Determinants Of R&D Investment:  
Strategic And Entrepreneurial Characteristics  
In Japanese New Technology-Based Firms†

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Abstract

The aim of this paper is to examine the determinants of R&D investment in Japanese new technology-based firms (NTBFs) by considering several strategic and entrepreneurial characteristics thought to be causative factors. It uses original data from a questionnaire survey conducted in Japan. We find that, at the strategic level, firms’ technological capability, the availability of internal funds, and several factors associated with universities have a positive effect on R&D investment. At the entrepreneurial level, a CEO’s human capital and prior business experience in an R&D role are positively related to R&D investment. One aspect of these results is that universities play a quantifiable role in firms’ R&D investments; the former result is a direct effect of higher education, while the latter implies at least a tertiary education in order to have such prior R&D experience. The results for these two variables, coupled with the finding that joint R&D projects with universities is positively related to R&D investment, lead us to conclude that universities impact on R&D investments in NTBFs, both directly and indirectly, with implications for small firms’ innovative activities.

Key words: Strategic Characteristics; Japan; Entrepreneurial Characteristics; New Technology-Based Firms; R&D Investment, Universities.

JEL Classification: L20, M21, O32

1. Introduction

The creation and growth of new firms is recognised as imperative, not least because they are a manifestation of entrepreneurship and a source of economic growth. New technology-based firms (NTBFs), in particular, play a significant role in productivity growth and job creation in the national economy, and are associated with a sizable share of new technological innovations. Several studies, using either panel or cross-sectional data across a broad range of firm sizes, attest to the idea that smaller firms account for a disproportionately large share of innovations relative to their size, and that R&D productivity (i.e., innovations per unit of R&D) tends to decline with increasing firm size.

NTBFs have distinct characteristics that distinguish them from larger, established firms and which shape the challenges that their management face. For example, the newness and small size of these firms, the uncertainty of their endeavour, as well as the dynamics of their environment are all challenges for managers in the pursuit of business opportunities. In order to develop an understanding of

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the challenges associated with the evolution of such firms, researchers have developed models that depict their development. Though these models give insights on various challenges, they typically fail to differentiate between those tasks that are operational in nature and those that are of more strategic importance. Moreover, they generally focus on ‘hard’, tangible factors and neglect the personal characteristics of the entrepreneur, which play a particularly important role in NTBF success.

In Japan, considerable emphasis has been placed on the creation of NTBFs in the anticipation that they will contribute to the growth of the economy (Imai and Kawagoe, 2000). This has been reflected in the introduction of various governmental reforms (see Boltho and Corbett, 2000; Eshima, 2003) and legislation to generate institutional change conducive to entrepreneurship and the growth of such firms (Lynskey, 2006).

Despite this expectation that NTBFs will become more important to Japan economically, surprisingly few empirical studies (e.g. Harada, 2004; Honjo, 2004) have considered the innovative activities of such firms, or the effectiveness of policies to support such activities.

The purpose of this paper is to help address this gap by considering the determinants of R&D investment in Japanese NTBFs. In order to do so, we apply an integrative perspective and examine several strategic and entrepreneurial characteristics. Generally, studies have not undertaken such a comprehensive examination with respect to Japan; and even in the West, few studies have explicitly examined both factors together. This is surprising, because investment in R&D is clearly an important input measure of R&D capability and innovation, and a driver of future competitive advantage. Also, small- and medium-sized enterprises (SMEs) make up almost all businesses in Japan. Until recently, however, SMEs were regarded as ‘weak enterprises’ and afforded little credence, even among Japanese policymakers, or they were simply ignored.

2. Extant Research

Prior research on determinants of R&D investment has mainly considered strategic factors, such as a firm’s industry, corporate strategy and institutional shareholders. These studies, however, have examined R&D investment only in large, multinational or diversified firms, and they have not included entrepreneurial characteristics as determinants.

Other studies have specifically considered R&D investment in small technology-based firms, but again have taken only strategic factors into account, such as the impact of regulatory measures, productivity, and factors such as size, industrial sector, ownership and location (e.g., Shefer and Frenkel, 2005).

Separate from this stream of research, fewer studies have examined R&D investment in firms through another lens: from the perspective of entrepreneurial characteristics. The relative paucity of such research is surprising, since decisions on the allocation of R&D investment reside with the chief executive officer (CEO) and senior managers of firms (Green, 1995). Moreover, since R&D investment represents a long-term allocation of resources with which there is associated risk and uncertainty, the CEO invariably monitors closely such investment and adjusts it according to his preferences and the strategic direction of the firm (Zahra, 1999b). CEOs and senior managers inevitably play a role in strategic decisions on the deployment of organisational resources and the conversion of these resources into valuable products to confer managerial rents and competitive advantage (Lado et al., 1992). Penrose (1959: 5) emphasised the importance of “the productive services available to a firm from its own resources, particularly the productive services available from management with experience within the firm”. Thus, entrepreneurial characteristics, such as prior experience, are likely to impact on firm performance (Castanias and Helfat, 2001).

Those studies that have considered entrepreneurial characteristics as determinants of R&D investment have been confined mainly to large firms. Among other things, these have revealed that CEO characteristics vary according to the industry, and that those firms in high-technology sectors, where R&D investment is greater, have different CEO profiles than firms in low-technology sectors. A study
by Daellenbach et al. (1999) examined how entrepreneurial characteristics varied with R&D investment in 52 firms within two industries. While more generalisable than earlier single-industry studies, the study of only two industries limits application to a broader context.

Studies specifically examining the entrepreneurial characteristics of small firms have been far fewer. In one, Deeds et al. (2000) considered the relationship between the number of new products and R&D management capabilities - captured by educational background, such as doctorate qualifications - by using data from biomedical start-up firms. However, few, if any, studies have examined the strategic and entrepreneurial determinants of R&D investment in Japanese NTBFs.

3. Theoretical Perspective

Our theoretical perspective is that a firm’s investment in R&D is determined by factors at the strategic level and the entrepreneurial level. As mentioned above, much of the literature considers only attributes associated with the strategy of the firm; while other literature adopts the contrary approach, and considers human capital characteristics of the founder or CEO, while disregarding strategic characteristics of the firm in which the CEO operates (and, indeed, which s/he may have founded). We contend that neither approach is satisfactory, since it provides only a partial picture. The optimal methodology is to consider elements from both perspectives. In doing so, we were guided by the literature from both strategic-level and entrepreneurial-level perspectives as to which variables to consider.

The literature associated with firm strategy considers several factors. These include the availability of internal funds (e.g., Lach, 2000); the effectiveness of venture capital funding (e.g., Kortum and Lerner, 1998, 2000); geographic location (e.g., Audretsch and Feldman, 1996), and the economic benefits of university research on industrial R&D, particularly for new firms (e.g., Henderson et al., 1995; Mansfield and Lee, 1996).

The literature on entrepreneurial-level perspectives suggests that a firm’s strategies and effectiveness are associated with the values and cognitive biases of senior management, and examines features such as the CEO’s age, education and prior experience.

We refer to both of these streams of study below, when we outline hypotheses about the association between R&D investment by firms and various strategic and entrepreneurial characteristics.

4. Econometric Model

Perhaps the greatest obstacle to understanding the role of innovation in economic processes has been the lack of meaningful measures of innovation inputs and outputs. One measure that is used as an indicator of innovative activity is the intensity of a firm’s expenditure on R&D. Accordingly, then, we consider the following R&D equation:

\[ r_i = \text{const} + \alpha X_i + \delta Y_i + u_i \]

The dependent variable \( r_i \) denotes the natural logarithm of company-financed annual R&D expenditure in firm \( i \). Since many of our data on R&D take the value zero, we employ a Tobit regression model, instead of using Ordinary Least Square analysis.\(^1\)

In running regressions, we transform the dependent variable \( RD \) into \((RD+1)*10\) by using the logarithmic linear transformation. The Tobit censoring boundary is set to correspond to a zero observation (Acs et al., 1994a).

On the right-hand side of the equation, there are two categories of variables that we propose determine the level of R&D investment. The first category is represented as a vector of the strategic characteristics, \( X \); and the second category is represented as a vector of the entrepreneurial characteristics, \( Y \). These variables and the hypotheses related to them are discussed below. The complete set of variables is shown in Table 1.

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\(^1\) Tobit regression assumes the data are truncated, or censored, above or below certain values, and is used to handle the truncation at zero. See Greene (1997: 959-963).
5. Explanatory Variables and Hypotheses

5.1 Strategic Variables

Technological Capability

First, we propose that a firm’s level of ‘technological capability’ is likely to affect the extent of R&D investment. We define technological capability as the potential for firms “to undertake a set range of productive tasks aimed at improving their ability to operate specific functions and compete in specific markets and industries” (Lynskey, 1999). Technological capability provides the basis for in-house innovation and competitive advantage (Cohen and Levinthal, 1990). Specifically, it is seen as the resource that enables a firm to generate innovations in products, process and engineering projects. As such, technological capability is regarded as a strategic resource enabling firms to achieve competitive advantage within their industry. Those firms with superior technological capability can secure greater efficiency gains and deliver innovation in response to the changing market environment.

Several studies (e.g., Afuah, 2002; Schoenecker and Swanson, 2002) employ R&D expenditure as the core measurement indicator of technological capability; this is not surprising, since a firm’s technological capability correlates significantly with the development, absorption and application of technological knowledge. Moreover, technological capability has been shown to be a determinant of performance in technology-based venture firms (e.g., Lee et al., 2001).

Here we denote technological capability by the independent variable TC, defined as the number of R&D personnel to total employees. We expect that R&D investment in a firm will increase if technological capability increases; hence, the coefficient of TC is predicted to be positive in our regressions.  

H1: R&D investment is positively related to the technological capability of a firm.

Internal Funds

Theoretical reasons for the existence of capital market imperfections in the financing of R&D are well known. The nature of R&D is typically characterised by substantial sunk costs and is accompanied by a great deal of uncertainty, such that it is difficult to evaluate the outcome of R&D, and predict the investment value precisely, which prevents firms from borrowing to finance R&D projects. Thus, equity finance or debt-based finance often becomes difficult to attract, especially for start-up firms that have no reputation in the market (Hall, 2002). Additionally, the traditional low levels and late-stage provision of venture capital in Japan, coupled with the reluctance of venture capital firms to invest in start-up firms, compounds the difficulties faced by Japanese NTBFs (Lynskey, 2004, 2006). Moreover, the firm may seek secrecy for strategic reasons and prefer internal financing of R&D. These factors tend to result in R&D investment being financed through internal funds and bank loans, at least in the early stages.

Here, the independent variable SALES is defined as the natural logarithm of firms’ sales in the previous year. This is a plausible proxy for the availability of internal funds, a fraction of which is allocated to R&D in the successive year. Hall (1992) notes that firms finance most R&D from their internal funds; and other studies (e.g. Himmelberg and Petersen, 1994; Mulkay et al., 2001) provide further empirical evidence of a significant positive relationship between R&D and available internal funding. Moreover, a firm’s probability of undertaking R&D activities and its R&D expenditure increase with market power (Gonzáles and Pazó, 2004). Hence, we predict that there is a positive relationship between R&D investment and sales.

H2: R&D investment is positively related to the availability of internal funds.

2 Naturally, there may be other elements of firms that might make up their technological capability, e.g. physical assets such as laboratories and computer resources.

3 The variable SALES may also be interpreted as a proxy for demand. See, for example, Cohen and Klepper (1996).
Venture Capital

The amount of venture capital funding in Japan is one of the lowest among developed countries. Although a series of legislations and modifications to the investment system have been enacted in recent years to encourage risk capital investments, the amount of venture capital funding in Japan remains small compared to Europe and the USA. The main impediment to venture capital funding in Japan lies in the risk-averse nature of its investors and the practice of portfolio investment rather than true venture capital investment (Schaede, 2008).

Although venture capital firms in Japan exhibit several differences in their funding strategy when compared to similar firms elsewhere (see Kuemmerle, 2001; Mayer et al., 2003), we test if venture capital funds stimulate R&D investment in our sample of firms, as one might suppose from studies of venture capital firms in the West (e.g. Kortum and Lerner, 2000). One might reasonably expect venture capital funding to stimulate R&D investment in Japanese NTBFs, if they can attract such funding. We introduce the variable VC, which we define as the share of venture capital financing to the total initial funds available to a firm.

**H3:** R&D investment is positively related to venture capital funding.

Business Planning

The literature is divided as to whether business planning is an important precursor to action in new firms, or if it impedes the efforts of the founders of such firms. Rue and Ibrahim (1998) investigated the relationship between planning and business performance, and in their review of the literature they stated that, “the literature strongly supports the argument that, in small business, planning is a key issue”. Their own results, however, were statistically inconclusive, except for the finding that firms with no written plans exhibited slower growth rates than those with sophisticated planning. Later research (e.g., Perry, 2001; Delmar and Shane, 2003, 2004) supported the idea that planning produces desirable outcomes, and that it enhances both product and venture firm development.

Other literature, however, contends that it is likely that NTBFs do not - and perhaps cannot - allocate sufficient resources to business planning. According to these studies, the uncertainty and pace of entrepreneurial situations undermine the value of business planning, so founders should move directly to action (Carter et al., 1996). Research by Bhidé (2000) on start-ups firms indicates that they do not formulate elaborate business plans because they must make decisions quickly in response to changing circumstances, thereby making redundant previously formulated plans. Indeed, Allinson et al. (2000) contend that entrepreneurs should rely more on their intuition, rather than engage in planning and risk using information that is likely to be inaccurate or out-of-date. Moreover, data from Japan claims that over 40 percent of Japanese SMEs make business plans purely for ‘negative’ reasons, such as their inability to attract investment without such a plan, or because outsiders have advised them to do so. This is consistent with findings elsewhere. In such cases, planning is merely symbolic: it is seen as desirable because it lends legitimacy to a venture; or, by emulating the practices of successful firms, ventures hope to become imbued with the same quality.

Despite these ambiguous results, we concur with several researchers (e.g., Szakonyi, 1990; Zantout and Tsetsekos, 1994) that it is incumbent on firms to articulate a business plan, and that this clarifies the allocation of investment in R&D. We introduce a binary dummy variable, B_PLAN, which is assigned a value of one if a firm makes a business plan, and zero otherwise.

**H4:** R&D investment is positively related to making a business plan.

R&D with Universities

Universities are recognised as a repository of public knowledge, and knowledge emanating from them has become important, owing to the development of new and improved products depending on
academic research (David, 1994; Hall et al., 2000). University research often stimulates and enhances the power of R&D done in industry, rather than provides a substitute for it. Consequently, academic and business research should be seen as overlapping and interacting, with the former augmenting the capacity of the latter to solve an increasing range of complex questions.

Empirical studies show that strategic-level effects induced by university knowledge occur on two levels (Stephan, 1996). First, internalising scientific knowledge leads to the expansion of firms technological capabilities (mentioned previously) for developing new or improved products (Jaffe, 1989; Cockburn and Henderson, 1997), which becomes manifest in an improvement of technological know-how and skills. Secondly, knowledge generated in universities improves firms’ research efficiency. Such knowledge accelerates the lead-time of innovations and increases the rates of return of R&D.

After the pioneering work of Jaffe (1989), economists have investigated who best utilises university knowledge to achieve industrial innovations. According to their empirical results, university knowledge is thought to benefit NTBFs in particular, by enabling them to compensate for their competitive disadvantage due to their size (Acs et al., 1994a; Cohen and Klepper, 1996a, b). Small high-technology firms that engage in university-based research are likely to exhibit a higher rate of return to R&D and have an advantage compared with larger firms in exploiting university research (Lee et al., 2001). Mansfield (1991) also asserts that smaller firms have an advantage in commercialising the results of university research. Acs et al. (1994a) revealed that external knowledge contributes more to the innovation process in small firms than in large firms, which tend to rely more on their in-house R&D activities. Small firms have more to learn from external sources of knowledge, and have greater potential for growth stimulated by collaborative R&D linkages with universities than do their larger counterparts (Sakakibara, 1997). Thus, university knowledge is part of the total stock of externally available and relevant technological knowledge available to start-up innovative firms (Mansfield, 1995), especially those that have not accumulated enough R&D assets through their own in-house efforts, as is the case with start-up firms (Santoro and Chakrabatri, 2002).

In addition to this literature referring to research from Europe and the USA, similar results are reported from empirical studies conducted in Japan. In an examination of Japanese manufacturing firms undertaking R&D, Motohashi (2004) reports that small firms have increasingly become involved with university linkages, and newer firms are likely to engage in joint research with university-based scientists. Moreover, based on the exploitation of university knowledge through collaborative research, newer firms were found to achieve more technical and commercial success in innovations, measured as patent productivity and value-added growth, respectively. Elsewhere, it was reported that new and small firms are likely to achieve higher sales growth on the basis of university-industry collaboration (JSBRI, 2003). Furthermore, analysis of longitudinal data suggests that small firms are likely to exploit university knowledge in an attempt to optimise the use of relatively few internal resources to enhance their core competence (Nakayama et al., 2003).

Here, we examine the effect of collaborative R&D projects with universities on R&D investment made by NTBFs. The independent variable JRDU is defined as the number of joint R&D projects that a firm undertakes with universities. We expect that a firm’s R&D investment is positively related to JRDU. This follows from the idea that a NTBF needs to conduct additional R&D in order to absorb and sufficiently utilise scientific knowledge that is transferred from universities, in accordance with the concept of absorptive capacity (Cohen and Levinthal, 1989, 1990).

H5: R&D investment is positively related to the number of R&D projects with universities.

Location

March and Simon (1958) suggested that ‘borrowing’ is the catalyst in most innovation; as such, innovation is dependent on a firm’s ability to be aware
of and associate with such sources of knowledge, together with its capacity to assimilate and apply such knowledge to R&D (Lynskey, 1999). Such ‘borrowing’ is easier where the benefits of agglomeration economies, such as knowledge spillovers, labour pooling and specialised suppliers, come into effect and provide firms in a localised cluster with a competitive advantage over firms located outside the cluster. ‘Technological externalities’ or knowledge spillovers (Marshall, 1949; Porter, 1990; Krugman, 1991; Saxenian, 1994; Audretsch and Feldman, 1996; Feldman, 1999) are associated with ‘hot spots’ - the concentration of similar firms in close geographic proximity (Pouder and St. John, 1996; von Burg and Kenney, 2002).

Empirical studies on knowledge spillovers suggest that knowledge tends to be localised (Jaffe et al., 1993; Audretsch, 1998). Since such knowledge enhances the ‘technological capabilities’ of firms, those firms in close proximity to one another should exhibit benefits. For example, Deeds et al. (2000) show that the concentration of same-sector firms in a biotechnology firm’s geographic area is positively related to the number of new products developed by the firm. The benefits of location have also been explored in other technology sectors, such as computer software and optoelectronics. Moreover, the overall level of R&D investment is an important factor associated with geographic location (Acs et al., 1994b).

In addition to knowledge spillovers from other firms in a location, firms may enjoy externalities from proximity to universities or research institutes (Jaffe, 1989; Link and Rees, 1990; Acs et al., 1992; Acs et al., 1994a; Lissoni 2001; Lynskey, 2008). The rationale for this is that, since some of the knowledge of university-based scientists required for industrial innovation is not codified, the transfer of tacit knowledge requires firms to maintain face-to-face interactions with such scientists (see Beise and Stahl, 1999; Nooteboom, 1999). Mansfield (1995) contends that proximity is significant when the knowledge that is transferred is applied rather than basic. This has been supported in more recent studies by Autant-Bernard (2001) and Acs et al. (2002). Zucker and Darby’s (1998, 1999) notion of ‘star scientists’ are examples of university biomedical specialists whose proximity to, or close collaboration with, biotechnology firms is thought to assist the commercialisation of academic research and impact favourably on firm creation and growth.

Owing to the centralised nature of Japanese academia and society, R&D activities are focused largely on Tokyo (see Masser, 1990; Kubo and Harada, 2001; Suzuki, 2001; Lynskey, 2006). In addition, the recipient firms of new and follow-on venture capital investments in Japan are also concentrated in Tokyo, with 47.5 percent of new and follow-on investments by amount, and 46.8 percent by number, directed to firms in Tokyo.

For the purpose of this study, therefore, we look specifically at Tokyo, and define TOKYO as a binary dummy variable that takes the value 1 when a firm is located in Tokyo, or zero otherwise. We expect this variable to be positively related to R&D investment because of the presence of agglomeration economies.

H6: R&D investment is positively related to the location of the firm.

Age of the Firm

The final firm-level variable, F_AGE, is a control variable defined as the number of years that have elapsed since a firm was established. We consider firm age because research suggests that firm growth and the probability that a firm will fail decrease with firm age (Evans 1987). This variable partly reflects the macroeconomic conditions that prevailed in the year when a firm was founded. Highfield and Smiley (1987) suggest that macroeconomic factors are one of two factors (the other one being microeconomic factors) that influence the rate of creation of new firms. One of the incentives for an entrepreneur to establish a NTBF and engage in research is to commercialise the results of R&D and to seek rents thereby from doing so (Kirzner, 1973; Lynskey, 2002). The macroeconomic conditions prevailing in the year when a firm is established have some effect on the rent-seeking activities of the firm, however, and influence its subsequent development and
R&D expenditure. Since such effects might bias the regression results, we control for these macroeconomic effects by using the variable F_AGE.

5.2 Entrepreneurship Variables

In addition to these strategic characteristics, we propose that R&D investment in NTBFs is affected also by entrepreneurial characteristics, such as human capital. Entrepreneurship here is used in the sense of Schumpeterian types, as well as the managerial types who manage their business and compete for market share. The following refer to the entrepreneurial variables shown in Table 1.

Education – Direct Effect

Human capital (education) is one of the fundamental variables explaining entrepreneurship (Evans and Leighton, 1989; Kim et al., 2006). We consider the tertiary-level education of the founder or CEO of the NTBF to be an important factor in the level R&D investment, because discernment of the value of R&D and its capabilities requires specialised knowledge acquired through higher education. Studies (Hitt and Tyler, 1991; Wally and Baum, 1994) suggest that more educated managers have greater cognitive complexity. It is generally assumed that such cognition provides greater ability to absorb new ideas and accept innovations. Studies also indicate a positive effect between education and self-employment (Robinson and Sexton, 1994; Reynolds, 1997b). Bates (1995), who controlled for differences in industry when examining the role of education, also found a positive relationship between education and self-employment.

Studies suggest that education is a key differentiating factor between high-technology entrepreneurs and the general population of entrepreneurs, since the former exhibit high levels of educational attainment (Klandt and Szyperski, 1988; Roberts, 1991; Westhead and Storey, 1994). Studies have also found that CEOs with higher levels of education lead more innovative firms (Kimberly and Evanisko, 1981; Bantel and Jackson, 1989; Thomas et al., 1991). Klandt and Szyperski’s (1988) study found that 88 percent of the founders of new technology based firms had attended university, compared to 32 percent of founders in general and 7.5 percent of employees. In their study, Westhead and Storey (1994) revealed that 84 percent of high technology entrepreneurs have a degree and 48 percent have a higher degree, while only 20 percent of entrepreneurs in general are educated to degree level and only 2 percent have a post-graduate qualification. Bhidé (2000) revealed that more than 80 percent of the entrepreneurs in his study had a university education. Thus, education appears to have a positive impact on self-employment, at least in some (knowledge-intensive) industries.

Studies also report a positive relationship between education and firm growth (e.g., Van de Ven et al., 1984; Roberts, 1991; Jo and Lee, 1996; Almus and Nerlinger, 1999; Wilbon, 2000), although this does not appear to be straightforward. Van de Ven et al. (1984) and Jo and Lee (1996), for example, find a direct and linear relationship between education and performance. The relationship between performance and education beyond degree level is not supported, however, in Almus and Nerlinger (1999); and Roberts (1991) does not find a relationship between performance and education beyond master’s degree level. Almus and Nerlinger (1999) examine the impact of degree type on performance in technology-based new firms, and find that firms established by entrepreneurs with technical degrees grow more rapidly than those with other qualifications. This may be because science and engineering degrees create managers that have a more thorough understanding of technology and a more positive attitude to innovation (Tyler and Steensma, 1998).

Almus and Nerlinger (1999) also affirm that neither postgraduate business education, in the form of an MBA, nor the combination of an MBA and a technical degree, impact on growth. This supports findings that MBA programmes do little to develop innovative or risk-taking skills in students (see Hambrick and Mason, 1984; Finkelstein and Hambrick, 1996). Stuart and Abetti (1990) find a negative, though not significant, relationship between education and performance, resulting primarily from the relatively poor performance of PhDs. Likewise a
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study by Roberts (1991) reveals that education beyond master’s degree level is negatively linked to success. In other words, while entrepreneurs with degrees generally outperform those without degrees, entrepreneurs with PhDs do not perform as well as those with master degrees. Roberts (1991) suggests that the association between education and success in high technology firms is most likely to represent an ‘inverted “U”’ relationship rather than any statistically significant direct relationship. Here, we consider a CEO’s tertiary-level education to be a determining factor in the level of R&D investment in NTBFs. Since the proportion of CEOs with first degrees is very high in Japan, we decided that an opposite measure is how many CEOs have postgraduate degrees.

**Education – Indirect Effect**

In addition to this direct effect, human capital (educational background) is also likely to have an indirect effect on R&D investment in NTBFs. It helps to overcome barriers in obtaining credit/equity, as well as fostering social networks, which in turn help to reduce transactions costs (Williamson, 1971; Nanda and Sorenson, 2007). Bates (1990), for example, shows that entrepreneurs with higher educational qualifications can raise money from capital markets more easily, and can survive in the market longer. Similarly, Scherer and Huh (1992) make a link between senior managers’ education and the level of R&D investment. In such cases, educational credentials appear to signify the entrepreneur’s potential in managing a successful firm. Here, UNIV_G denotes a dummy variable that takes the value 1 when a CEO has graduated from a post-graduate programme, and is otherwise zero.

**H7:** R&D investment is positively related to the CEO’s educational background.

**Prior Experience in R&D**

In an early study on the influence of managers’ career experiences, Dearborn and Simon (1958) argued that experience of a particular business function in a firm causes managers to perceive and interpret information in ways that are consistent with and replicate their functional training. Later studies suggest that CEOs with significant career experience in output functions (i.e. R&D/engineering and marketing/sales) favour innovation strategies because these functions emphasise growth through discovering new products and markets (Hambrick and Mason, 1984; Finkelstein and Hambrick, 1996). Consequently, CEOs with output function career experience are likely to favour higher R&D investment as part of their focus on innovation. Indeed, Thomas et al. (1991) found that firms in the computer industry pursuing strategies of product and market innovation had CEOs whose primary career experience was in output functions.

Determining the appropriate level of R&D investment is likely to require a CEO to have practical knowledge that can only be gleaned from actual business experience in an R&D function. In contrast to the explicit or codified knowledge gained through formal education, and accounted for above under education, this type of knowledge is tacit in nature (Polanyi, 1958). It may be evident, for example, in the know-how needed to allocate proper resources to R&D, to organise research projects, and in other ‘hands-on’ tasks. Hills et al. (1999) suggest that between 50–90 percent of start-up ideas derive from prior work experience. Such findings lend support to Stinchcombe’s (1965) notion of the ‘liability of newness’, and the argument that firms tend to be established in those fields of previous relevant experience to the founder. Therefore, a CEO’s prior experience in an R&D capacity will impact on a NTBF’s ability to grow and be innovative, and may in part substitute for its lack of a track record. We assume that this prior experience is essential in conducting R&D efficiently in NTBFs, and in determining the appropriate level of R&D investment in such firms. Here, EXP_RD is a binary dummy variable that is set to one when a CEO has such prior experience before founding his own firm, but is otherwise zero.

**H8:** R&D investment is positively related to a CEO’s prior experience in an R&D role.
Next, we consider the effects of overt ‘entrepreneurship’ on the level of R&D investment. Entrepreneurship is a notoriously difficult concept to measure, and researchers from different disciplines have attempted to capture it using different constructs (Lynskey, 2002). Here, we attempt to examine entrepreneurship by four variables that attempt to capture ‘entrepreneurship experience’.

**CEO as Firm Founder**

We assume that the CEO who is also the founder of the firm will tend to exhibit greater flexibility and swiftness in decision-making, which we see as a quality of entrepreneurship in new firms because the position still has novelty and is challenging. The founder-CEO is likely to be a leader with both a clear entrepreneurial vision and the means to implement it (Penrose, 1959; Greiner, 1972). The founder-CEO is likely to have a ‘self-set’ goal (e.g., to create a new product) rather than a relative goal (e.g., to make more money than other firms), and as a result his motivation to reach his goal is likely to be higher. Moreover, those firms where the founder is still the CEO have most likely not yet reached the stage of ‘bureaucratic sclerosis’ or the ‘entrepreneurial paradox’ signified by a firm in which bureaucracy impedes innovation and individual action (Schumpeter, 1942). Nor have they reached the level identified by Chandler (1962) where professional managers replace the founding entrepreneur.

Since the NTBFs under consideration in this study are by nature new firms, they are unlikely to have CEOs of long tenure. Studies on the tenure of CEOs suggest that long-tenured CEOs tend to make fewer changes in strategy as their tenure increases (Grimm and Smith, 1991). Hambrick and Fukutomi (1991) asserted that this lack of change occurs because, with increasing length of tenure, CEOs became more strongly committed to implementing their own paradigm for how a firm should be run. Hambrick and Fukutomi (1991) also argued that longer-tenured CEOs might lose interest in implementing organisational changes as their outside interests increase and the novelty of a CEO’s job decreases. Moreover, Miller (1991) argued that longer-tenured CEOs may lose touch with their firms’ environments and may not make the changes and investments necessary to keep the firm evolving over time. Given such findings, longer-tenured CEOs may have little interest in pursuing strategies of innovation through higher R&D investment.

On the other hand, we expect that NTBFs with a founder-CEO react quickly to changes in the business environment and pursue a business model of higher R&D investment. It is interesting that Graber (2003) found an inverse relationship between turnover of senior management in technology-based firms, especially the CEO, and R&D expenditure, and that this was particularly pronounced in small firms. Here, ENTRE denotes whether the current CEO is also the founding entrepreneur of the firm; this dummy variable takes a value of 1 if the current CEO is the founder of a firm, and is otherwise zero.

**H9**: R&D investment is high in a firm whose CEO is also the founder.

**Age of the CEO**

The subsequent variable, M_AGE, denotes the age of the CEO. Cressy (1996) suggests a model that assumes the probability of a new firm’s survival is an increasing function of an entrepreneur’s age. According to Harada (2003), however, an entrepreneur’s age is negatively related to entrepreneurial success in Japan. In this study, we assume that a younger CEO is likely to be more entrepreneurial, in terms of having ‘energy, drive and a willingness to accept change’ (Child, 1974: 181), and being more comfortable with ambiguity and uncertainty - a quality recognised by Bhidé (2000) - than an older CEO, whom, we assume, is likely to be more cautious and risk averse. This is in agreement with several empirical studies, which have shown that older CEOs follow lower-growth strategies (Child, 1974), and tend to be more conservative (Hambrick and Mason, 1984) and risk averse (MacCrimmon and Wehrung, 1986). In terms of R&D investment, research by Dechow and Sloan (1991) showed that CEOs often reduce R&D investment in the years leading up to their exit, while younger CEOs are
more risk tolerant in increasing R&D investment because their career and financial security concerns have a longer time horizon. Gwynne (2003: 13) suggests that, ‘It may be logical for older CEOs to focus on short-term goals rather than long-term R&D investment’.

H10: R&D investment is negatively related to the age of the CEO.

Prior experience in the role of CEO

Similar prior experience, as a CEO or a founder of a start-up firm, plays a prominent role in successful opportunity recognition processes in entrepreneurs (Hills and Shrader, 1998; Shane, 2000; Shepherd and De Tienne, 2001; Ardichvili et al., 2003), and provides the most relevant experience for new firm managers. Ronstadt (1988) proposed the notion of the ‘corridor principle’ to account for multiple venture formation by the same entrepreneur. This concept suggests that the act of having established a venture firm moves an entrepreneur down a corridor that allows him to see intersecting corridors leading to new venture opportunities that he could neither see, nor take advantage of, until he had started his first venture. The first time entrepreneur subsequently sees more attractive opportunities after the initial venture is launched; new venture ‘corridors’ open to him, often because more is known or discovered about relevant contacts, reliable suppliers, viable markets, product availability, competitive resources and response time. The essential point here is that this knowledge and the opportunities they reveal most often emerge only after one establishes a business. Venkataraman (1997) uses similar imagery, and suggests that each person develops a knowledge corridor that enables one to see the potential benefit in an opportunity because one has an existing frame of reference with which to interpret it. Stuart and Abetti (1990) find a strong positive correlation between entrepreneurial experience and performance, and rank prior experience as an owner manager as the highest level of management experience attainable in their study. Such prior experience enables CEOs to avoid the ‘liability of newness’ in adjusting to a new role (Stinchcombe, 1965), and thus avoid one of the difficulties to which a new organisation is exposed.

Thus, those CEOs that have experience of running other companies, including previous ventures, before founding and/or running their current firm are more likely to possess better know-how about management in technology start-ups. The penultimate variable, EXP_CEO, is a dummy variable that signifies the CEO’s similar prior experience, as a CEO in another firm. This takes the value of 1 if the current CEO has previous experience of managing other firms, and is otherwise set to zero.

H11: R&D investment is positively related to the CEO’s prior experience in running other firms.

CEO’s participation in networks

The final management variable, NWK, is a dummy variable that represents whether the CEO is engaged in a social network with other entrepreneurs and researchers, including university researchers (Aldrich and Zimmer, 1986; Saxenian, 1990, 1991; Dubini and Aldrich, 1991; Burt, 1993). The advantages of being a member of such a network are that the CEO has established socially embedded strong and weak ties (Granovetter, 1973), redundant and non-redundant ties (Burt, 1992b) and direct and non-direct ties (Ahuja, 2000) to the sources where useful information is likely to arise, and has reliable channels to convey such knowledge from those sources. Such kinds of networks could bring useful information on, for example, new technology and competing businesses, and also permit the CEO to obtain resources cheaper than they could be obtained on markets and to secure resources that would not be available on markets at all, such as reputation and customer contacts (Witt, 2004). Network relationships with various actors also positively affect innovation performance and productivity (Pittaway et al., 2004). In the case of small firms, innovation appears to be related to the extent to which they are embedded locally in networks (Freel, 2003). NWK is set to 1 if the CEO is actively engaged in such a network.
H12: R&D investment is positively related to the CEO’s extent of networking.

Finally, since differences among industries may have an effect on the innovative activities of NTBFs, we introduce six industry dummies based on the Standard Industrial Classification of Japan (SICJ) to treat these differences. Table 1 lists the complete set of variables and their definitions.

6. Data

The data for this study is from an original database compiled from a questionnaire survey sent to firms in several sectors: (1) chemical, (2) metalworking machinery, (3) special industrial machinery, (4) electrical machinery, (5) motor vehicles and associated parts, and (6) precision instruments. An identical follow-up survey was sent to firms in the information technology and biotechnology sectors. Our sample, representing a response rate of 27.9 percent, were firms classified into one of eight sectors, and which had been established for 10 years or less. Regarding the distribution of the ages of the firms, 36.2 percent of the firms were formed in the initial three years, but this ratio declined later; only 6.9 percent of the firms were formed in the final three years. Table 1 shows a list of the variables we consider, and Table 2 shows the summary statistics of our sample firms.

7. Empirical Results

We conducted five regressions depending on the combination of ‘entrepreneurship’ variables. The estimated results are reported in table 3. This shows that the pseudo R-squared is 0.14, indicating a valid regression model.4 The following discusses the results of our estimations for each of the independent variables.

As expected, the coefficient of TC shows a significantly positive sign in each regression. This indicates that a firm’s technological capability is an important determinant of R&D and augments the level of R&D investment, confirming hypothesis H1. Table 3 also shows that SALES is significantly and positively related to current R&D investment. Taking into account the existence of both information asymmetries and capital market imperfections, it is often difficult for start-ups to raise funds for R&D from outside the firm. This suggests that our sample firms had to depend substantially on internal funds such as sufficient cash flows; and, indeed, this has invariably been the case with venture firms in Japan (Lynskey, 2004, 2006). Conversely, one could also interpret SALES as a proxy for demand (Cohen and Klepper, 1996a,b).5 An increase in demand enables a firm to appropriate some of its R&D expenditure, in which case R&D is positively related to demand. In any case, our results corroborate hypothesis H2.

The coefficients of VC are positive, confirming hypothesis H3, but insignificant in the regressions. Table 2 shows that the mean of the variable VC is only about 0.0008, which implies that venture capital funds were almost negligible in our sample firms and not an important determinant of R&D investment. This appears to be an accurate reflection of the situation in Japan (Lynskey and Yonekura, 2001). Unlike venture capital firms in the USA or Europe, venture capital in Japan has tended to be invested later - at, or just before, an initial public offering (IPO), when a firm is already looking successful. Moreover, the scale of venture capital investment in Japan has been much less than that in Europe or the USA. Since many Japanese venture capital firms are subsidiaries of banks or securities companies, their primary goal was not to achieve the highest return on investment but, instead, to increase the business of their parent company. They have also lacked the expertise to assess technology projects and have been risk-averse in providing funds for R&D in NTBFs.

The coefficient of the variable B_PLAN is positive, supporting hypothesis H4, but insignificant. This is consistent with the results gleaned for small

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4 Pseudo R-squared is an indicator used to check the fitness of non-linear regression models such as Tobit.

5 SALES is also a proxy for the firm size. Estimated results show that elasticity of sales is below unity. This means that innovative activities are simply proportional to firm size.
Dollars in the USA by Perry (2001), who found a positive relationship between planning and firm failure, although the explanatory power of the relationship was weak. Perry (2001) makes the observation that there is likely to be some minimum employment level, perhaps in the range of five to 15 employees, below which formal (written) planning has marginal value. For businesses below this threshold, the limited scope, scale and complexity of a business are conducive to simple and intuitive planning, and the communication of plans may not require documentation, since so few people are involved. We surmise that in Japan, small, start-up firms, typically with very few employees, rarely undertake formal, written planning. Indeed, it may have limited value and utility, even for technology-based ventures, since, generally, they have not been required to develop an elaborate and sophisticated business plan in order to attract finance or to establish commercial credit with lenders (Bhidé, 2000). Our results are consistent with other findings from Japanese SMEs, which indicate that approximately 70 percent of those with fewer than 20 employees, and nearly two-thirds of those with fewer than 100 employees, make no business plan whatsoever. Moreover, 18.9 percent of Japanese SMEs make a business plan merely because, otherwise, they are unable to borrow capital; and a further 22.2 percent do so only because of the advice from outsiders (SMEA, 2000). The value of business planning, therefore, appears to be ‘context dependent’ (Castrogiovanni, 1996). In addition, of course, there is a distinction between the actual writing of a business plan and the process of planning – which may not result in a business plan. Moreover, it is likely not business planning per se, but the quality and content of the business plan that is important (Matherne, 2004).

The coefficient of JRDU is positive and significant in the estimations, validating hypothesis H5. These results suggest that joint R&D projects with universities augment firms’ in-house R&D and stimulate them to increase R&D investment. As previous studies (e.g., Cohen and Levinthal, 1989, 1990; Cockburn and Henderson, 1997) suggest, firms may have to develop their own technological capabilities by means of in-house R&D to assimilate and apply knowledge from universities, which may be especially important for technology-based new firms.

The variable TOKYO is insignificant in our equations. We were unable to find evidence that the sampled NTBFs located in Tokyo enjoy positive externalities from their location in a concentration of other similar firms. Moreover, despite our introducing a new dummy variable METRO, which was set to one when a firm was located in Tokyo or Osaka, we could not derive a significantly positive coefficient from this variable. This may be because the number of NTBFs has to attain a critical value before the effect of knowledge spillovers and other attributes of agglomeration economies set in. Indeed, this may also help to explain why venture capital has not been as prominent in Japan as in other advanced economies. Studies imply that the scarcity of liquidity events in Japan, such as IPOs and acquisitions of new ventures, impacts negatively on the formation of new ventures in metropolitan areas such as Tokyo. Since access to venture capital has hitherto been unimportant for Japanese start-up firms, which instead have relied on infusions of capital from personal wealth or traditional banks, and since there are few IPOs and acquisitions of new ventures, location in a concentration of similar firms provide few agglomeration economy benefits.

Turning to the entrepreneurial characteristics, both UNIV_G and EXP_RD show significantly positive coefficients in the regressions, corroborating hypotheses H7 and H8. The former result implies that a CEO with a higher level of formal education more successfully manages the innovative activities of technology start-ups. Likewise, the fact that EXP_RD also shows positive signs suggests that experience in an R&D function before founding one’s own technology-related firm is useful to founder-CEOs after starting up their firms. Hence, R&D management capability described in terms of educational background or previous experience in an R&D role is an important factor in technology-based start-ups.

On the other hand, we could not derive significant results from the four variables designated for entrepreneurship. First, ENTRE did not show sig-
significant signs in the regressions, suggesting that it is unimportant if the current CEO is the founder of the firm. This implies, from our initial speculations, that a flexible decision-making process is not crucial to R&D and R&D investment in technology start-ups. This is perhaps reasonable given the exploratory and long-term nature of much R&D. It may be more important, however, for ‘output functions’ other than R&D, such as engineering, marketing or sales. M_AGE was also insignificant in our results, suggesting that the age of a CEO is irrelevant to the R&D management of such firms. One of the reasons for this may be that R&D management is affected, not by the general experience captured by M_AGE, but by the special experience captured by EXP_RD, which was significantly positive in our results. Another explanation is that the CEOs in our sample firms were relatively old, with an average age of 51, and we did not have enough younger CEOs in our sample.\(^6\) Indeed, studies suggest that the founding entrepreneurs of NTBFs are relatively old in Japan. Similarly, the variable NWK did not show a significant sign in our regressions. Networking with university researchers may well be an important element in R&D activity, but it does not appear to be an indispensable element in R&D investment; or else JRDU, which was significant in our results at the firm-level, may have absorbed the effects of this variable. The variable EX_CEO was also insignificant in the regressions. This may be because the entrepreneurial characteristic captured by EX_CEO is an aggregation related mainly to management of the firm as a whole, and is either too broad to capture R&D management per se, or is irrelevant to it.

8. Conclusion

This study attempted to examine empirically the determinants of R&D investment in Japanese new technology-based firms, using firm data compiled from an original questionnaire survey. We proposed that R&D investment in NTBFs are likely to be affected both by *strategic* characteristics, such as technological capability or the availability of internal funds, and by *entrepreneurial* characteristics, such as university education.

Three of the seven strategic variables we selected (technological capability, sales and the number of joint R&D projects with universities) show statistically significant signs in our models. Technological capability shows a significantly positive sign in each regression, suggesting that it augments the level of R&D investment. Sales also show significantly positive signs in our results, implying that the availability of internal funds is an important determinant of R&D investment in Japanese NTBFs. This is particularly so since venture capital funding in the early stage of a firm’s development is difficult to attract in Japan. Indeed, our results showed that venture capital funding is insignificant in our regressions, suggesting that venture capital is not important in stimulating R&D investment in new Japanese firms. This has been borne out in several other studies. Research with universities, however, is positively related to company financed R&D. This suggests that joint R&D with universities and in-house R&D are complementary, and a firm may have to conduct additional R&D to absorb knowledge efficiently from universities. Surprisingly, the variable TOKYO did not show statistically significant signs in our regressions. We could not find evidence that technology start-ups enjoy positive externalities from their location where many firms concentrate. This may be owing to the relatively small number of firms in our sample (145), or because there is a tendency for such technology-based firms to collaborate instead with universities, which we were able to capture in our regressions.

Regarding the entrepreneurial characteristics, a CEO’s educational background and prior experience in an R&D function both show significantly positive coefficients in the regressions. These results suggest that universities play a role in firms’ R&D investments; the former result is a direct effect of higher education, while the latter implies at least a tertiary education in order to have such prior R&D experience. The results for these two variables, coupled with the finding that joint R&D pro-

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\(^6\) We tested whether there is a non-linear relationship between age of the manager and R&D intensity, introducing the square term of M_AGE, but we did not find significant results from these models.
Determinants Of R&D Investment: Strategic And Entrepreneurial Characteristics In Japanese New Technology-Based Firms (Michael J. Lynskey)

Projects with universities is positively related to R&D investment, lead us to conclude that universities impact on R&D investments in NTBFs, both directly and indirectly.

Finally, we refer to limitations in our analysis. Firstly, we were unable to examine the determinants of R&D investment in firms that did not conduct such investments in the year under consideration. Reports from the Japanese government indicate that many small firms in Japan do not conduct in-house R&D – usually undertaking collaborative R&D instead - because of the lack of managerial resources and finance. Unfortunately, the results of our survey did not allow us to examine what differences there are between research-based firms and those less inclined to pursue research activities. This may be a topic for future examination when data on such firms becomes available. Secondly, our definition of new technology-based firms may be too broad. As such, we were unable to consider the effects of industry characteristics on R&D investment, one of which is the degree of appropriability in each industry. How these differences between industries alter the level of R&D investment in start-up firms may also be an interesting topic for further research.

Another limitation, which we recognise, is that the R&D variable measures only inputs to the R&D process, not intermediate-stage outputs such as patents or the commercialisation of products. If venture capital financing is generally beyond the seed stage, and R&D is an input to the innovation process, and therefore occurs early, it is more likely that venture capital will be linked to later stage innovation variables like product introductions. R&D investment may even lead to venture capital financing, because such firms are more attractive to venture capital companies. In addition, location may provide advantages for later-stage outcomes, such as product introductions, for example, because of proximity to partnering firms or suppliers.

Nevertheless, we have made an attempt to examine some strategic and entrepreneurial characteristics of NTBFs in Japan, a field that has hitherto been largely unexplored because of insufficient up-to-date data.

Table 1 List of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>RD</td>
<td>Natural logarithm of R&amp;D expenditure in year Y_n</td>
</tr>
<tr>
<td>TC</td>
<td>Technological capability: researchers to total employees in year Y_n-1</td>
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<tr>
<td>SALES</td>
<td>Natural logarithm of sales in year Y_n-1 (in ¥ millions)</td>
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<td>VC</td>
<td>Share of venture capital funds in total initial funds</td>
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<td>B_PLAN</td>
<td>Dummy variable: = 1 if a firm makes business plans</td>
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<td>JRDU</td>
<td>Number of joint R&amp;D projects with universities</td>
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<td>TOKYO</td>
<td>Geographical dummy: = 1 if a firm is located in Tokyo</td>
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<td>F_AGE</td>
<td>Number of years passed since a firm was founded</td>
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<td>Dummy variable: = 1 if CEO has experience working in R&amp;D</td>
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<td>NWK</td>
<td>Dummy variable: = 1 if CEO engaged in network with other researchers</td>
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Table 2 Summary Statistics

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## Table 3 Estimated Results: Tobit Regressions

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Note: The logarithmic transformation of the dependent variable (R&D) uses a linear transformation of ((RD+1)*10). The Tobit censoring boundary is set to correspond to a zero observation. Standard error is in parentheses. *, ** and *** show statistical significance at the 10 percent, 5 percent and 1 percent levels.
References


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