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Debt, Ownership Structure, and R&D Investment: Evidence from Japan*

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Abstract

Financial factors and ownership structure are both part of the determinants of corporate R&D investment. Considering listed firms in the R&D intensive industries during the 2000s, this paper examines whether financial factors and ownership structure explain R&D investment in Japan. Following the methodology of Brown et al. (2009), which extends the dynamic investment model of Bond and Maghir (1994) to R&D investment, we find that only small, young firms mainly listed on new emerging markets face financial constraints. We also find that large firms finance R&D investment partly from debt. For firms with relatively limited assets, however, higher leverage leads to lower R&D investment. Finally, we find no evidence that large shareholdings by foreign investors enforce myopic behavior on firms in R&D intensive industries.

Keywords: R&D, debt, cash flow, and ownership.

JEL classification: D22; G32

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1. Introduction

In Japan domestic physical investment peaked in 1991, dropped sharply in the 1990s, and remained low even during recovery period in the 2000s. Investment in research and development (R&D), on the other hand, has increased continuously, surpassing physical investment between 2002 and 2004 (METI, 2009). Currently, the scale of R&D and physical investment are at comparable levels in Japan.

From 1994 to 2004 in the United States, firms that listed recently accounted for a large part of R&D investment (Brown et al., 2009). For example, firms listed on the market at most 15 years previously accounted for 45.7% of the aggregate R&D in 1998 and 26.1% in 2004 in the United States. By contrast, in Japan, large mature firms that drove the rapid growth from the 1960s to the 1980s are still the main players in R&D expenditure. While domestic emerging equity markets have been established since 1999 and many new firms have gone public, especially in the Information Technology (IT) and related industries, firms that went public after 1990 account for only 3% of total R&D spending in R&D intensive industries in our sample. In contrast, large mature firms whose consolidated assets are more than 500 billion yen account for nearly 80% of total R&D spending in R&D intensive industries. For example, Toyota Motor, the top corporate R&D investor in Japan, outlaid 890 billion yen in 2006, about 60% of its physical investment. The second largest R&D investor, Panasonic, spent 580 billion yen, more than its physical expenditure of 420 billion yen.

The main purpose of this paper is to examine whether financial factors explain the relatively limited presence in R&D investment by small, young firms in Japan. Following Brown et al. (2009), we apply the dynamic investment model of Bond and Meghir (1994) to R&D investment, and examine whether the shift of internal funds can explain the change in R&D investment. We do not observe financing constraints on R&D investment of firms with larger assets. For small, young firms mainly listed on the new emerging markets, however, we observe financing constraints, which is consistent with the finding of Brown et al. (2009). On the other hand, we find no relationship between R&D investment and equity finance in firms with relatively limited assets. This result contrasts with the theoretical prediction as well as the U.S. case, in which the changes in equity finance by young, high-tech firms explain most of the 1994 to 2004 aggregate R&D cycle (Brown et al., 2009).

We also examine the role of debt in R&D investment. We extend the work of Brown et al. (2009) by focusing on debt in addition to equity finance, since debt is the major source of incremental funding for most firms in Japan. Ogawa (2007) investigates the relationship between R&D investment and debt in Japan using the sample period from 1988-1991 and 1999-2001. He shows that the ratio of debt to total assets had a significant, negative effect on R&D investment in the late 1990s, while the effect of the debt-asset ratio on R&D investment was insignificant in the late 1980s.

Using the sample period from 2001 to 2008 focusing on the role of changes in debt while Ogawa (2007) focuses on debt level, we find that the coefficient of lagged debt and lagged debt squared is significantly negative, as implied by tax-bankruptcy specification for firms with large assets. This result implies that large firms finance R&D investment at least partly from debt. In contrast, estimation results for firms with relatively limited assets show that the coefficient of lagged debt is significantly negative, while that of lagged debt squared is insignificant, suggesting that a higher level of debt financing leads to lower R&D investment.

Finally, this paper highlights the effect of increasing foreign ownership on R&D investment. One characteristic of the changes in corporate governance structure for Japanese firms is the rapid increase of both domestic and foreign institutional investors and reduction in cross shareholding since the late 1990s (Miyajima and Kuroki, 2007). It is plausible that if investors are myopic and their preferences are biased toward immediate dividends, then managers may take into account these myopic investors and pay dividends by sacrificing R&D investment (Narayanan, 1985 and Stein, 1989). For small firms which face financial constraints, we do not find any evidence that large shareholdings by foreign investors enforce myopic behavior.

The remainder of this paper is organized as follows. Section 2 overviews R&D expenditure in Japan from the late 1990s. Section 3 summarizes the financial structures of R&D intensive firms. Section 4 describes the empirical model and Section 5 reports the estimation results. Section 6 concludes.

2. An Overview of R&D Investment

2.1 Macro Trend and R&D Intensive Industries

We first overview the trend in R&D expenditures from 1980 based on Figure 1 from METI (2009). After reaching its peak value of 20 trillion yen in 1991, domestic physical investment plunged in the 1990s, to around 13 trillion yen, where it remained even during the recovery in the 2000s. On the other hand, R&D expenditure steadily increased from 9 trillion yen in 1985 to 12 trillion yen in 2007. Today, R&D investment in Japan matches physical investment.[1]

== Figure 1 about here ==

Table 1 shows industry-level R&D expenditure. Industry classifications are based on Securities Identification Code Committee's 33 sectors (excluding financial sectors) (Syoken Code Kyogikai 33 Gyoshu).[2] The sample is all listed firms contained in the Toyo Keizai dataset.[3] We did not take R&D spending data from profit-and-loss statements since it undervalues R&D spending by not taking into account salaries for researchers. Table 1 shows that manufacturers account for 94% of R&D expenditures. The electric appliances sector has the largest share of R&D spending, at 38%, followed by transportation equipment, at 24%. Chemicals, machinery, precision instruments, and information & communication also have high R&D expenditure shares.[4] Looking at

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[1] According to the Ministry of Economy, Trade and Industry (METI) (2009), a breakdown of R&D spending by corporations in 2007 was as follows: labor costs 39.8%, materials 18.4%, depreciation 7.3%, leases 0.7%, and other 33.7%.

[2] According to the *Basic Survey of Japanese Business Structure and Activities* by METI, public firms account for 87% of R&D spending.

[3] The data is based on the *Kaisha Shikiho* (Japan Company Handbook). Branstter (1996) discusses the quality of R&D data for Japanese firms.

[4] Among firms in the Information & Communication sector classified according to the Securities Identification Code Committee's 33 sectors, we only look at firms in three major groups;

R&D intensity (R&D expenditure/sales), pharmaceuticals is easily the highest, while electric appliances and precision instruments have intensities of over 4%. We define these seven industries as R&D intensive industries.[5] The total R&D expenditure by the seven industries is 12.5 trillion yen, accounting for 87% of the whole sample in the Toyo Keizai dataset.

== Table 1 about here ==

2.2 R&D Investment by Firm Type

Figure 2 summarizes the time-series trend of R&D expenditures by the sample firms in the seven R&D intensive industries used in the empirical analysis. The average R&D spending-asset ratio is stable in the sample period. This is different from the U.S. case, where there was a R&D boom in the late 1990s and a decline in the early 2000s. While the R&D-asset ratio has been stable at around 4% since the late 1990s, the coefficient of variation has been trending upward.

== Figure 2 about here ==

The size and age of firms are likely to have influence on their R&D investment through their financing conditions. Hadlock and Pierce (2010) argue that size and age of a firm are closely related to financial constraints, while the KZ index advocated by Kaplan and Zingales (1997) is unlikely to be a useful measure of financial constraints. We classify sample firms in the 1st or 2nd section of the Tokyo Stock Exchange as Large firms if their consolidated assets were 300 billion yen or greater in 1999. We classify sample firms in the 1st or 2nd section of the Tokyo Stock Exchange as Small

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Communications (37), Information Services (39), and Internet Based Services (40) in Division G: Information and Communications by Japan Standard Industrial Classification.

[5] Brown et al. (2009) take the following seven industries in their sample: drugs, office and computing equipment, communications equipment, electronic components, scientific instruments, medical instruments, and software. It is difficult to compare the sample industries in Brown et al. (2009) and the seven industries in this paper given different industry classifications. However, one noticeable difference is the absence of the transportation equipment industry in the sample of Brown et al. (2009).

firms if their consolidated assets were less than 100 billion yen in 1999.[6] Firms are defined as Young firms if they went public after 1990 on the Tokyo Stock Exchange, Mothers, Hercules, or JASDAQ. We do not impose any condition on how long a firm is listed to be classified as Large or Small firms. Thus, some firms are classified into both Large and Young (or Small and Young) at the same time.[7] Figure 3 shows that most R&D spending in our sample is by Large firms, with Young firms accounting less than 3% in 2006, although their presence in the sample is increasing. In the U.S. high-tech industries, young firms accounted for 40% of R&D expenditure in the late 1990s.[8] The trend in U.S. R&D expenditure was largely influenced by the behavior of young firms from the mid 1990s (Brown et al., 2009). In contrast to the U.S. case, most R&D investment in Japan was conducted by mature firms, despite the increase of young firms in IT related sectors.

== Figure 3 about here ==

3. Financial Structure of R&D Intensive Industries

Figure 4 describes the financial structure of the sample firms in R&D intensive industries. While financial variables fluctuate, R&D expenditure is fairly stable throughout the sample period. This tendency continues even after the financial crisis in 2008, which accompanied the decline in cash flow and increase in debt, as far as 2008 data is concerned. The dispersion in R&D-asset ratio increased, especially after 2002, while leverage has declined. The mean R&D-asset ratio declined slightly, but the standard deviation held steady, with the result that the coefficient of variation increased. This dispersion of the R&D-asset ratio became more pronounced after the financial

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[6] The median of total assets for the sample firms is 71 billion yen. We also set 200 billion yen as a threshold for defining Small firms, and 400 billion and 500 billion yen for Large firms in the following analyses and observe similar results (weaker results for Small firms with an alternative definition).

[7] For example, a firm with total assets of 50 billion yen that listed on the 1st section of the Tokyo Stock Exchange in 1995 is classified as a Small and Young firm.

[8] In Brown et al. (2009), a firm is classified as young for the 15 years following the year it first appears in Compustat as a listed firm, and is considered mature thereafter.

crisis in 2008.

== Figure 4 about here ==

Panel 1 of Table 2 provides descriptive statistics for the variables of the sample firms. All variables except for the foreign shareholding ratio (Foreigner) are scaled by beginning-of-period total assets. The total consists of all firms in the sample in the seven R&D intensive industries described above. Large firms have a higher R&D-asset ratio and less dispersion between firms. Small firms have a lower R&D-asset ratio of about 2.9% on average, but have greater dispersion. Young firms have a similar R&D-asset ratio to Small firms and greater dispersion compared to the former two groups. According to Panel 2 of Table 2, firms in R&D intensive industries reduced their debt-asset ratio during the sample period. As a consequence, the debt-asset ratio went down from 26% in 1999 to 13% in 2006. Meanwhile, they experienced a rapid increase in foreign and institutional shareholdings and a decrease in cross-shareholdings or stable shareholdings. The foreign shareholding ratio rose from 6.1% in 1999 to 13.7% in 2006.

== Table 2 about here ==

Observing by firm group, Large firms had a higher debt-asset ratio than other groups, with bonds accounting for the majority of debt finance by Large firms in 1999. Regarding ownership structure, outsiders held greater shareholdings at Large firms. Two important points can be seen in the change of corporate finance and governance structure for Large firms in the 2000s.[9] First, Large firms reduced debt rapidly. One of our interests after section 5 is how this reduction in debt affected their R&D investment. Second, ownership structure also changed rapidly. Foreign and institutional shareholding ratios reached 30% and 44%, respectively in 2006. Moreover, the variance

[9] Arikawa and Miyajima (2007) investigate the change in corporate finance and governance of Japanese firms in the 1990s.

in ownership structure declined. The coefficient of variation of foreign ownership dropped from 0.68 in 1999 to 0.39 in 2006. The ownership structure of Large firms became more homogeneous with respect to outsider-oriented ownership.

Small firms reduced their debt-asset ratio, which fell from 14% in 1999 to 12% in 2006. A reduction in bond financing was also evident, and the bond-asset ratio became 1% in 2006. Regarding outsider shareholdings, Small firms have higher dispersion than Large firms. How differences in shareholdings by foreigners affect R&D investment is one of the questions considered in this paper.

Finally, we observe the financial and ownership structure of Young firms. The debt-asset ratio of Young firms remained relatively low during the sample period. On the other hand, although Young firms finance by stock issue more than mature firms, the size is not large. They show the characteristics of entrepreneur firms; director's stock holding ratio is high. The ratio of shareholding by foreigners and institutional investors is low compared to Large firms.

4. The Empirical Model and Data

In this section we explain the empirical specification for the following analysis. As in Brown et al. (2009), we apply the dynamic investment model of Bond and Meghir (1994) to R&D investment. The empirical model is based on the Euler equation, which is derived from the dynamic optimization of investment of a firm under imperfect competition with convex adjustment costs.[10] The baseline empirical specification including debt finance is as follows.

$$RD_{jt} = \beta_1 RD_{jt-1} + \beta_2 RD^2_{jt-2} + \beta_3 S_{jt-1} + \beta_4 CF_{jt-1} + \beta_5 D_{jt-1} + \beta_6 D^2_{jt-1} + d_t + \alpha_t + \nu_{jt}$$

where RD_{jt} is R&D spending for firm *j* in time *t*, RD^2_{jt-1} is the square of R&D spending and derived from the existence of a nonlinear adjustment cost, S_{jt-1} is sales,

[10] Derivation of the estimation equation is referred to Bond and Meghir (1994) or Bond and Van Reenen (2007).

CF_{jt-1} is cash flow, D_{jt-1} is the amount of debt at t-1, and D^2_{jt-1} is the square of debt. All variables are scaled by the beginning of period total assets. d_t is the time effect on R&D spending to capture effects such as tax rates; α_t is the time invariant firm effect; and ν_{jt} is the error term. We also estimate using the interaction terms of year and industry dummies as Brown et al. (2009) to control for an industry specific environment that changes yearly.

According to Bond and Meghir (1994), β_1 is positive and greater than 1, β_2 takes an absolute value greater than 1, β_3 takes zero under perfect competition and takes positive values otherwise. The coefficient of the lagged cash flow, β_4 is negative.

The debt terms are included to capture tax-bankruptcy effects. Under the existence of bankruptcy costs and a tax advantage of debt, the firm raises debt until the tax advantages have been fully exploited. The coefficient of the square of the debt term should be negative unless firms are in a situation where the Modigliani-Miller theorem does hold. We also add the lagged debt term to the Bond and Meghir (1994) model.

The specification in this paper has a dynamic panel structure which has a lag of the dependent variable as an independent variable. We estimate it using the system GMM of Blundell and Bond (1998). Here all independent variables are treated as endogenous variables and use t-3 and t-4 independent variables as instruments.[11]

We take financial variables from Nikkei NEEDS, and variables on ownership from Nikkei NEEDS-Cges (Corporate Governance Evaluation System). We use consolidated data for all variables. We construct an unbalanced panel of publicly traded firms in the seven R&D intensive industries during 2001 to 2008. We require firms to have at least five R&D observations. Panel 1 of Table 2 presents descriptive statistics of the estimation sample.

5. Estimation Results

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[11] If there is no serial correlation, instruments dated t-2 can be used, but when the error is MA(1), the instruments must be at least dated t-3.

5.1 Pooled Sample Estimates

The pooled sample estimation results are summarized in Table 3. Hansen's J test does not reject the validity of the instruments in any specifications but the one in column (1). The coefficient of the lagged R&D spending is significantly positive, but larger than one only in column (3).

== Table 3 about here ==

We observe that several variables take coefficients different from the theoretical predictions. In each regression result, the coefficient for cash flow is positive, although it should be negative given the assumption that the firm can raise as much money as it wants at a given cost. This positive coefficient is in line with other literature, such as Fazzari et al. (1988), and may reflect a liquidity constraint. We also find that the coefficient on debt and the square of debt are not significantly negative in the regression results.[12]

We find similar results when we include the lagged values of funds raised by new stock issues scaled by beginning-of-period total assets (*Stk*) following Bond and Meghir (1994) and Brown et al. (2009). Columns (3) and (4) of Table 3 show that the coefficients for lagged cash flow are positive but insignificant, and the coefficient of debt and the square of debt are not significantly negative, with the exception of the lagged debt in column (3). The coefficients of the lagged stock are also insignificant in both regression results. In sum, financial factors do not show a clear result, which would be caused by the heterogeneity among sample firms with respect to characteristics such as size and age.

5.2 Comparison of Large and Small Firms

To further investigate the effect of financial variables on R&D spending, we split the sample into groups by a firm characteristic that is likely to be associated with financial constraints. As explained in Section 2, we split our sample into two groups,

[12] The coefficient of the lagged square of R&D and lagged Sales is also insignificant.

Large and Small, based on firm size. Expecting that the cost of debt finance differs based on firm's size, we compare the regression results between Large and Small firms.

Table 4 shows the results. We find again that the coefficient for lagged cash flow is positive and insignificant for both Small and Large firms. We further examine this insignificance in the next subsection.

For Large firms, we find that the coefficients of lagged debt and lagged square debt are significantly negative in column (4) and (8) as implied by tax-bankruptcy specifications. This suggests that Large firms finance their R&D investments at least partly from debt.[13] For Large firms a one standard deviation (0.049) increase in debt scaled by total assets reduces R&D investment by 8%. For Small firms, the coefficient of lagged debt is significantly negative, while that of lagged square debt is insignificant in each regression result. The relationship between debt and R&D investment is linearly negative. Firms with limited assets do not have an optimal leverage ratio, and higher leverage leads to lower R&D investment. This result suggests that Small firms are more likely to face a higher cost from the marginal increase in debt because of the lack of collateralized assets or the greater uncertainty of future profits. This means that the cost of debt finance outweighs its benefits as a whole for Small firms. Thus, higher leverage monotonically raises the capital cost of R&D investment, with the result that R&D investment decreases. For Small firms, one standard deviation (0.054) increase in debt scaled by total assets reduces R&D investment by 3%.

== Table 4 about here ==

To further explore the relationship between leverage and R&D investment, we conduct two additional tests. First, we investigate whether a firm with higher leverage on its balance sheet at the beginning of the investment decision is more likely to reduce R&D investment at period t when debt finance increases at period t-1. To this end, we divide the sample into firms with high and low leverage by median debt-asset ratio at

[13] This result holds when using alternative cutoff values such as 400 billion or 500 billion yen to define Large firms.

the beginning of the sample period. When firms increase debt finance at one unit, the marginal increase in the cost of debt is likely to be higher for high-levered firms than it is for firms with less leverage, because of the higher default probability. This difference in marginal cost for debt finance leads to different results between high-levered and low-levered firms. Table 5 shows the results. Column (1) and (2) show the results when firms have a higher debt-asset ratio at the beginning of the sample period. We find that the coefficient of the lagged debt is significantly negative in the regression. On the other hand, for low-levered firms at the initial period, the coefficient of the lagged debt term and the lagged square debt is insignificant. Thus, for high-levered firms, the increase in debt financing leads to a reduction in R&D investment, while the larger debt financing does not have any effect on R&D investment for low-levered firms.[14] Among high-levered firms, one standard deviation (0.064) increase in debt scaled by total assets reduces R&D investment by 4.8%.

== Table 5 about here ==

Second, we explore how the negative relationship between the lagged debt and R&D investment differs across firms with differing business risks, as measured by the number of business units for each firm. We assume here that a larger number of business units helps to reduce a firm's business risk. If debt finance leads to a reduction in R&D investment because of the increase in default risk, we would expect to see a weaker relationship between the lagged debt and R&D investment in firms with more business units. When we introduce the interaction term between the lagged debt and the indicator variable that is equal to one if the number of business units within a firm is more than four, and zero otherwise, we find that the coefficient of the interaction term is significantly positive only for Small firms (the results are not shown in the table). In fact, the magnitude of the coefficient is large enough to offset the negative effect of the lagged debt on R&D investment. These results suggest that the higher default

[14] We also estimate the same model for the high and low levered firms within small firms. The results for the lagged debt terms are similar to Table 5.

probability for Small firms increases the cost of debt financing, and that is the main reason of the negative relationship between debt finance and R&D investment.

5.3 Cash Flow and Financial Constraint

To explore the presence of financing constraints on R&D investment, we add contemporaneous cash flow, which is the standard measure of internal equity financing in the financing constraint literature following Brown et al. (2009).

$$RD_{jt} = \beta_1 RD_{jt-1} + \beta_2 RD_{jt-2}^2 + \beta_3 S_{jt-1} + \beta_4 CF_{jt} + \beta_5 CF_{jt-1} + \beta_6 D_{jt-1} + \beta_7 D_{jt-1}^2 + d_t + \alpha_t + \nu_{jt}$$

Table 6 presents the regression results. Column (1) and (2) gives the results for Small and Large firms, respectively. In both specifications, the contemporaneous cash flow variables have no significant effect, and the coefficients on lagged cash flow terms are also not significantly negative. In this specification, the coefficient on lagged debt and lagged square debt is significantly negative for Large firms, while only the coefficient of lagged debt is significantly negative for Small firms.[15]

== Table 6 about here ==

To further investigate the sensitivity of R&D investment to contemporaneous cash flow, we add firms that are listed on the “emerging markets,” namely JASDAQ, Mothers, and Hercules (formerly NASDAQ Japan). These three markets, especially Mothers and Hercules, were established for start-up firms. In terms of industry distribution, JASDAQ is more diverse and the two newer markets are highly oriented toward the IT industry (Arikawa and Imad'Eddine, 2010). Moyen (2004) shows that the investment-cash flow sensitivities in the sense of Fazzari et al. (1988) hold only when constrained firms do not have funds to match the amount they wish to invest. This condition is likely to apply to the firms listed on JASDAQ, Mothers, and Hercules. We expect that Small firms, including those listed on emerging markets, are more likely to

[15] The results are the same when we use the year dummy in the regression.

face severe financial constraints than other firms are.

Columns (3) and (4) of Table 6 show the results for Large and Small firms with firms in emerging markets, respectively. We expect that for Small firms only, the contemporaneous cash flow has a significant effect. Consistent with our prediction, we find that the coefficient on contemporaneous cash flow is significantly positive for Small firms, while for Large firms it is insignificant.[16] We therefore conclude that "emerging" firms with a small size are likely to face financial constraints for R&D investment, and a marginal increase in internal funds leads to an increase in R&D investment. Comparing the results between column (1) and (3), it is clear that firms listed on JASDAQ, Mothers, and Hercules face financial constraints for R&D investment. This result corresponds to the result for the young American firms in Brown et al. (2009).

We also find that the coefficient on lagged debt and lagged square of debt are both negatively significant for Large firms. In contrast, for Small firms, we find no significant result in terms of debt-related variables. The result would suggest that Small firms, especially start-up firms, who face the financial constraints do not use debt finance for R&D investment because it is very costly.

Finally, we find no significant result for the coefficient of the lagged external equity, even when we add "emerging" firms that are listed on JASDAQ, Mothers, and Hercules. In the United States, Brown et al. (2009) point out that the supply of equity finance for young publicly traded firms in high-tech industries drove much of the R&D boom in the 1990s. In Japan, we find no robust evidence to support the contention that the stock market is the important source of funds for technological development.

5.4 Ownership Structure and R&D Investment

One characteristic of the changes in corporate governance structure for Japanese firms from the late 1990s is the rapid increase of both domestic and foreign institutional

[16] The models that strictly follow the Brown et al. (2009) model, namely models that have contemporaneous variables for all financial variables (both with and without debt terms), provide similar results.

investors and reduction in cross shareholding, as shown in Section 3. The question naturally arises as to whether this change of ownership structure would influence R&D investment or not. One possibility is that myopic investors negatively influence R&D investment, which takes a long time to generate revenues (Narayanan, 1985, and Stein, 1989). If investors are myopic and their preferences are biased toward immediate dividends, managers may take into account these myopic investors and pay dividends by reducing R&D investment. In this case, firms with more myopic investors are more likely to under-invest in R&D.[17]

To study the effect of myopic investors on R&D expenditure, we add the foreign shareholding ratio and the interaction term between the contemporaneous cash flow and the foreign shareholding ratio. We then estimate the following equation:

$$RD_{jt} = \beta_1 RD_{jt-1} + \beta_2 RD_{jt-2}^2 + \beta_3 S_{jt-1} + \beta_4 CF_{jt} + \beta_5 CF_{jt-1} + \beta_6 D_{jt-1} + \beta_7 D_{jt-1}^2$$
$$+ \beta_8 FRGN_{jt} + \beta_9 FRGN_{jt} \times CF_{jt} + d_t + \alpha_t + \nu_{jt}$$

where $FRGN_{jt}$ is the foreign shareholding ratio for firm j in period t and $FRGN_{jt} \times CF_{jt}$ is the interaction of foreign shareholding ratio and cash flow. If foreign investors myopically demand excessive dividends, we would expect the interaction term to take positive coefficients.

Table 7 shows the estimation results. We use firms that are listed on the 1st and 2nd section of the Tokyo Stock Exchange, JASDAQ, Mothers, and Hercules. First, the estimation results for Small firms, Column (1) and (2), show that although coefficients of foreign shareholding ratios are not significant, their interaction terms with cash flow take significantly negative coefficients. For these firms, then, foreign investors mitigate the financial constraints for R&D investment.[18] Second, for Large firms, columns (3) and (4), we find that the coefficients of foreign shareholding ratios and the

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[17] It is also possible that investors' preferences are biased toward high R&D investment, and firms overinvest in R&D (Aghion and Stein, 2008).

[18] We also test the institutional shareholding ratio, including both domestic and foreign institutional investors, in the same fashion and observe similar, but weaker results, both in terms of the magnitude of the coefficients and their significance levels.

interaction terms with cash flow are insignificant.

In summary, we do not find any evidence that large shareholdings held by foreign investors enforce myopic behavior on firms.

== Table 7 about here ==

6. Conclusion

Since the 1990s, young firms that have recently listed on the market have accounted for a large part of R&D investment in the U.S. By contrast, in Japan, the large and mature firms that drove the Japanese economy during its high growth period are still the main players in R&D spending. While domestic emerging equity markets have been set up since 1999 and many new firms have listed, firms that went public after 1990 account for only 3% of total R&D spending in R&D intensive industries. On the other hand, large firms with consolidated assets of more than 500 billion yen account for nearly 80% of total R&D spending in R&D intensive industries.

In this paper, we examine whether the financial factor explains the limited presence of R&D investment by small, young firms in Japan. We then find that contemporaneous cash flow have no statistically significant effect on R&D spending by firms with larger assets. For small, young firms mainly listed on new emerging markets, however, the coefficient on contemporaneous cash flow is significantly positive. We also find that firms with large assets finance R&D investment partly from debt. For firms with limited assets, higher levels of debt financing lead to lower R&D investment.

One characteristic of the changes in corporate governance in Japan was the increase of both domestic and foreign institutional investors and reduction in cross shareholding. If investors are myopic and their preferences are biased toward immediate dividends, then managers may take into account these myopic investors and pay dividends by sacrificing R&D investment. To study the effect of corporate governance factors on R&D expenditure, we add the interaction term between contemporaneous cash flow and foreign shareholding ratio. We find no evidence that large shareholdings by foreign investors enforce myopic behavior on firms in R&D intensive industries.

Finally, we do not find any positive relationship between R&D investment and equity finance in firms with limited assets. This result contrasts with the U.S. case, in which changes in equity financing by young high-tech firms explain most of the 1994 to 2004 aggregate R&D cycle (Brown et al., 2009).

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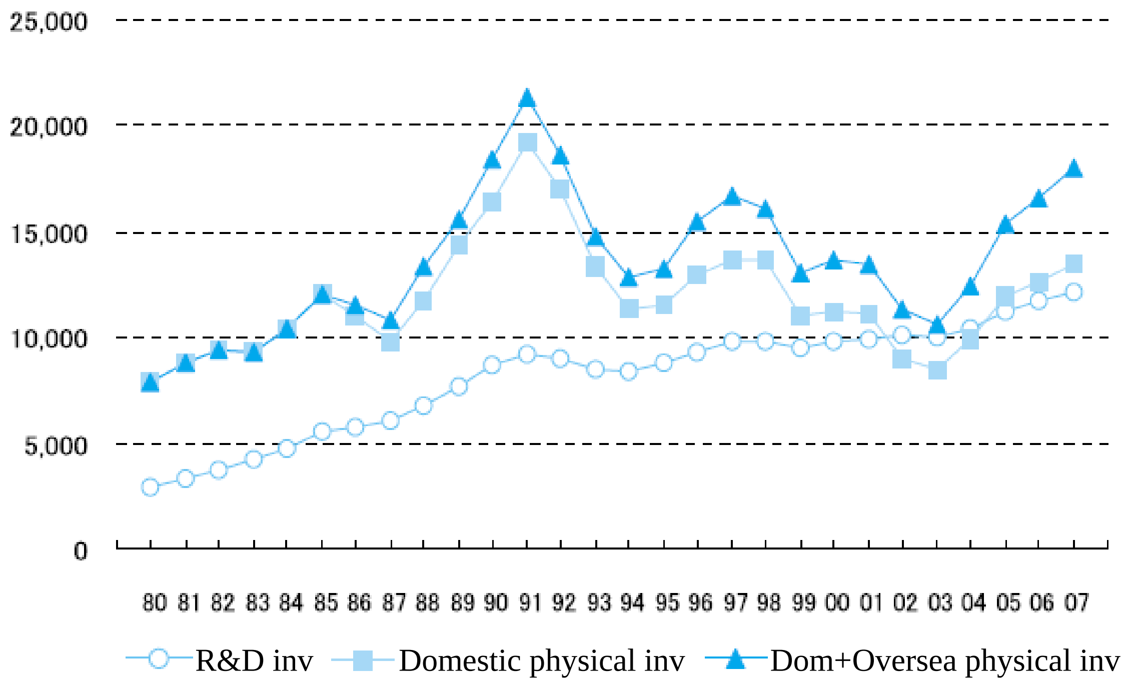
Figure 1: R&D and Physical Investments by Manufacturers

Taken from the Ministry of Economy, Trade and Industry, *Basic Survey of Japanese Business Structure and Activities*. Unit: One billion yen.



R&D inv. Domestic phys. inv. Domestic + Overseas phys. inv.

Figure 2: Trend of R&D Expenditure

The sample consists of firms in the seven R&D intensive industries listed on the 1st or 2nd section of the Tokyo Stock Exchange and young firms in the same industries that went public after 1990 on the Tokyo Stock Exchange, Mothers, Hercules, or JASDAQ. The seven industries consist of chemicals, pharmaceuticals, machinery, electric appliances, transportation equipment, precision instruments, and information & communications. The industry classification is based on the Securities Identification Code Committee's 33 sectors (excluding financial sectors) (Syoken Code Kyogikai 33 Gyoshu). Among firms in the Information & Communication sector, we only look at firms in three major groups; Communications (37), Information Services (39), and Internet Based Services (40) in Division G: Information and Communications by Japan Standard Industrial Classification.

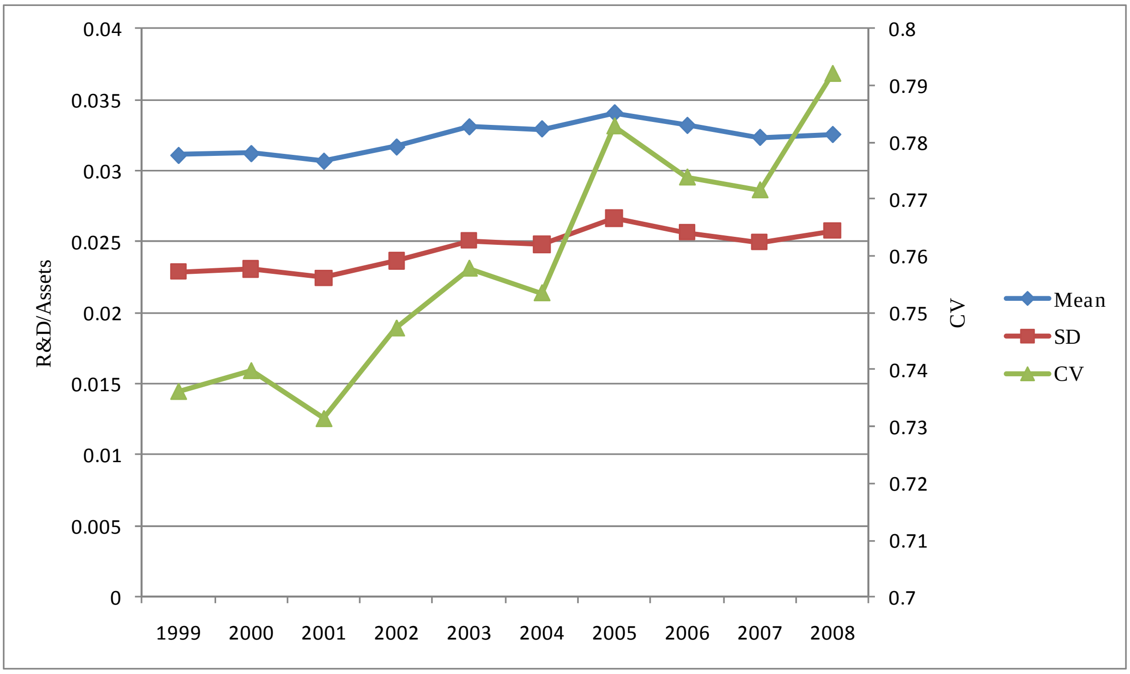


Figure 3: R&D Expenditure by Firm Size

The sample contains firms in the seven R&D intensive industries. Large firms are those listed on the 1st or 2nd section of the Tokyo Stock Exchange and had consolidated assets of 300 billion yen or greater in 1999. Small firms are listed on the 1st or 2nd section of the Tokyo Stock Exchange and had consolidated assets of less than 100 billion yen in 1999. Young firms went public after 1990 on the Tokyo Stock Exchange, Mothers, Hercules, or JASDAQ.

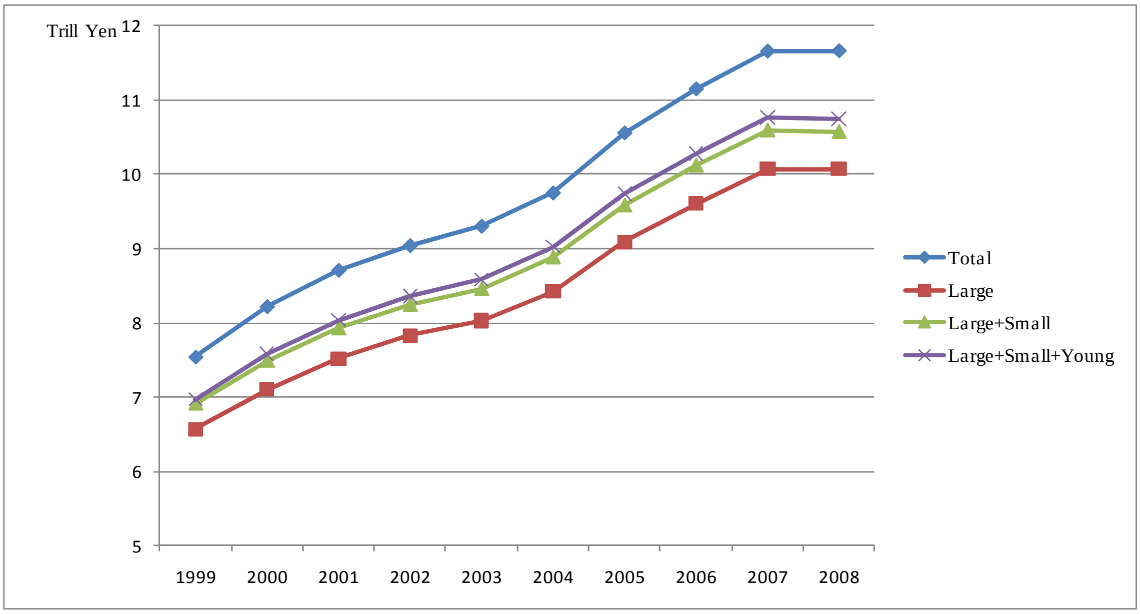


Figure 4: R&D Expenditure and Finance

The sample contains firms in the seven R&D intensive industries. CF is cash flow. Debt is flow value.

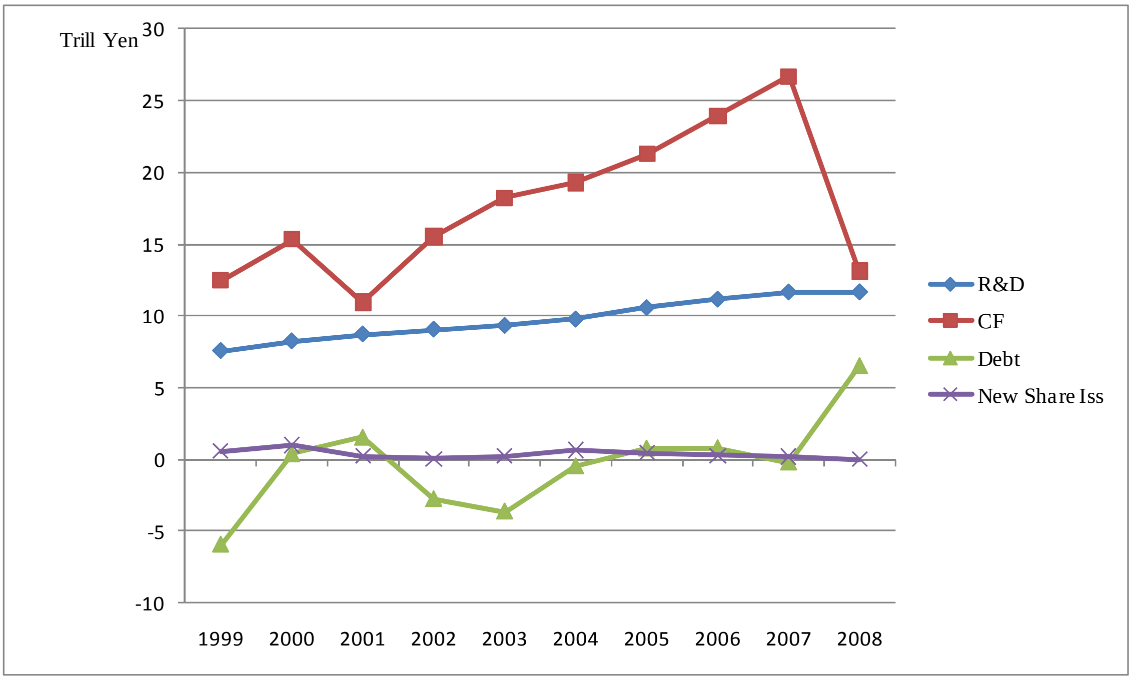


Table 1: R&D Expenditure by Industry

The sample contains all listed firms in the Toyo Keizai dataset in 2006. The industry classification is based on the Securities Identification Code Committee's 33 sectors (excluding financial sectors) (Syoken Code Kyogikai 33 Gyoshu). RD/S is R&D expenditure-sales ratio. SD and CV stand for standard deviation and coefficient of variation, respectively. The unit is 100 million yen.

Sector code	Sector name	Num. firm	Total R&D	R&D share	Av. R&D/S	SD R&D/S	CV
50	Fish., Ag. & Forest.	11	98	0.07%	1.29%	1.96%	1.52
1050	Mining	7	17	0.01%	0.53%	0.75%	1.43
2050	Construction	215	1,045	0.78%	0.24%	0.32%	1.35
3050	Foods	153	2,399	1.78%	1.11%	1.76%	1.58
3100	Textiles & Apparels	79	1,509	1.12%	1.08%	1.23%	1.13
3150	Pulp & Paper	27	307	0.23%	0.83%	0.91%	1.10
3200	Chemicals	215	10,745	**7.97%**	**2.95%**	2.35%	0.80
3250	Pharmaceutical	51	10,347	**7.67%**	**29.66%**	74.37%	2.51
3300	Oil & Coal Products	13	443	0.33%	1.23%	2.16%	1.76
3350	Rubber Products	21	1,465	1.09%	2.44%	1.22%	0.50
3400	Glass & Ceramics	71	1,283	0.95%	1.59%	1.45%	0.91
3450	Iron & Steel	56	1,633	1.21%	0.63%	0.74%	1.19
3500	Nonferrous Metals	43	1,598	1.19%	1.08%	0.88%	0.81
3550	Metal Products	97	911	0.68%	1.20%	1.14%	0.96
3600	Machinery	247	6,325	**4.69%**	**2.24%**	2.27%	1.01
3650	Electric Appliances	309	50,933	**37.77%**	**4.65%**	4.55%	0.98
3700	Transport Equip.	106	32,017	**23.74%**	**2.02%**	1.86%	0.92
3750	Precision Inst.	53	2,291	**1.70%**	**4.82%**	6.46%	1.34
3800	Other Products	116	2,105	1.56%	1.24%	1.48%	1.19
4050	Electric Power & Gas	25	1,349	1.00%	0.41%	0.35%	0.84
5050	Land Transport.	66	412	0.31%	0.05%	0.20%	3.96
5100	Marine Transport.	18	13	0.01%	0.01%	0.01%	2.86
5150	Air Transport.	6	5	0.00%	0.44%	0.34%	0.78
5200	Warehousing & Harbor	44	4	0.00%	0.04%	0.15%	3.51
5250	Info & Communication	359	4,791	**3.55%**	**2.28%**	5.55%	2.43
6050	Wholesale Trade	387	530	0.39%	0.29%	1.45%	4.93
6100	Retail Trade	384	37	0.03%	0.03%	0.19%	6.54
8050	Real Estate	132	15	0.01%	0.04%	0.23%	5.42
9050	Services	377	228	0.17%	1.38%	10.84%	7.84
Total		3,688	134,854	100.00%			

Table 2: Descriptive Statistics

The estimation sample contains firms in the seven R&D intensive industries. The seven industries consist of chemicals, pharmaceutical, machinery, electric appliances, transportation equipment, precision instruments, and information & communications. The industry classification is based on the Securities Identification Code Committee's 33 sectors (excluding financial sectors) (Syoken Code Kyogikai 33 Gyoshu). Among firms in the Information & Communication sector, we only consider firms in three major groups; Communications (37), Information Services (39), and Internet Based Services (40) in Division G: Information and Communications by the Japan Standard Industrial Classification. The estimation period is 2001-2008. We classify firms on the 1st or 2nd section of Tokyo Stock Exchange as Large if their consolidated assets are 300 billion yen or greater in 1999. We classify firms on the 1st or 2nd section of Tokyo Stock Exchange as Small if their consolidated assets are less than 100 billion yen in 1999. Firms are defined as Young if they went public after 1990 on the Tokyo Stock Exchange, Mothers, Hercules, or JASDAQ. Outliers in all variables that are three standard deviations away from their mean are eliminated from the sample. Firms that have five or fewer observations in the sample period are dropped. All variables except for ownership variables are scaled by beginning-of-period total assets. The numbers of firms for ownership related variables are in parentheses in Panel 2.

Panel 1: R&D Expenditure and Finance

	Total			Large			Small			Young		
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Obs		5,660			788			2,866			1,330	
R&D	0.032	0.025	0.761	0.044	0.024	0.552	0.029	0.022	0.768	0.031	0.027	0.875
Sales	0.938	0.318	0.339	0.942	0.286	0.303	0.932	0.305	0.327	0.935	0.374	0.400
Debt	-0.004	0.056	-13.856	-0.003	0.049	-17.608	-0.006	0.054	-9.335	0.001	0.059	42.604
CF	0.059	0.052	0.887	0.071	0.049	0.688	0.056	0.049	0.866	0.055	0.058	1.053
New Share Iss	0.002	0.019	7.794	0.002	0.011	6.228	0.002	0.013	7.180	0.005	0.031	6.338
Foreigner (%)	0.104	0.114	1.094	0.251	0.129	0.512	0.065	0.075	1.162	0.063	0.079	1.259

Panel 2: Ownership Structure

		Total			Large			Small			Young		
		1998	2001	2006	1998	2001	2006	1998	2001	2006	1998	2001	2006
Obs		584	595	647	86	88	88	278	297	329	123	120	161
Debt/Assets	Mean	0.26	0.20	0.13	0.30	0.23	0.16	0.26	0.20	0.12	0.22	0.15	0.11
	SD	0.19	0.15	0.11	0.17	0.14	0.11	0.20	0.16	0.11	0.18	0.14	0.12
Borrowing/Assets	Mean	0.21	0.17	0.11	0.20	0.16	0.12	0.22	0.18	0.11	0.20	0.13	0.10
	SD	0.18	0.15	0.10	0.16	0.12	0.10	0.19	0.16	0.11	0.18	0.13	0.11
Bond/Assets	Mean	0.05	0.03	0.02	0.10	0.07	0.04	0.03	0.02	0.01	0.02	0.02	0.02
	SD	0.07	0.05	0.03	0.07	0.05	0.04	0.06	0.04	0.03	0.04	0.05	0.04
Foreigner (%)	Mean	6.11	7.03	13.74	16.15	20.50	30.32	2.82	3.44	9.15	2.83	3.36	8.36
	SD	8.24	9.98	12.38	10.99	13.27	11.84	4.30	5.53	8.25	4.40	5.33	9.20
Inst investors (%)	Mean	13.18	14.40	22.89	22.23	31.37	43.91	6.72	7.49	16.93	8.15	12.79	14.01
	SD	10.90	14.20	17.30	11.24	14.47	13.49	6.35	8.80	12.82	3.81	10.76	12.64
Cross-holding (%)	Mean	13.44	11.42	9.15	12.70	9.52	7.48	13.97	12.11	10.70	6.02	7.18	5.08
	SD	7.88	8.21	8.00	7.11	6.97	5.59	8.17	8.58	8.67	3.32	6.83	5.38
Director share (%)	Mean	6.28	5.53	4.98	0.61	0.49	0.45	3.42	3.67	3.48	26.93	20.27	15.25
	SD	22.26	10.31	9.42	1.73	1.60	1.73	6.09	6.84	6.20	48.42	14.00	13.25

Table 3: Estimation Results (Baseline Model)

The dependent variable is R&D expenditure. Estimated by system GMM of Blundell and Bond (1998) using independent variables dated t-3 and t-4 as instruments. All variables are scaled by beginning-of-period total assets. Heteroskedasticity and autocorrelation robust z-values are in parentheses. Hansen is the p-value of Hansen's J test for over-identification. AC1 and AC2 are the p-values of the Arellano-Bond test for first and second order autocorrelation which have a null hypothesis of no autocorrelation and is applied to the differenced residuals. ***, **, * significant at the 1 %, 5 % and 10% level, respectively.

	(1)	(2)	(3)	(4)
RD_{t-1}	0.996	0.938	1.003	0.938
	(13.92)***	(12.16)***	(14.56)***	(12.72)***
RD^2_{t-1}	-0.24	0.047	-0.328	0.01
	(-0.32)	(0.06)	(-0.45)	(0.01)
$Sales_{t-1}$	-0.002	-0.001	-0.002	-0.001
	(-1.39)	(-0.50)	(-1.45)	(-0.66)
CF_{t-1}	0.014	0.003	0.013	0.006
	(1.32)	(0.33)	(1.41)	(0.60)
$Debt_{t-1}$	-0.019	-0.014	-0.018	-0.013
	(-2.07)**	(-1.52)	(-2.08)**	(1.56)
$Debt^2_{t-1}$	0.002	0.013	-0.034	-0.031
	(0.03)	(0.18)	(-0.41)	(-0.38)
Stk_{t-1}			-0.002	0.01
			(-0.08)	(0.33)
Year Dummies	YES		YES	
Year*Indust Dum.		YES		YES
AC1	0	0	0	0
AC2	0.278	0.226	0.305	0.251
Hansen	0.097	0.147	0.125	0.238
Observations	4632	4632	4615	4615

Table 4: Estimation Results by Firm Size

The dependent variable is R&D expenditure. Estimated by system GMM of Blundell and Bond (1998) using independent variables dated t-3 and t-4 as instruments. All variables are scaled by beginning-of-period total assets. The sample is divided by firm size in 1999. Large firms are listed on the 1st or 2nd section of the Tokyo Stock Exchange and had consolidated assets of 300 billion yen or greater in 1999. Small firms are listed on the 1st or 2nd section of Tokyo Stock Exchange and had consolidated assets of less than 100 billion yen in 1999. Heteroskedasticity and autocorrelation robust z-values are in parentheses. Hansen is the p-value of Hansen's J test for over-identification. AC1 and AC2 are the p-values of the Arellano-Bond test for first and second order autocorrelation that has a null hypothesis of no autocorrelation and is applied to the differenced residuals. ***, **, * significant at the 1 %, 5 % and 10% levels, respectively.

	Small	Small	Large	Large	Small	Small	Large	Large
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RD_{t-1}	1.036	0.984	1.264	1.18	1.032	0.986	1.238	1.151
	(11.82)***	(10.09)***	(7.86)***	(8.10)***	(12.34)***	(10.94)***	(8.23)***	(7.88)***
RD^2_{t-1}	-1.246	-1.012	-2.358	-2.067	-1.184	-1.029	-2.11	-1.754
	(-1.26)	(-0.94)	(-1.54)	(-1.39)	(-1.25)	(-1.04)	(-1.45)	(-1.18)
$Sales_{t-1}$	-0.001	0	-0.005	-0.001	0	0	-0.004	0
	(-0.36)	(-0.15)	(-1.74)*	(-0.31)	(-0.10)	(-0.06)	(-1.64)	(-0.26)
CF_{t-1}	0.009	0.003	-0.002	0.012	0.007	0.005	0.001	0.012
	(0.83)	(0.28)	(-0.16)	(0.82)	(0.75)	(0.47)	(0.05)	(0.86)
$Debt_{t-1}$	-0.016	-0.013	-0.021	-0.031	-0.018	-0.016	-0.028	-0.037
	(-1.74)*	(-1.39)	(-1.76)*	(-2.93)***	(-2.15)**	(-1.93)*	(-2.32)**	(-3.53)***
$Debt^2_{t-1}$	0.017	0.01	-0.115	-0.241	-0.028	-0.04	-0.119	-0.241
	(0.24)	(0.15)	(-1.31)	(-2.21)**	(-0.47)	(-0.70)	(-1.29)	(-2.24)**
Stk_{t-1}					-0.008	-0.007	-0.008	-0.006
					(-0.31)	(-0.26)	(-0.21)	(-0.15)
Year Dummies	YES		YES		YES		YES	
Year*Indust Dum.		YES		YES		YES		YES
AC1	0	0	0	0	0	0	0	0
AC2	0.58	0.612	0.433	0.119	0.602	0.637	0.315	0.104
Hansen	0.328	0.516	1	1	0.525	0.775	1	1
Observations	2883	2883	761	761	2866	2866	761	761

Table 5: The Effect of Debt

The dependent variable is R&D expenditure. Estimated by the system GMM of Blundell and Bond (1998) using independent variables dated t-3 and t-4 as instruments. All variables are scaled by beginning-of-period total assets. The sample is divided at the median value of the debt-asset ratio in 1999. Heteroskedasticity and autocorrelation robust z-values are in parentheses. Hansen is the p-value of Hansen's J test for over-identification. AC1 and AC2 are the p-values of the Arellano-Bond test for first and second order autocorrelation that has a null hypothesis of no autocorrelation and is applied to the differenced residuals. ***, **, * significant at the 1 %, 5 % and 10% level, respectively.

	Above Med (1)	Above Med (2)	Below Med (3)	Below Med (4)
RD_{t-1}	1.054	1.031	1.028	0.933
	(11.56)***	(9.40)***	(10.88)***	(9.25)***
RD^2_{t-1}	-1.028	-0.88	-0.659	-0.224
	(0.98)	(0.74)	(0.73)	(0.23)
$Sales_{t-1}$	0.001	0.001	-0.003	-0.001
	(0.32)	(0.38)	(1.94)*	(0.53)
CF_{t-1}	0.015	0.015	0.011	0.006
	(1.23)	(1.16)	(0.92)	(0.55)
$Debt_{t-1}$	-0.026	-0.022	-0.018	-0.004
	(2.56)**	(2.34)**	(1.29)	(0.28)
$Debt^2_{t-1}$	0.023	0.024	-0.012	-0.048
	(0.47)	(0.47)	(0.12)	(0.50)
Year Dummies	YES		YES	
Year*Indust Dum.		YES		YES
AC1	0	0	0	0
AC2	0.253	0.356	0.607	0.597
Hansen	0.033	0.167	0.576	0.212
Observations	2274	2274	2341	2341

Table 6: Tests for the Existence of Financial Constraint

The dependent variable is R&D expenditure. Estimated by the system GMM of Blundell and Bond (1998) using independent variables dated t-3 and t-4 as instruments. All variables are scaled by beginning-of-period total assets. The sample is divided by firm size in 1999. Large firms are listed on the 1st or 2nd section of the Tokyo Stock Exchange and had consolidated assets of 300 billion yen or greater in 1999. Small firms are listed on the 1st or 2nd section of the Tokyo Stock Exchange and had consolidated assets of less than 100 billion yen in 1999. Emerging firms went public after 1990 on the emerging markets; Mothers, Hercules, or JASDAQ. Heteroskedasticity and autocorrelation robust z-values are in parentheses. Hansen is the p-value of Hansen's J test for over-identification. AC1 and AC2 are the p-values of the Arellano-Bond test for first and second order autocorrelation that has a null hypothesis of no autocorrelation and is applied to the differenced residuals. ***, **, * significant at the 1 %, 5 % and 10% level, respectively.

	Small	Large	Small+Emerging	Large+Emerging
	(1)	(2)	(3)	(4)
RD_{t-1}	0.983	1.148	0.888	1.156
	(10.73)***	(7.66)***	(11.06)***	(8.15)***
RD^2_{t-1}	-1.036	-1.736	0.066	-1.814
	(-1.02)	(-1.15)	(0.09)	(-1.25)
$Sales_{t-1}$	0	0	0.001	-0.001
	(-0.26)	(-0.22)	(0.76)	(-0.37)
CF	0.021	0.004	0.046	0.017
	(1.32)	(0.26)	(2.95)***	(1.08)
CF_{t-1}	-0.006	0.009	-0.014	-0.005
	(-0.55)	(0.60)	(-0.94)	(-0.36)
$Debt_{t-1}$	-0.016	-0.037	-0.006	-0.032
	(-1.87)*	(-3.53)***	(-0.47)	(-3.35)***
$Debt^2_{t-1}$	-0.037	-0.242	-0.082	-0.208
	(-0.66)	(-2.26)**	(-1.57)	(1.98)**
Stk_{t-1}	-0.015	-0.006	-0.029	-0.005
	(-0.54)	(-0.15)	(1.79)*	(-0.17)
Year Dummies				
Year*Indust Dum.	YES	YES	YES	YES
AC1	0	0	0	0
AC2	0.726	0.114	0.955	0.069
Hansen	0.768	1	0.627	1
Observations	2866	761	3848	788

Table 7: The Effect of Foreign Investors

The dependent variable is R&D expenditure. Estimated by system GMM of Blundell and Bond (1998) using independent variables dated t-3 and t-4 as instruments. All variables are scaled by beginning-of-period total assets. The sample is divided by firm size in 1999. Large firms are listed on the 1st or 2nd section of the Tokyo Stock Exchange and had consolidated assets of 300 billion yen or greater in 1999. Small firms are listed on 1st or 2nd section of Tokyo Stock Exchange and had consolidated assets of less than 100 billion yen in 1999. Emerging firms went public after 1990 on the emerging markets: Mothers, Hercules, or JASDAQ. Heteroskedasticity and autocorrelation robust z-values are in parentheses. Hansen is the p-value of Hansen's J test for over-identification. AC1 and AC2 are the p-values of the Arellano-Bond test for first and second order autocorrelation, which has a null hypothesis of no autocorrelation and is applied to the differenced residuals. ***, **, * significant at the 1 %, 5 % and 10% level, respectively.

	Small+Emerging		Large+Emerging	
	(1)	(2)	(3)	(4)
RD_{t-1}	0.987	0.946	1.318	1.302
	(15.74)***	(13.53)***	(9.53)***	(10.49)***
RD^2_{t-1}	-0.576	-0.376	-2.889	-3.067
	(-0.93)	(-0.59)	(-2.18)**	(-2.45)**
$Sales_{t-1}$	-0.001	0.001	-0.006	-0.002
	(-0.55)	(0.50)	(-2.19)**	(-0.87)
CF	0.057	0.058	0.006	0.03
	(3.19)***	(3.39)***	(0.30)	(1.44)
CF_{t-1}	-0.008	-0.012	-0.025	-0.016
	(-0.67)	(-0.91)	(-1.97)**	(-1.21)
$Debt_{t-1}$	-0.009	-0.005	-0.03	-0.038
	(-0.8)	(-0.51)	(-2.88)***	(-3.97)***
$Debt^2_{t-1}$	-0.068	-0.075	-0.143	-0.178
	(-1.24)	(-1.42)	(-1.78)*	(-1.92)*
Stk_{t-1}	-0.032	-0.033	-0.002	-0.003
	(1.98)**	(2.25)**	(-0.09)	(-0.11)
$Frgn_{t-1}$	0.009	0.008	-0.005	0
	(1.48)	(1.52)	(-0.65)	(-0.07)
$Frgn*CF_{t-1}$	-0.228	-0.215	0.036	-0.043
	(2.41)**	(2.37)**	(0.53)	(-0.82)
Year Dummies	YES		YES	
Year*Indust Dum.		YES		YES
AC1	0	0	0	0
AC2	0.675	0.753	0.478	0.111
Hansen	0.173	0.261	1	1
Observations	3845	3845	787	787