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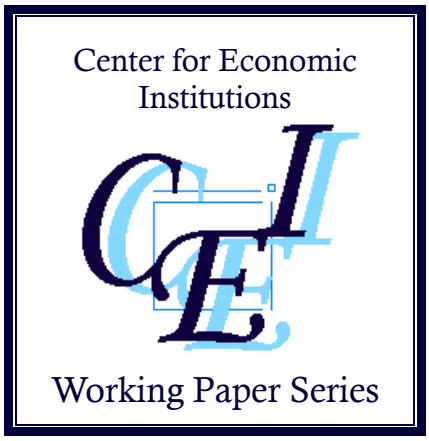

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Does founders' human capital matter for innovation? Evidence from Japanese start-ups*

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Abstract

Using a sample from an original questionnaire survey in Japan, this paper explores whether and how founders' human capital affects innovation outcomes by start-ups. The results provide evidence that founders with greater human capital are more likely to yield innovation outcome. However, because certain types of founders' human capital may boost R&D investment, which possibly results in innovation outcomes, we estimate the determinants of innovation outcomes by an instrumental variable probit model taking into account the endogeneity of R&D investment. Our findings suggest that *specific* human capital for innovation, such as founders' prior innovation experience, is directly associated with innovation outcomes after start-up, while *generic* human capital, such as founders' educational background, indirectly affects innovation outcomes through R&D investment.

JEL Classification: L24; M13; O31

Keywords: Start-up; Founder; Human capital; Innovations; R&D investment.

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1. Introduction

It is widely recognized that the emergence of start-ups and their post-entry performance significantly contribute to economic growth and that small businesses plays significant roles in a large fraction of innovations (e.g., Acs and Audretsch, 1990). More recently, start-ups have been paid attention as the sources of innovation and productivity in regions (e.g., Audretsch et al., 2006). On the other hand, it has often been argued that, as is known as the so-called "Schumpeterian hypothesis," large firms have more advantages in innovations than small firms.[1] In fact, it may be quite difficult for start-ups to be successful in innovations because of their limited resources and experience. Whereas scholars and policy makers pay attention to what types of start-ups contribute to innovation, there has been quite limited evidence on whether and how start-ups can be successful in innovation.

Meanwhile, it has often been argued that founders' human capital play a critical role in determining firm performance (e.g., Cressy, 1996). Because knowledge and skills that are key components of human capital are required to generate innovations, human capital is an inevitable resource for research and development (R&D). Especially for R&D-oriented start-ups that undertake R&D activities at the start-up stage, founders' human capital may relate more significantly to the post-entry performance of their firms. To date, nevertheless, little is known about whether and how founders' human capital affects the firms' innovations. In this respect, it is worth to highlight the role of founders' human capital in determining innovation outcomes of start-ups.

[1] For more discussion on the relationship between innovation and firms size, see, for example, Cohen et al. (1987), and Acs and Audretsch (1990).

This paper explores whether and how founders' human capital affects innovations among start-ups in Japan. It is a widely held view that innovation activities differ considerably across firms, and founders' human capital may help to explain these differences. In this paper, using a sample from an original questionnaire survey in Japan, we examine whether founders' human capital affects innovations. The results provide evidence on the determinants of innovations in start-ups, and, in particular, we shed light on the role of founders' human capital in determining innovation outcomes. To better understand how start-ups achieve innovation outcomes, we identify what types of founders' human capital affect innovation outcomes in start-ups.

The remainder of the paper is organized as follows. In the following section, we review the background and related literature to this paper. Section 3 presents some testable hypotheses. Section 4 describes the data and variables used in the analysis. The empirical methods and results are presented in Section 5. The final section includes some concluding remarks.

2. Background and related literature

Despite increasing public interest in innovation created by high-tech start-ups, many start-ups encounter difficulties in conducting R&D. This is mainly because start-ups are likely to lack capital for R&D. Not surprisingly, the access to external financial markets tends to be limited when founders start their businesses. Even if a start-up has high growth potential, external financial markets do not always provide funds because of market imperfections due to information asymmetries between the founder and the providers of external finance; that is, founders are likely to face financial constraints. In fact, a large number of studies have addressed the effects of financial constraints on the level of capital used at start-up (e.g., Evans and Jovanovic, 1989;

Åstebro and Bernhardt, 2005). Perhaps, the information asymmetries are more severe for R&D-oriented start-ups because it is quite difficult to gauge the success of R&D at the start-up stage. Therefore, these start-ups cannot easily obtain funds for R&D investment, even though they require a large amount of capital for R&D.

Whereas it is considered that the innovation outcomes of R&D-oriented start-ups depend on the amount of capital for R&D, it has often been argued that the success of start-ups is dependent on their founders' human capital. Bates (1990), for example, argued that the entrepreneurs' human capital inputs affect small business longevity, and Cressy (1996) emphasized that human capital is the true determinant of firm survival. In addition, some empirical studies have provided evidence on the relationship between firm growth and the human capital of founders or entrepreneurs (e.g., Honjo, 2004; Colombo and Grilli, 2005). These studies have indicated that founders' human capital is a valuable resource for start-ups and plays a critical role in the firm's performance, partly because it can compensate for the lack of business experience and resources.

More specifically, Bates (1990) found that human capital measured by the years of education is strongly linked to business viability. Åstebro and Bernhardt (2005) also argued that increased human capital provides founders with greater ability to create and manage viable enterprises. In addition, Colombo and Grilli (2005) indicated that individuals with greater human capital are likely to have better entrepreneurial judgment, and that firms established by founders with greater human capital outperform other firms because of their unique capabilities. They emphasize the "capability effect" of founders' human capital, which explains the positive effect of human capital on the performance. Colombo and Grilli (2005) then found that the nature of the education and

of the prior work experience of founders exerts a key influence on the growth. Colombo et al. (2004) also showed that founders' human capital, such as educational background and work experience, have a crucial influence on the start-up size of new technology-based firms (NTBFs).[2] These findings indicate that founders' human capital serves as a valuable resource to achieve better firm performance.

To date, however, few studies have addressed the role of founders' human capital in determining firms' innovations at the start-up stage. A related paper is Marvel and Lumpkin (2007), which studied the effects of technology entrepreneurs' human capital on innovation radicalness using a sample of 145 technology entrepreneurs operating within university-affiliated incubators. They found that entrepreneurs' human capital, such as educational background and prior technology knowledge, positively affects innovation radicalness. However, it is unclear whether innovation radicalness represents innovation outcomes, because it may depend on subjective evaluation by entrepreneurs. In this paper, we use multiple measures of innovation outcomes (product/process innovations and patent applications). Moreover, most previous studies, including Marvel and Lumpkin (2007), focus on the effects of human capital on innovation output, but not on innovation input. In this paper, we will fill these gaps by examining the effects of founders' human capital on both R&D investment (innovation input) and innovation outcomes, considering its indirect effect through the R&D investment and employing multiple measures of innovation outcomes.

[2] More recently, Coleman (2007) also showed that human capital, such as education and experience, plays an important role in the profitability and growth of small firms.

3. Hypotheses

In this section, we present some testable hypotheses for the role of founders' human capital in determining innovation outcomes in start-ups. As discussed in the previous section, it is considered that founders' human capital plays a more important role in R&D activities of start-ups, than in those of large and established firms, because of limited resources at the start-up stage. For R&D-oriented start-ups, founders' human capital is an essential factor in the innovative process, and it will compensate for deficiencies in physical capital at the start-up stage. As Colombo and Grilli (2005) argued, founders' human capital may reflect firms' capabilities for R&D. In addition, founders with greater human capital have better access to research network with external organizations (e.g., Okamuro et al., 2011). For these reasons, we consider that

H1: Founders with greater human capital are more likely to generate innovation outcomes in start-ups.

Previous literature often distinguishes between *generic* and *specific* human capital. According to Colombo et al. (2004), generic human capital relates to the general knowledge acquired by entrepreneurs (founders) through both formal education and professional experience, while specific human capital consists of the capabilities of individuals that can directly be applied to the entrepreneurial job in the newly created firms. Colombo et al. (2004) found that variables that reflect specific components of human capital, such as work experience in the same sector as the new firm as well as managerial and entrepreneurial experience exhibit greater explanatory power than those that reflect generic components, such as work experience in other sectors. Åstebro and Bernhardt (2003) also examined the effects of human capital on firm performance, by distinguishing between formal and informal human capital that reflects general and specific

human capital. These studies suggest that the effects of founder's human capital depend heavily on its types.

In fact, some types of founders' human capital affect organizational performance; for example, prior work experience is likely to lead to efficient production within the organization. However, it is doubtful whether this type of human capital directly relates to innovation outcomes. More specifically, managerial experience may be indispensable for management, but it is unclear if this type of human capital is significantly associated with innovation outcomes. Because technological knowledge and skills differ significantly from managerial ones, technological knowledge and skills possessed by founders would rather play a critical role in generating innovation outcomes. In this respect, we should distinguish between the types of founders' human capital. More precisely, innovation outcomes depend heavily on specific human capital for R&D activities, such as prior experience of product/process innovations. Hence, we can say that

H2: Specific human capital for R&D activities is positively and more strongly associated with innovation outcomes in start-ups than generic human capital.

Founders with greater human capital are capable of gaining better access to external finance under the financial market imperfections. As Åstebro and Bernhardt (2005) pointed out, such founders can relax financial constraints that otherwise hinder firm performance. Whereas start-ups cannot easily access external finance for R&D, some types of founders' human capital play a role in creating opportunities to access it. More specifically, work experience may be useful to negotiate with banks and investors. In addition, some types of founders' human capital, such as academic experience, may serve as a signal of creditworthiness to the providers of external

finance under information asymmetries between founders and these providers. In accordance with these arguments, it is hypothesized that founders' human capital does not only directly relate to innovation outcomes, but also facilitates access to financial capital for R&D. Hence, we hypothesize that

H3: Generic human capital is more likely to boost R&D investment rather than innovation outcomes in start-ups.

Parker and van Praag (2006) emphasize the possibility that human capital has an indirect effect on performance by facilitating access to financial capital, thus diluting any financial constraint. Following them, we argue that founders' human capital has not only a direct, but also an indirect effect on innovation outcomes. Both roles of founders' human capital are expected to be particularly important at the start-up stage because of severe information asymmetries.

4. Data

4. 1. Data sources

To the best of our knowledge, there exists no publicly available data source for R&D activities by start-ups in Japan. In order to construct a data set of start-ups for our research project, we conducted a postal questionnaire survey in November 2008. We sent questionnaires to 13,582 firms in the Japanese manufacturing and software industries, which had been incorporated between January 2007 and August 2008. The list of firms for the survey was obtained from a database compiled by Tokyo Shoko Research (TSR), a major credit investigation company in Japan. In the questionnaire survey, we asked the founders about firm-specific characteristics, including R&D activities, as well as their personal attributes.

The number of effective responses was 1514 (approximately 11% of the target). With regard to industry structure and location, the respondents were not considerably different from the target firms as a whole, though software firms are more strongly represented among the respondents than manufacturing start-ups. From among the responses, we selected 1060 "real" start-ups that had started their businesses during 2007 and 2008[3]. Moreover, we excluded from the dataset the firms that did not invest in R&D at start up and afterwards and that provide no information on R&D investment (together approximately 250 firms). We further excluded 40 subsidiaries and affiliated firms of existing firms, because they have quite different characteristics from independent start-ups at the founder and firm levels, especially with regard to the amount and structure of initial funds. After excluding some observations due to missing values, we obtained a final sample of 204 firms.

In addition, we use another data source to collect data on industry-specific characteristics. Industry's R&D intensity is measured by the industry's R&D expenditures divided by its sales, which were taken from the *Results of Basic Survey of Japanese Business Structure and Activities* by the Ministry of Economy, Trade, and Industry (METI). Data on the appropriability of innovation outcomes and technological opportunities were taken and calculated from the Report on the Japanese National Innovation Survey 2003, compiled by the National Institute of Science and Technology Policy (NISTEP) of the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

[3] Other firms were founded before 2006 and incorporated in 2007 or 2008.

4. 2. Innovation outcomes

The effects of founders' human capital may differ according to the types of innovation outcome, but it is quite difficult to determine appropriate measures of innovation outcomes. Perhaps, profits or market values are ultimate objectives of R&D for private firms, but these values are not an appropriate index at the start-up stage because of the time lag existing between innovation and profits.

Instead, in this paper, we attempt to capture innovation outcomes by asking the founders whether or not their start-ups achieved product or process innovations in our questionnaire survey. Based on the survey, the variable for product or process innovations (*INN*) is used as a dependent variable in our empirical model.

Also, intellectual property right---that is, patent---has often been used to measure innovation outcomes in previous literature (e.g., Hausman et al., 1984). Although patent applications may not completely reflect the quality of innovation outcomes, they will be able to reveal the degree of the firm's innovative activities. In our questionnaire survey, we inquired about patent applications. Using this data, we defined the variable, *PAT*, which indicates whether or not the firm applied for patents after the foundation, as innovation outcomes. Using these variables, we attempt to understand factors affecting differences in innovation outcomes among R&D-oriented start-ups.

4. 3. Determinants of innovation outcomes

Founders' human capital is measured by founder-specific characteristics, which can be retrieved from the data source. In this paper, we define two types of variables: *generic* and *specific* human

capital for R&D. Colombo and Grilli (2004) argued that *generic* human capital is related to the general knowledge acquired by entrepreneurs through both formal education and professional experience. In fact, a number of studies have used educational attainments as a measure of founders' human capital (e.g., Bates, 1990; Åstebro and Bernhardt, 2005). Following these studies, we measure the educational background of founders by dummy variables, *UEDU* and *GEDU*, which correspond to undergraduate university education and graduate school education levels, respectively.

Also, the variables for prior work experience in the related field at start-up (*WEXP*) and prior managerial experience in other firms prior to start-up (*MEXP*) are used as independent variables representing *generic* human capital in our model. Contrary to Colombo and Grilli (2005) that considered them to be *specific* human capital for business performance, we regard them as *generic* human capital for innovative performance, because these experiences are not necessarily and exclusively associated with innovative activities.

As for *specific* human capital, we measure founders' prior innovation experience to capture founders' human capital more specified to innovative activities. A dummy variable, *INNEXP*, is used to measure founders' experience of product/process innovations prior to start-up, in the model with product/process innovations as the dependent variable (*INN*). Also, a dummy variable for founders' prior experience regarding patent applications is alternatively used as independent variables representing technological capabilities of founders in the model with patent applications (*PAT*) as another dependent variable. These may indicate the degree of founder's technological capabilities. Moreover, a dummy variable, *ACAD*, is used to measure the founder's affiliation to academic associations in the natural sciences. This may indicate the extent of founder's professional

network as well as technological capabilities. Finally, we include the variable for the founder's age, *AGE*, in order to control for differences in age and generation among founders.

With respect to independent variables other than those variables for founders' human capital, the variables for firm-specific and industry-specific characteristics are used in the analysis. First, the firm's intensity of R&D investment, *RDEXP*, which represents R&D inputs, is defined as R&D expenditures divided by the number of employees. The variable, *SIZE*, measured as the number of employees, is also used to control for differences in firm size at the start-up stage. Since some firms were established by multiple founders, a dummy variable for multiple founders, *MFOUND*, is used as a control variable. Furthermore, we use the industry's R&D intensity (*INDRD*), appropriability of technological outcomes (*APPROP*) and technological opportunities (*TECHOPP*), to control for differences in the technological characteristics across industries[4].

5. Empirical methods and results

5. 1. Methods

Based on the sample of R&D-oriented start-ups, we examine the effects of founders' human capital on the firms' innovation outcomes at the start-up stage. As discussed, innovation outcomes depend on R&D investment because financial constraints hinder R&D activities. Moreover, as hypothesized in *H1* and *H2*, innovation outcomes may depend on founder's human capital as well. In this paper, we thus write a model explaining innovation outcomes, which is defined as the function of both R&D investment and founders' human capital. Assuming for simplicity that the relationships are linear, we estimate the effects of R&D investment and founders' human capital on

[4] See Okamuro (2009) for details for the construction of these variables.

innovation outcomes of R&D-oriented start-ups. Since, as already mentioned, the variables for innovation outcomes are measured as binary variables, we employ a probit model to estimate the model for the determinants of innovation outcomes.

As described in *H3*, we consider that *generic* human capital affects R&D investment, rather than innovation outcomes for R&D-oriented start-ups. In this respect, R&D investment may be regarded as a function of founders' human capital. Taking into account the endogeneity of R&D investment, therefore, we employ a probit model with an endogenous regressor to estimate the model for the determinants of innovation outcomes. Assuming that R&D investment is endogenously determined, we examine whether innovation outcomes are significantly associated with R&D investment. By doing so, we can identify which type of founders' human capital affects innovation outcomes, R&D investment or both of them. In the analysis, we first estimate the model for the determinants of R&D investment, using instrumental variables for R&D investment, and then examine the determinants of innovation outcomes.

We employ the probit model with an endogenous regressor, in order to estimate the determinants of innovation outcomes. In this paper, we use two variables, *REQRD and IF*, as the instruments that control for differences in the demand and supply for R&D investment across firms. In the questionnaire, we asked how much firms require R&D investment for one year, in order to obtain sufficient innovation output. Using this value, we capture the demand for R&D investment, which indicates investment opportunities for R&D. Moreover, we consider that the demand for R&D investment is not directly associated with innovation outcomes because of technological and market uncertainties. Hence, the variable for the demand for R&D investment (*REQRD*) is included as an instrument in the first-stage regression.

In the traditional investment model, cash-flow has often been used to capture the availability of internal finance that hypothetically mitigates financial constraints. However, cash-flow is not appropriate as a proxy for the availability of internal finance at start-up, because most start-up firms cannot establish sufficient cash-flow at the initial stage. Alternatively, we pay attention to the sources of initial funds at start-up, because start-up firms use their initial funds for operation and investment at the early stage. In the questionnaire, we asked for the amount of initial funds obtained from each type of funding sources at start-up including founders themselves and their family and friends. We regard the initial funds provided by the founders themselves and their family and friends as internal finance and use them as a proxy for internal finance (*IF*). We argue that internal finance measured as this type of initial funds is strongly associated with R&D investment, but is not directly associated with innovation outcomes because of uncertainties of R&D, and thus include this variable as an instrument in the first-stage regression.

Table 1 summarizes the definitions of the variables used in the analysis.

5. 2. Results and discussion

Table 2 describes the summary statistics for the dependent and independent variables used in the analysis. As shown in Table 2, about 44% and 17 % of R&D-oriented start-ups have achieved product/process innovations and applied for patent applications after their start-up, respectively.

With respect to founders' human capital, as shown in Table 2, 52% of the founders had achieved a bachelor's degree and 13% a master's or doctorate degree. Table 2 also shows that, before start-up, 85% of the founders worked in a related field and 35% as managers of other firms. Moreover, founders had prior experience of product/process innovations and patent applications,

before start-up, in 36% and 22% of firms, respectively. As shown in Table 2, 18% of the founders in our sample are affiliated to academic associations in the natural sciences. The founders were on average 46 years old at start-up, with the minimum and the maximum being 20 and 80 years old, respectively. Table 3 shows the correlation matrix of these variables.

We show the estimation results in Table 4. The variables, *INN* and *PAT*, are the dependent variables of the regressions. While Columns (i) and (ii) of Table 4 describes the estimation results with *INN* and *PAT*, respectively. The numbers of observations are 179 and 174 in Columns (i) and (ii), respectively. In addition, we estimate the determinants of innovation outcomes, using the probit model with an endogenous regressor, in which R&D investment is regarded as endogenously determined. Table 5 describes the estimation results. Columns (i) and (ii) of Table 5 describe the results with *INN* and *PAT*, respectively. While the first stage regression indicates the estimation results for the determinants of R&D investment, the second stage indicates those for the determinants of innovation outcomes in Table 5.

As shown in Table 4, we find that the coefficients of *RDEXP* are positive and strongly significant, indicating that innovation outcomes are positively associated with R&D investment. This result indicates that firms investing more heavily in R&D among R&D-oriented start-ups are likely to obtain innovation outcomes. In addition to R&D investment, we find that certain types of founders' human capital have positive effects on innovation outcomes.[5] The coefficients of *GEDU* are positive and significant in both the models of Table 4, suggesting that founders with higher educational attainments are more likely to obtain innovation outcomes. Also, the

[5] We also employed ordinary least squares method and a negative binomial model, using data on the number of patent applications as a dependent variable and obtained similar relationships between innovation outcomes and founders' human capital.

coefficients of *INNEXP* and *PATEXP* are positive and significant in Columns (i) and (ii) of Table 4, respectively. These results indicate that founders' prior experience of product/process innovations and patent applications relates to innovation outcomes. Overall, these types of founders' human capital may reflect the firm's technological capabilities, and our findings indicate that founders' human capital is positively associated with innovation outcome for R&D-oriented start-ups. It can be concluded that founders' human capital plays a critical role in achieving innovations at the start-up stage.

Also, as shown in Table 4, founders' age positively affects innovation outcomes. This result suggests that older founders are more likely to obtain innovation outcomes, although this variable was simply included as a control variable in the regression. On the other hand, other founder-specific characteristics, such as work and managerial experiences, *WEXP* and *MEXP*, and the affiliation to academic associations, *ACAD*, are not significant in any models of Table 4. Also, Table 4 indicates that some firm-specific characteristics, *SIZE*, *IND*, and *MFOUND*, have no significant effect on innovation outcomes. Moreover, in Column (ii) of Table 4 indicates that the industry's appropriability of innovation outcomes, *APPROP*, has a significantly positive effect on innovation outcomes, while the industry's R&D intensity and technological opportunities has no significant effect. These results suggest that industry conditions matter for innovative activities.

Meanwhile, as shown in Table 5, some types of founders' human capital affect R&D investment. More specifically, the coefficient of *GEDU* is positive at the 1% significance level in the first stage regression, while no significant relationship between innovation outcomes and founders' educational background is found in the second stage. This result suggests that highly educated founders invest more in R&D, but are not more likely to achieve innovation outcomes.

Thus, such human capital has rather an indirect effect on innovation outcomes of R&D-oriented start-ups. In the second stage of Table 5, moreover, the coefficient of *RDEXP* is positive and significant, and *INNEXP* and *PATEXP* have strongly significant effects on innovation outcomes. This is consistent with the results of Table 4.

To sum up, these empirical results partially support all of our hypotheses: H1 and H2 are supported with regard to the founders' innovation experience prior to start-up (*INNEXP* and *PATEXP*), measures of *specific* human capital, while H3 is supported with regard to the founders' educational attainment at the graduate school level (*GEDU*), a measure of *generic* human capital. It is also noteworthy that not all types of founders' human capital contribute to achieving innovation outcomes, directly or indirectly.

A number of studies have pointed out the significant and direct effects of founders' human capital on firm performance until now (e.g., Colombo and Grilli, 2005). However, we argue that indirect effects of founders' human capital are also important to innovation outcomes. Indeed, as our estimation results demonstrate, founders' educational level affects R&D investment rather than innovation outcomes. Hence, we suggest that, in order to better understand the effects of founders' human capital, one should pay more attention to its indirect effects on innovation outcomes.[6]

[6] In this paper, we considered the effects of founders' human capital on innovation outcomes through R&D investment. Needless to say, there remains the possibility that founders' human capital has an impact on innovation outcomes through another factor, such as R&D cooperation. In this respect, further investigation may be required to deepen our understanding of the complex relationships between founders' human capital and innovation outcomes of start-ups.

6. Conclusions

This paper explored the determinants of innovation outcomes of R&D-oriented start-ups. Using a sample from an original questionnaire survey in Japan, we examined whether and how founders' human capital affects innovation outcomes at the start-up stage. We provided evidence that certain types of founders' human capital, namely their innovation performance prior to start-up, are directly associated with innovation outcomes. Our findings also suggested that founders' higher (graduate school) education is associated with R&D investment, indicating that part of founders' human capital has an indirect effect on innovation outcomes through R&D investment.

While, as is often argued, Japan has achieved technological catch-up and is now striving for technological leadership in the manufacturing sector, this country is characterized by almost the lowest ratio of business start-ups among OECD countries. In this respect, policy makers are concerned about the lack of entrepreneurship. High-tech start-ups are expected to stimulate future economic growth, but indeed it is not easy for these firms to achieve successful innovation. In this regard, as this paper suggested, founders' human capital may enhance the probability of success in innovations---not only specific human capital but also generic human capital of founders has an impact, though indirectly, on innovation outcomes. Our findings imply that founders' human capital is indispensable to propel innovation introduced by high-tech start-ups. For future economy, we should pay more attention to the development of entrepreneurial human capital in support of national innovation systems in the countries with low start-up ratios, such as Japan.

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Table 1: Definitions of variables

Variable	Definition
(Dependent variable)	
INN	Dummy variable: 1 if the firm has product/process innovations after start-up.
PAT	Dummy variable: 1 if the firm has conducted patent applications after start-up.
(Independent variable)	
Founder-specific characteristics	
UEDU	Dummy variable: 1 if the founder has undergraduate education, 0 otherwise.
GEDU	Dummy variable: 1 if the founder has graduate school education, 0 otherwise.
WEXP	Dummy variable: 1 if the founder has prior work experience in the related field at start-up, 0 otherwise.
MEXP	Dummy variable: 1 if the founder has prior managerial experience in other firms at start-up, 0 otherwise.
INNEXP	Dummy variable: 1 if the founder has prior experience of product/process innovations at start-up, 0 otherwise.
PATEXP	Dummy variable: 1 if the founder has prior experience of patent applications at start-up, 0 otherwise.
ACAD	Dummy variable: 1 if the founder is a member of academic association in the natural sciences, 0 otherwise.
AGE	Founder's age at start-up.
Firm-specific characteristics	
RDEXP	R&D expenditures (million yen) divided by the number of employees.
SIZE	Number of employees at start-up.
SUB	Dummy variable: 1 if the firm is founded a subsidiary or an affiliated firm, 0 otherwise.
MFOUND	Dummy variable: 1 if the firm has multiple founders, 0 otherwise.
Industry-specific characteristics	
INDRD	R&D expenditures divided by sales.
APPROP	Degree of appropriability of innovation outcomes.
TECHOPP	Degree of technological opportunities.
Others: Instruments	
REQRD	Required R&D investment (million yen)
IF	Amount of internal funding, measured as founder's own funding plus his or her family's and friends' funding (million yen).

Table 2: Summary statistics of variables

Variable	Obs.	Mean	S.D.	Min.	Max.
(Dependent variable)					
INN	179	0.436	0.497	0	1
PAT	174	0.172	0.379	0	1
(Independent variable)					
Founder-specific characteristics					
UEDU	179	0.520	0.501	0	1
GEDU	179	0.134	0.342	0	1
WEXP	179	0.849	0.359	0	1
MEXP	179	0.352	0.479	0	1
INNEXP	179	0.363	0.482	0	1
PATEXP	174	0.218	0.414	0	1
ACAD	179	0.179	0.384	0	1
AGE	179	46.330	11.357	22	80
Firm-specific characteristics					
RDEXP	179	5.297	10.389	0.050	80
SIZE	179	3.838	5.471	1	53
MFOUND	179	0.480	0.501	0	1
Industry-specific characteristics					
RDINT	179	1.489	0.601	0.364	2.656
APPROP	179	1.209	0.224	0.869	1.834
TECHOPP	179	0.897	0.171	0.559	1.071
Instruments					
REQRD	179	13.059	22.714	0.100	100
IF	179	6.764	10.314	0	70

Note: This table is based on the data sets used in the instrumental variable probit regressions.

Table 3: Correlation matrix of variables (Number of obs.: 169)

Variable	*INN*	*PAT*	*UEDU*	*GEDU*	*WEXP*	*MEXP*	*INNEXP*	*PATEXP*	*ACAD*	*AGE*	*RDEXP*	*SIZE*	*MFOUND*	*RDINT*	*APPROP*	*TECHOPP*	*REQRD*	*IF*
INN	1.000																	
PAT	0.295	1.000																
UEDU	0.060	-0.061	1.000															
GEDU	0.072	0.263	-0.399	1.000														
WEXP	0.062	-0.100	-0.022	0.157	1.000													
MEXP	0.034	0.025	0.029	-0.095	-0.099	1.000												
INNEXP	0.465	0.297	0.078	0.091	0.009	0.029	1.000											
PATEXP	0.184	0.386	-0.044	0.201	-0.092	-0.052	0.508	1.000										
ACAD	0.133	0.187	0.065	0.290	0.050	0.002	0.200	0.281	1.000									
AGE	0.019	0.153	-0.027	0.096	0.008	0.157	0.193	0.303	0.236	1.000								
RDEXP	0.270	0.252	-0.094	0.323	-0.007	0.042	0.040	0.077	0.118	-0.038	1.000							
SIZE	0.078	-0.029	-0.020	-0.064	-0.075	0.145	0.097	0.002	0.004	0.132	0.189	1.000						
MFOUND	0.109	-0.003	-0.005	-0.024	-0.148	0.121	0.021	-0.074	-0.002	-0.013	0.177	0.216	1.000					
RDINT	0.108	0.123	-0.141	0.098	0.153	-0.051	0.037	0.173	0.230	0.220	0.179	-0.009	0.192	1.000				
APPROP	0.068	0.179	0.030	-0.055	-0.051	0.110	0.115	0.004	0.014	0.075	-0.047	-0.029	0.106	0.009	1.000			
TECHOPP	-0.034	-0.059	0.026	0.017	0.155	-0.065	-0.088	-0.178	-0.053	-0.266	-0.046	-0.009	0.147	0.073	0.114	1.000		
REQRD	0.366	0.270	0.010	0.113	-0.057	0.116	0.004	0.050	0.012	-0.091	0.695	0.141	0.276	0.197	0.016	0.033	1.000	
IF	0.064	-0.044	-0.004	0.123	0.082	0.036	-0.031	0.030	0.196	0.069	0.299	0.349	0.056	0.064	-0.046	-0.033	0.163	1.000

Note: This table shows the correlations between all the variables used in the instrumental variable probit regressions. Thus, the number of observations is different from those of the empirical regressions.

Table 4. Estimation results: Probit model

	(i) *INN*		(ii) *PAT*	
Variable	Coef.	S.E.	Coef.	S.E.
Founder-specific characteristics				
UEDU	0.284	0.225	0.212	0.300
GEDU	0.028	0.352	0.694*	0.411
WEXP	0.175	0.301	-0.523	0.331
MEXP	0.078	0.222	-0.086	0.283
INNEXP	1.467***	0.224		
PATEXP			0.982***	0.271
ACAD	-0.111	0.308	0.223	0.315
AGE	-0.013	0.010	0.021*	0.012
Firm-specific characteristics				
RDEXP	0.050***	0.017	0.032**	0.013
SIZE	0.005	0.025	-0.042	0.038
MFOUND	0.059	0.216	-0.207	0.283
Industry-specific characteristics				
RDINT	0.291	0.186	-0.101	0.207
APPROP	-0.125	0.461	1.276**	0.542
TECHOPP	-0.215	0.676	0.314	0.805
Constant term	-0.817	0.935	-3.723***	1.126
Pseudo R^2	0.263		0.258	
N of obs.	204		199	
Log likelihood	-102.631		-68.716	

Note:
1. S.E. indicates robust standard errors.
2. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 5. Estimation results: Probit model with an endogenous regressor

(Second stage)	(i) *INN*		(ii) *PAT*	
Variable	Coef.	S.E.	Coef.	S.E.
Endogenous variable				
RDEXP	0.098***	0.020	0.058***	0.019
Founder-specific characteristics				
UEDU	0.021	0.233	0.130	0.326
GEDU	-0.599	0.392	0.446	0.495
WEXP	0.288	0.320	-0.553	0.367
MEXP	0.070	0.225	0.009	0.301
INNEXP	1.287***	0.268		
PATEXP			1.042***	0.301
ACAD	0.069	0.309	0.087	0.348
AGE	-0.005	0.011	0.021	0.014
Firm-specific characteristics				
SIZE	-0.018	0.023	-0.045	0.037
MFOUND	-0.014	0.220	-0.284	0.315
Indsutry-specific characteristics				
RDINT	0.047	0.198	-0.237	0.231
APPROP	0.410	0.475	1.590***	0.598
TECHOPP	0.135	0.697	0.211	0.878
Constant term	-1.673*	0.971	-3.817***	1.224
(First stage)	*RDEXP*		*RDEXP*	
Founder-specific characteristics				
UEDU	0.341	1.099	0.024	1.103
GEDU	6.569***	1.734	7.145***	1.776
WEXP	-1.322	1.438	-0.407	1.488
MEXP	-0.558	1.071	-0.426	1.082
INNEXP	0.487	1.060		
PATEXP			-0.515	1.301
ACAD	-0.432	1.432	0.547	1.483
AGE	-0.048	0.049	-0.041	0.049
Firm-specific characteristics				
SIZE	0.109	0.099	0.153	0.100
MFOUND	-0.497	1.069	-0.217	1.083
Industry-specific characteristics				
RDINT	0.711	0.905	0.645	0.918
APPROP	-1.814	2.256	-1.006	2.252
TECHOPP	-4.135	3.112	-4.705	3.156
Instruments				
REQRD	0.295***	0.024	0.286***	0.024
IF	0.175***	0.050	0.125***	0.057
Constant term	7.338	4.467	6.116	4.496
N of obs.	179		174	
Log likelihood	-671.322		-624.424	
Wald test of exogeneity	7.33***		3.34*	

Note:
1. S.E. indicates standard errors.
2. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.