.624	
Wald test of ρ=0 (χ^2)	12.260*** (p-value: 0.001)	

Notes: Robust standard errors are in parentheses.
*** Significance level 1%.
** Significance level 5%.
* Significance level 10%.

Table 7. Probit model with endogenous regressor: Independent start-up sample and 1st survey sample.

	Independent start-up sample		1st survey sample	
Variable	(i) *EXT*	(ii) *RD_INV*	(iii) *EXT*	(iv) *RD_INV*
(Endogenous variable)				
RD_INV	0.186*** (0.036)		0.188*** (0.041)	
(Founder-specific characteristics)				
TECHEXP	0.498*** (0.114)	0.332* (0.189)	0.577*** (0.154)	0.496* (0.261)
REL_W	0.572*** (0.179)	0.193 (0.283)	0.379* (0.227)	-0.503 (0.353)
MEXP	0.050 (0.117)	-0.057 (0.209)	0.141 (0.154)	0.131 (0.277)
U_EDU	-0.008 (0.116)	0.593*** (0.191)	0.062 (0.154)	0.402 (0.259)
G_EDU	0.043 (0.184)	0.788** (0.331)	0.040 (0.253)	0.832* (0.480)
REG_W	0.217 (0.207)	-0.343 (0.368)	0.357 (0.269)	-0.369 (0.395)
FO_AGE	-0.300 (0.220)	-0.414 (0.392)	-0.138 (0.278)	-0.008 (0.501)
(Firm-specific characteristics)				
IF	-0.034 (0.037)	0.102(0.069)	-0.050 (0.037)	0.066 (0.067)
FI_AGE	0.070 (0.154)	-0.062 (0.249)	-0.058 (0.149)	0.045 (0.247)
SIZE	0.079(0.068)	0.259** (0.114)	-0.057 (0.081)	0.102 (0.156)
IND			-0.316 (0.209)	-0.201 (0.360)
MFO	0.155 (0.111)	0.054 (0.186)	0.191 (0.152)	0.339 (0.259)
(Industry-specific characteristics)				
COMP	-0.0849** (0.040)	-0.136** (0.067)	-0.024 (0.052)	-0.006(0.095)
APPRO	0.394* (0.234)	0.158 (0.399)	0.373 (0.324)	0.440 (0.553)
TECHOP	-0.489 (0.350)	-0.368 (0.620)	-0.058 (0.466)	-0.629 (0.843)
(Instrumental variable)				
IPO		0.632*** (0.236)		0.907*** (0.285)
REQ_RD		0.571*** (0.038)		0.569*** (0.042)
Constant term	-0.605(1.086)	0.727 (1.881)	-1.016 (1.317)	-0.623(2.350)
Year dummies	Yes	Yes	---	---
Number of observations	690	690	389	389
Log pseudolikelihood	-1949.162		-1096.992	
Wald test of exogeneity (χ^2)	9.390*** (*p*-value: 0.0022)		5.50** (*p*-value: 0.0191)	

Notes: Robust standard errors are in parentheses.
*** Significance level 1%.
** Significance level 5%.
* Significance level 10%.