Chapter 53
Keiretsu Style Main Bank Relationships, R&D Investment, Leverage, and Firm Value: Quantile Regression Approach

Hai-Chin Yu, Chih-Sean Chen, and Der-Tzon Hsieh

Abstract Using quantile regression, our results provide explanations for the inconsistent findings that use conventional OLS regression in the extant literature. While the direct effects of R&D investments, leverage, and main bank relationship on Tobin's Q are insignificant in OLS regression, these effects do show significance in quantile regression. We find that firms' advantages with high R&D investment over low R&D monotonically increase with firm value, appearing only for high Q firms; while firms' advantages with low R&D over high R&D monotonically increase with firm value for low Q firms. Tobin's Q is monotonically increasing with leverage for low Q firms; whereas it is decreasing in high Q firms. Main banks add value for low to median Q firms, while value is destroyed for high Q firms. Meanwhile, we find the interacted effect of main bank and R&D investment which increases with firm value, only appears in medium quantiles, instead of low or high quantiles. Results of this work provide relevant implications for policy makers. Finally, we document that industry quantile effect is larger than the industry effect itself, given that most of the firms in higher quantiles gain from industry effects while lower quantile firms suffer negative effects. We also find the results of OLS are seriously influenced by outliers. In stark contrast, quantile regression results are impervious to either inclusion or exclusion outliers.

Keywords R&D investment • Quantile regression • *Keiretsu* • Main bank • Leverage

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53.1 Introduction

Research and development (R&D) investment is considered a crucial input for firms' growth and performance, especially in technology and science intensive industries. Among developed countries, Japan is thought to be one of the most successful countries in manufacturing. Why is manufacturing so successful in Japan but not in the U.S. or other countries? Our data shows that more than 50% of Japanese listed firms belong to the technology-based industry underscoring the importance of R&D in boosting long-term economic growth.

Owing to the fact that R&D investments is intangible, the asymmetric information problem with respect to R&D investment is expected to be more serious than physical investment, since managers may be inclined to keep confidential information to maintain competitive advantage. This, in turn, makes it difficult for investors to measure the effect of R&D investment on firm value. Extant literature shows divergent findings regarding the impacts of R&D on firms' value rendering these results inconclusive. For example, Woolridge (1988) finds a significant market response to the increase in R&D expenditure; however, the reaction differs based on different industries. Chan et al. (1990) and Zantout and Tsetsekos, (1994) report a positive market response to R&D increases for firms in high-tech industries vs. a negative market response for low-tech industries. Acs and Isberg (1996) suggest the final impact of financial leverage and R&D investment on Tobin's Q depends on firm size. Ho et al. (2006) also indicates that a firm's growth opportunity from R&D depends on its size, leverage, and industry concentration. Conversely, some researchers such as Doukas and Switzer (1992) and Sundaram et al. (1996) find an insignificant effect. When combined, the above evidence suggests that due to an asymmetry of information outside investors may not completely understand the value-adding characteristic of R&D.

More to the point, if a significant asymmetric information problem exists in intangible R&D investment, then firms with main bank relationships may help reduce this uncertainty and convey a positive signal. If this logic is correct, then firms with a main bank relationship facing high R&D

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investment should provide more credible information in order for investors to accurately evaluate firm value than those firms without it. In turn, this superior level of information should be reflected on firm value. Additionally, this signal is expected to be stronger when the asymmetric information problem is more serious between managers and investors.

Another point that makes this issue valuable is the impact of R&D investment on long-term performance. This characteristic conforms with the Japanese sample where the main bank dominates almost 71% of outstanding shares (Sheard 1994). This concentrated and stable ownership structure promotes efficient monitoring and long-term performance without regard to short-term pressures. Given that the main bank helps to reduce the conflict between managers and creditors and positively aligns their relationship, using the main bank as a moderator variable is expected to produce different findings vs. to those countries that utilize highly individual ownership data (Aoki 1990; McGuire and Dow 2002).

In Japan, banks traditionally maintain multidimensional ties with their clients, providing security, insurance, or banking services. This approach of banking has come to be commonly known as *Keiretsu* (or main bank) style of banking. From a positive viewpoint, a main bank gathers proprietary information through the financing process. This inside information (and hence the quality of the firm) is then signaled to the market by way of a main bank financing decision. Specifically, if the main bank is willing to continue financing, a signal of firm quality is conveyed to outside investors. It is through this mechanism that affiliation with main banks creates value. Moreover, due to lower agency cost induced by significant equity holdings of main banks, a higher level of performance is expected. From a negative point of view, some high-tech intensive firms may not prefer to interact with a main bank because potential activity on the part of the main bank may inadvertently reveal a firm's prospects to its competitors. Additionally, in the case of financial distress, managers may expect the main bank to solve their financial shortcomings, leading to moral hazard problems and an increased propensity for bankruptcy. Therefore, main bank relationships may exacerbate a firm's problems and reduce its performance. Extant literature has not revealed a consistent finding regarding whether main banks help increase or decrease firm value. Given that main banks serve simultaneously as the internal governance (board) and external monitoring (principal creditor), more research designed to clarify the relationship of main banks and their influence on a firm's values is warranted.

Our paper differs from the existing literature in a number of ways. First, we use quantile regression instead of conventional OLS to add additional evidence that helps explain the empirical puzzle concerning the effects of R&D expenditure, leverage, and main bank relationships on firms' value. Since there were a great deal of bubble Internet stocks in the high-tech industry during 1990s in Japan, the average Tobin's Q would be overestimated by using conventional OLS. To avoid this upward bias resulting from including extremely high Tobin's Q firms, a more realistic view may be gained by using lower quantiles as the target point. Our data from 1994 to 2004 covers the whole Internet evolution period, illustrating again the advantage of using quantile approach. Second, we include the presence of main bank relationships in model of firm value in order to capture the impact of this relationship and its ability to reduce asymmetric information and enhance firm value. Third, besides testing the independent effects of R&D and main bank influence on firm value, the interaction effects of R&D with leverage and with main bank relationship are also included in the model. Prior research treats these characteristics as independent effects, thus failing to test for possible interaction effects of these variables. Fourth, industry dummies are being controlled in order to avoid any biases resulting from industry characteristics. Fifth, our data set is unique in that we are able to merge a number of sources of data (such as COMPUSTAT Global and Emerging Markets database and PACAP database), allowing for a through examination (by way of quantile estimators) of the impact of *Keiretsu* style banking on firm value.

We find that R&D investment, financial leverage, and *Keiretsu* style main banking all have quantile effects on firm value. The impact of R&D investment, financial leverage, and *Keiretsu* style banking on firm value varies with the various Tobin's Q quantile of the firms rather than firm size as suggested by Acs and Isberg (1996). These results are robust after controlling for industry types. Additional findings include, but are not limited to the following: (a) Firms' advantages with high (low) R&D investment over low (high) R&D monotonically increase with firm value for high (low) Q firms; (b) Tobin's Q is monotonically increasing (decreasing) with leverage for low (high) Q firms; (c) for low Q firms, R&D investment and leverage complement each other to create value; for high Q firms, R&D investment and leverage substitute each other; (d) main bank relationships play a significant role in adding value only for low to median Q firms whereas, in contrast, the main bank effect turns out to be negative with firms staying at extremely high Q; and (e) finally, we find that R&D efforts from the industry itself do not have a systematic positive or negative impact on firms' value. Instead, most of the firms in higher quantiles gain from industry effects while lower quantile firms suffer negative effects.

The paper is organized as follows. A review of the extant literature is provided in Sect. 53.2. Section 53.3 presents the data and sample. Section 53.4 reports the methodology and results, Section 53.5 concludes.

53.2 Literature Review

The effect of R&D investments on Tobin's Q and the relationship between R&D investments and debt financing is explored in numerous studies (Szewezyk et al. 1996; Zantout 1997; Vincente-Lorente 2001; O'Brien 2003). However, their findings are inconsistent. Some findings document that debt has a positive impact on R&D investment; others document a negative effect, while still others find no effect at all. These inconsistencies are not surprising. From one point, debt can act as a positive influence on managerial behavior by motivating managers to invest in projects with positive net present value. Thus, R&D investments undertaken in a high debt ratio regime are expected to positively enhance value. This helps explain why the relationships between stock returns and R&D investments announcements is positive only in firms with relatively high debt ratio (Zantout and Tsetsekos 1994).

From another point, R&D investments have been viewed as high risk and intangible such that managers may not be interested in firms with higher debt ratios. In such cases, underinvestment (or asset substitution) may occur more easily than other physical investments leading to negative impacts reflected in debt ratios. Hence, Bhagat and Welch (1995) suggest a negative relationship between R&D investments (witnessed through debt ratios) and firm value – Bradley et al. (1984) and Long and Malitz (1985) originally link leverage and R&D expenditures. Thereby, highly leveraged firms are supposed to invest less in R&D than other physical assets. Acs and Isberg (1996) address the additional issue of growth opportunities, finding that financial leverage's and R&D investment's influence on growth opportunities depends on firm size and industry structures.

As we know, agency cost and information asymmetry problems are likely to negatively influence the benefits of a highly leveraged firm from its R&D investments. Daniel and Titman (2006) suggest asymmetric information reduces the attractiveness of R&D projects to outside investors (debt holders) with managers keeping "know-how" for competitive reasons. This problem renders debt financing of R&D projects more expensive and less preferred. Daniel and Titman (2006) document that stock returns are positively related to price-scaled variables such as the book-to-market ratio (BM) and suggest the book-to-market ratio can forecasts stock returns because it is a good proxy for the intangible return. Daniel and Titman (2006) provide an argument for why high book-to-market value firms realize high future returns and find that future returns are unrelated to the accounting measures of past performance (tangible information), but are negatively related to future performance (intangible information). Among different types of intangible information, R&D is the most crucial variable when it comes assessing future performance. We measure firms' future performance by Tobin's Q ratio as reported in the extant studies (Lang et al. 1989, 1991; Doukas 1995; Szewczyk et al. 1996, etc.).[1] Chan et al. (1990) and Zantout and Tsetsekos (1994) suggest that R&D investment by firms with promising growth opportunities are basically worthy of inclusion into any model of firm value.

Due to the potential uncertainty caused by the presence of asymmetry of information between firms and investors and the unobservable nature of management, R&D is likely to be discounted in high-leverage firms. Said another way, asymmetric information problems and agency costs may render debt financing of R&D investments more expensive than other options. Support for this argument is found in Bhagat and Welch (1995), which find a negative relationship between debt ratios and R&D investments on firm value; and Kamien and Schwartz, 1982), which find that investors value a firm's investments in R&D when they use their own funds.

In addition to asymmetric information and agency, transaction cost economics may explain part of the evidence about the types of investments made by managers. Williamson (1988) points out that the choice of project financing depends on the characteristics of the assets. Titman and Wessels (1988) also postulate that "debt level is negatively related to the uniqueness of a firm's line of business." Therefore, firms with higher degrees of firm-specific assets are found to have less debt (Williamson 1988; Balakrishnan and Fox 1993; Vincente-Lorente 2001; O'Brien 2003).

Our results compensate the lack of literature in addressing the relationship between R&D and firm value, R&D and leverage, and main bank and R&D. The results are robust and consistent after making some relative tests.

53.3 Data and Sample

53.3.1 Data Source and Sample Description

To construct the sample for this research, two different databanks are employed: (a) COMPUSTAT Global and Emerging Markets database and (b) PACAP (Pacific-Basin Capital Markets) database. The financial data for Japanese-listed companies is obtained from PACAP database. Starting with an original sample of 3,499 non-financial firms listed on the Tokyo Stock Exchange and, after eliminating the firms with reported data that are not creditable,[2] an effective sample

[1] The theoretical Tobin's Q is the ratio of the market value to the replacement cost of the assets. Because some data is not available, it has been often estimated by a simple measure of Q (the "pseudo Q"): market value to book value of the total assets.

[2] For example, some firms are characterized by negative debt or negative sales without proper explanations in footnotes.

of 40,575 year-firm observations is derived from an original sample of 41,470 observations.[3] Additional data, such as firm R&D expenditure, is taken from the *Toyo Keizai's Tokei Geppo Statistics Monthly*.

The sample is next classified into eight industry types based on industry classifications proposed by Chan et al. (2001). Specifically, our samples is comprised of transportation (SIC = 37), communications (SIC = 48), electronic equipments (SIC = 36), measuring instruments (SIC = 38), computer and office equipment (SIC = 357), drugs and pharmaceuticals (SIC = 283), and computer programming and software (SIC = 737) eight industries.

Panel A of Table 53.1 reports the summary statistics of the full sample, while Panel B, C, and D presents the statistics for the main bank clients, unaffiliated firms, and selected industries, respectively. It is worth noting that in order to avoid biases resulting from extreme values in descriptive statistics, we drop the sample outliers based on if their Tobin's Q is less than 1% or larger than 99%.[4]

Panel A reveals that the mean (median) of RD_TA in Japan is 2.0% (1.2%), which is low compared with the current American firms that have an average of 10.2–16.0% (Ho et al. 2006; Cui and Mak 2002). The median of RD_TA is 1.2% (smaller than the mean of 2.0%), implying the distribution of RD_TA is dominated by firms with higher RD_TA. Figure 53.1a shows the trend of average RD_TA rose from 1.915% in 1994 to 2.15% in 1998, then dropped to 1.85% in 1999, and then increased to 2.003% in 2004, an increase of only 0.105% during these 10 years. This trend reveals there was no significant change on R&D investment in Japan during our sample period. Figure 53.1a also shows main bank clients do not always have significantly higher or lower R&D expenditure than their counterparts of unaffiliated firms. Besides, main bank clients manifest a similar trend on R&D expenditure as the full sample, which shows the highest peak during 1997–1998. This peak may have been caused by the shrinkage of total assets during Asian financial crisis.

The leverage ratio (LEV) is 0.591, which is extremely high compared to the American firms that have an average of 0.158–0.25 only (Ho et al. 2006; Johnson 1997). This figure implies Japanese firms use higher financial leverage in their capital structure, which may related to their main bank system. Furthermore, among these leverages, the long-term debt ratio is only 11.6%, which is lower than those of U.S. firms averaging 18% (Aivazian et al. 2005), revealing another unhealthy debt structure, since most of the leverages are short-term debts. Figure 53.1b shows the time trend of average leverage. The average leverage falls from 61.4% in 1994 to 53.8% in 2004. Figure 53.1b also shows main bank clients have significantly higher leverages (with an average of 0.652) compared to independent firms (with an average of 0.576) during 1994–2004.

The average Tobin's Q is 8.012 (with a median of 1.466), which is high compared to U.S. listed firms that have an average of 2.89 (Cui and Mak 2002). This high Tobin's Q may be attributable to the Asian Financial Crisis during 1997–1998 when the economy was bubbling and the dramatic volatility of high tech stocks in 1999. Figure 53.1c displays the trend of Tobin's Q over 1994–2004. It shows the average Tobin's Q rose to 66.0 in 2004 from 10.0 in 1994, an increase of six times the value of 1994 levels[5] It also shows main bank clients have the significantly lower Tobin's Q (5.137) vis-à-vis independent firms (8.78) over 1994–2004, indicating that main bank clients do not perform better.

Keiretsu-style main bank ratio (MB_D) is 19.5%, meaning only one fifth of listed firms have affiliated relationship with *Keiretsu*-style banking. The average log size (LOG_TA) is 4.3, which is small in comparison to American firms that average 17.89 (Cui and Mak 2002), implying a potential difference in size effect may exist. The average (median) capital expenditure rate (CAPEX_TA) is −2.35% (0.00%), which is negative, and the median of zero% revealed that half of the Japanese firms did not have capital expenditures during the sample period. The net cash flow ratio on average is −7.24% with a negative skewness, implying a high likelihood of negative cash flow among the listed firms. Earnings volatility (EBIT_VOL) is 5.316%, similar to American firms of 4.79% (Jonhson 1998) Dividend payout ratio (DIV_TA) on average (median) is only 0.5% (0.4%), which is low when compared to U.S. firms (Jonhson 1998).

Panels B and C then compare the characteristics of Keiretsu-style main bank clients and unaffiliated firms. Not surprisingly, main bank clients show higher leverage (0.65 vs. 0.58), larger size (4.47 vs. 4.25), and lower earnings volatility (3.21 vs. 5.84) than unaffiliated firms. However, it shows a lower median capital expenditure ratio (−3.89 vs. −1.97) and cash flow ratio (−1.82 vs. −0.46) in comparison to independent firms. This implies main bank clients are larger, have higher leverage, and lower earning volatility. However, these firms paid lower dividends and have lower cash flows ratios and capital expenditure.

[3] The financial firms were excluded from the overall sample as the financial firms exhibit different balance sheet items from those of the non-financial firms.

[4] Our extreme value definition is different from Ho et al. (2006) who deleted the extreme value below the first quantile less 1.5 times the interquantile range or any value greater than the third quantile plus 1.5 times the interquantile range. The reason why we need to delete the outliers is that we find some firms with Tobin's Q extremely high, which is beyond our understanding. We think it may be a result of the bubble Internet stock collapse before Asian Financial Crisis.

[5] The time trend utilizes the original sample without deleting the outliers. The summary statistics in Table 53.1 use the sample after deleting Tobin's Q, which is less than 1% or larger than 99% in the whole sample

Surprisingly, main bank clients show a lower R&D expenditure on average (0.019 vs. 0.020), but a higher R&D expenditure on median (0.012 vs. 0.011), suggesting there is no significant difference on investing R&D expenditures. Furthermore, main bank clients show a lower Tobin's Q on average (5.14 vs. 8.71), but a higher Tobin's Q on median (1.73 vs. 1.36), suggesting main bank clients perform poorly and are dominated by lower Q firms.

Panel D reports the selective statistics on different industries. The drug and pharmaceutical industry shows the highest R&D expenditure of 6% associated with the lowest leverage of 0.38, followed by the computer and office equipment industry with R&D expenditure of 4% associated with the leverage of 0.51, and the measuring instruments industry with R&D inputs of 3.6% and leverage of 0.54. Communication industry shows the highest Tobin's Q of 58.72, followed by the computer programming and software (26.79) and computer and office equipments (10.60). The extremely high Tobin's Q reflects the bubble stocks of high tech during the sample period and underscores the reason for employing quantile regression in this work. The transportation equipment industry shows the lowest Tobin's Q of 3.23 with the second lowest R&D inputs of 2.4% and highest leverage of 0.61, reflecting the general traditional industry characteristic: low R&D inputs, highly leveraged and low performance of Q.

53.3.2 Keiretsu and Main Bank Sample

The *Keiretsu* data comes from *Industrial Groupings in Japan.* This handbook provides the data for each company belonging to specific *Keiretsu* and its relationship strength with the

Table 53.1 Descriptive statistics and industry distribution

Variables	Obs	Mean	25%	Median	75%	Skewness	Kurtosis
Panel A: Full sample statistics							
TobinQ	35990	8.012	0.768	1.466	3.546	12.420	171.485
RD_TA	16694	0.020	0.004	0.012	0.026	2.707	14.896
LEV	36725	0.591	0.429	0.602	0.758	5.774	220.649
MB_D	36725	0.195	0.000	0.000	0.000	1.564	3.447
LOG_TA	36725	4.293	3.935	4.342	4.752	−0.657	3.945
CAPEX_TA	33700	−2.335	−0.008	0.000	0.015	−19.437	495.726
CF_TA	36080	−0.724	0.000	0.026	0.052	94.142	11695.460
EBIT_VOLA	25055	5.316	0.278	0.735	1.952	104.394	11331.750
DIV_TA	36725	0.005	0.000	0.004	0.007	8.201	186.577
Panel B: Main bank clients statistics							
Variables	Obs	Mean	25%	Median	75%	Skewness	Kurtosis
TobinQ	7018	5.137	1.100	1.726	3.114	18.995	403.701
RD_TA	4132	0.019	0.005	0.012	0.025	1.979	8.346
LEV	7049	0.652	0.521	0.668	0.800	4.004	135.686
MB_D	7049	1.000	1.000	1.000	1.000		
LOG_TA	7049	4.467	4.064	4.577	5.023	−0.743	3.165
CAPEX_TA	6386	−3.891	−0.011	0.000	0.009	−12.425	172.491
CF_TA	6964	−1.817	0.000	0.019	0.041	35.304	1982.061
EBIT_VOLA	5000	3.219	0.305	0.913	2.296	12.173	221.677
DIV_TA	7049	0.004	0.000	0.004	0.007	5.415	94.367
Panel C: Unaffiliated firms statistics							
Variables	Obs	Mean	25%	Median	75%	Skewness	Kurtosis
TobinQ	28972	8.708	0.700	1.362	3.674	11.629	150.366
RD_TA	12562	0.020	0.004	0.011	0.027	2.776	15.159
LEV	29676	0.576	0.410	0.583	0.745	6.170	234.627
MB_D	29676	0.000	0.000	0.000	0.000		
LOG_TA	29676	4.252	3.913	4.301	4.680	−0.711	4.321
CAPEX_TA	27314	−1.971	−0.008	0.000	0.018	−22.455	667.718
CF_TA	29116	−0.462	0.001	0.027	0.055	101.212	12523.120
EBIT_VOLA	20055	5.838	0.272	0.693	1.869	93.482	9081.347
DIV_TA	29676	0.005	0.000	0.004	0.008	8.173	179.844

(continued)

Table 53.1 (continued)

Panel D: Selected industries statistics

Industries	SIC	Obs	TobinQ	RD_TA	LEV
IND_D1(Transportation equipment)	37	1146	3.203	0.024	0.609
IND_D2(Communications)	48	150	58.720	0.007	0.532
IND_D3(Electrical equipment excluding)	36	2336	9.280	0.032	0.558
IND_D4(Measuring instruments)	38	754	7.442	0.036	0.537
IND_D5(Computers and office equipment)	357	335	10.599	0.039	0.513
IND_D6(Drugs and pharmaceuticals)	283	498	8.358	0.060	0.385
IND_D7(Computer programming, and software)	737	1199	26.789	0.022	0.419
IND_D8(Others)	–	29572	7.058	0.014	0.607

For sample period from 1994 to 2004, Panel A presents the basic statistics in the full sample, Panel B, C and D present the statistics for the main bank clients, unaffiliated firms, and selected industries, respectively. To avoid the bias from extreme value, we drop the sample outliers based on if their Tobin's Q is less than 1% or larger than 99%. TOBINQ is the sum of market value of firms' equity and book value of total liabilities divided by total assets; RD_TA is R&D expenditure divided by total assets; LEV is total debt divided by total assets; MB_D is the *Keiretsu* style main bank relationship which is given a 1 or 0; LOG_TA is the log of firm's total assets; CAPEX_TA is capital expenditure divided by total assets; CF_TA is the ratio of net cash flow to total assets; EBIT_VOLA, the volatility of earnings before interest and taxes, is the standard deviation of first differences of earnings before interest and tax (EBIT) divided by total assets; DIV_TA is the cash dividend payout ratio. IND_D is the dummy variable of industries, IND_D1 denotes transportation equipment, IND_D2 denotes communications industry, IND_D3 denotes electrical equipment excluding computers, IND_D4 denotes measuring instruments, IND_D5 denotes computers and office equipment, IND_D6 denotes drugs and pharmaceuticals industries, IND_D7 denotes computer programming, software, and services industries, IND_D8 denotes the others industries

Keiretsu. There are eight commonly recognized horizontal *keiretsu*: Mitsubishi, Mitsui, Sumitomo, Fuyo, DKB, Sanwa, Tokai, and IBJ. Our sample shows that these eight commonly recognized horizontal *keiretsu* – Mitsubishi, Mitsui, Sumitomo, Fuyo, DKB, Sanwa, Tokai, and IBJ – have 269, 209, 247, 222, 207, 191, 60, and 47 affiliated firms, respectively. Of those, only 127, 85, 109, 113, 91, 94, 37, and 26 are publicly listed. Hence, our data shows only 19.5% of Japanese listed firms having strong ties with one of the eight keiretsu groups; this ratio is lower than that of 89 out of 200 reported by Hoshi et al. (1991).

Our analysis of main banks is operationally defined as each firm's top bank on its trading bank list in *Kaisya Shikiho* (*the Japan Company Handbook*). Thus, a firm's main bank is its largest lender as well as the top shareholder among banks with the firm. This data is collected from *Toyo Keizai's Kigyou Keiretsu Soran* (*the Japanese Keiretsu Handbook*). Industrial groupings in Japan provides information about the amount of loans provided by each bank for *Keiretsu* members. Finally, data and names of lenders are obtained from the *Japan Company Handbook*. The handbook discloses the major sources of funding for each Japanese listed company. The names of principal banks were obtained from the reference list.

53.3.3 Model Specification

Our empirical quantile model is specified as Equation (53.1):

$$\begin{aligned} Tobin'sQ_{it} = {} & \beta_0 + \beta_1 RD\_TA_{it} + \beta_2 LEV_{it} + \beta_3 MB\_D_{it} \\ & + \beta_4 LOG\_TA_{it} + \beta_5 CAPEX\_TA_{it} \\ & + \beta_6 CF\_TA_{it} + \beta_7 EBIT\_VOLA_{it} + \beta_8 DIV\_TA_{it} \\ & + \beta_9 LEV^*_{it} RD\_TA_{it} \\ & + \beta_{10} MB^*_{it} RD\_TA_{it} + \beta_{11-17} IND_{it}\_D_{1-7} + \varepsilon_{it} \end{aligned} \tag{53.1}$$

We measure firm value by Tobin's Q similar to the prior studies (Lang et al. 1989; Doukas 1995; Szewczyk et al. 1996; Claessens et al. 2002, etc.) Tobin's Q is measured by market-to-book ratio. Market value is defined as the sum of the market value of common stock and the book value of debt and preferred stock. Following the approach of Chan et al. 1990), R&D expenditure ratio (RD_TA) is measured by R&D expenditure divided by total assets. R&D expenditure has been consistently found to be significantly positively related to a firm's Tobin's Q in at least two studies (Lang and Stulz 1994;

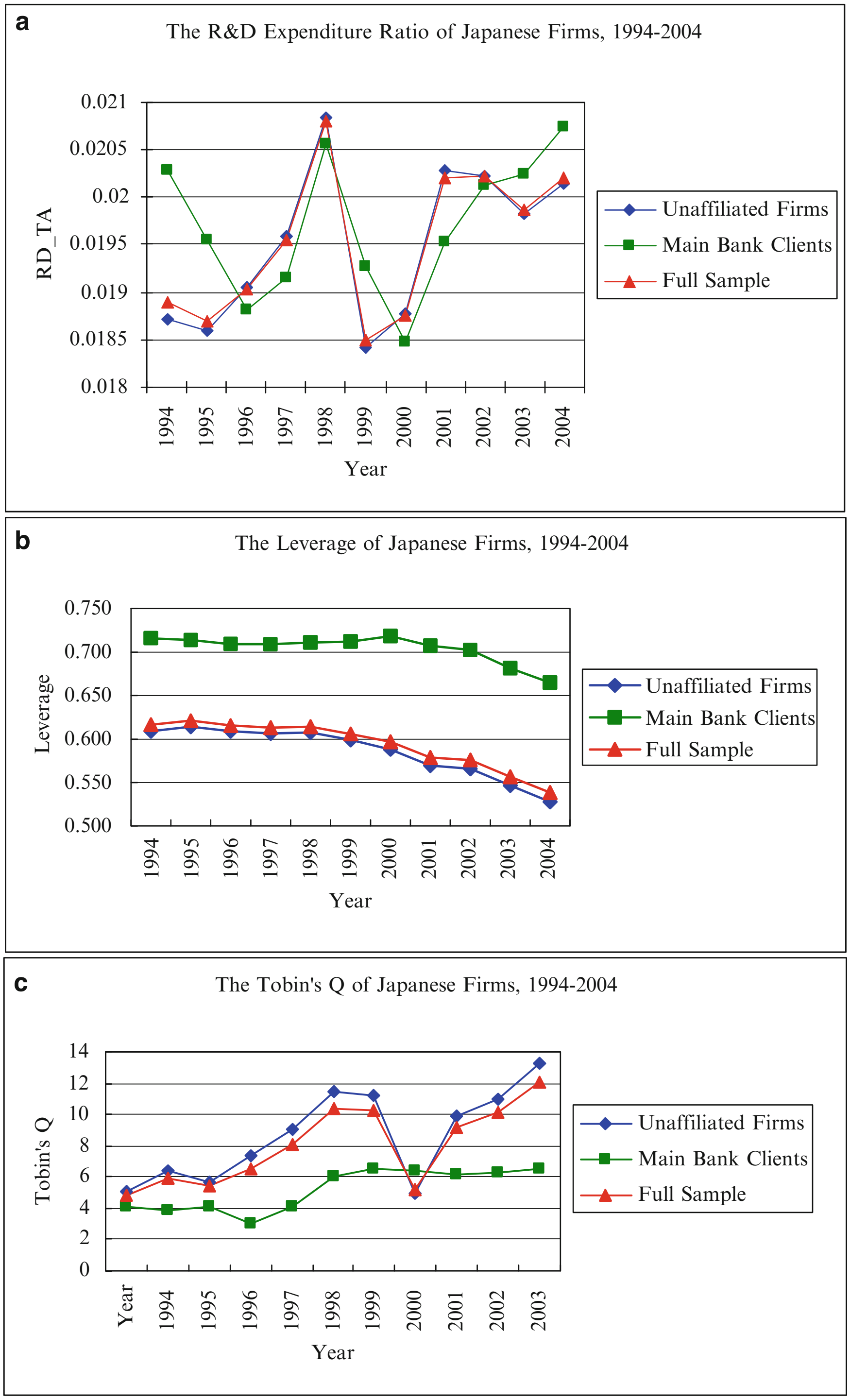

Fig. 53.1 **(a)** The R&D expenditure ratio (RD_TA) of Japanese firms, 1994–2004. **(b)** The leverage ratio of Japanese firms, 1994–2004. **(c)** The Tobin's Q of Japanese firms, 1994–2004

Chen and Steiner 2000). The main bank dummy (MB_D) is used to measure the impacts of bank monitoring on performance (Jensen and Meckling 1976), reducing information asymmetry and enhancing information signaling (Leland and Pyle 1977). If firms with *Keiretsu* style main bank relationships are expected to have lesser problems with asymmetric information or more efficient monitoring, then a lower cost and higher performance may appear. MB_D is given a "one" if firms affiliate with any of Keiretsu main bank groups, otherwise a "zero" will be given.

Firm size (LOG_TA) is included because large firms may be more successful in developing new technology (Chauvin and Hirschey 1993) resulting in different Q scores. The capital expenditure ratio (CAPEX_TA) is the ratio of capital investment expenditure to total assets. Houston and James (1996) document that market value (Tobin's Q) obviously relies on future growth opportunities, which are affected by capital expenditure. We also control free cash flow (CF_TA) for cross sectional differences among firms since R&D investment for low-free-cash-flow firms may increase the probability for seeking external financing. If main bank clients are expected to be less sensitive to cash flow problems, then the expenditure on R&D should have less aversive credit rationing from their main banks as well. Leverage ratio (LEV) and dividend yields (DIV_TA) are included as alternative measures of free cash flow (Jensen 1986) and investment opportunity (Smith and Watts 1992), respectively. Gugler (2003) finds an inverse relationship between payout ratios and R&D investments.

Although a tremendous amount of extant literature demonstrates a negative relationship between leverage and Tobin's Q, the impact of leverage on firms' value from R&D investments is ambiguous in our research. Bradley et al. (1984) and Long and Malitz (1985) find that the use of leverage decreases with R&D expenditures. However, these authors do not provide any evidence of the impact of leverage on firm value while R&D investment is high, or the impact of R&D expenditure on firm value while leverage is high (or low). To clarify this point, the interaction effects of leverage and R&D expenditure (LEV*RD_TA) is included. Moreover, the interaction effect of main bank dummy and R&D expenditure (MB*RD_TA) is also included to further elucidate our findings in supplementing the extent literature. Earnings growth volatility (EBIT_VOLA) as a proxy for controlling observable credit risk (Johnson 1997) is included in the model. Finally, seven industry dummies (IND_D1-IND_D7) are controlled in this model.

53.4 Empirical Results and Analysis

53.4.1 *Quantile Regression and Bootstrapping Analysis*

Quantile regression is originally proposed by Koenker and Bassett (1978). The general form of the equation is as follows: $y_i = \beta_q' x_i + u_{qi}$ (Koenker and Hallock 2001). This equation implies that the coefficients differ by quantile. Mean-based procedures such as ordinary least squares are more sensitive to outliers than median-based quantile estimators. The quantile estimator places less weight on outliers than do OLS estimators. Therefore, the bias should be smaller using a median-based quantile estimator.

The target for quantile regression estimates is a parameter specified before estimation. Letting e_{it} be the residuals and q represent the target quantile from the distribution of the residuals. Quantile parameter estimates are the coefficients that minimize the following objective function in Equation (53.2):

$$\sum_{eit>0} 2q|e_{it}| + \sum_{eit<=0} 2(1-q)|e_{it}| \qquad (53.2)$$

If q = 0.5, equal weighting is given to positive and negative residuals, and the parameters are estimated to minimize the sum of absolute errors. Depending on the quantile, varying weights are assigned to the residuals to lessen the impact of outliers. This result differs from ordinary least squares measures where the only constraint on the residuals is that their sum equals zero. Thus, this methodology is often employed to further investigate the differing relationships, if any, among varying quantiles. More specifically, our model's coefficients in 5, 25, 50, 75, and 95% quantiles are estimated. The results are presented in the next section.

53.4.2 *Analysis of Results of Quantile Regression and OLS*

Our quantile regression estimates are based on 20 replications of a boot-strapping algorithm at target quantiles of q = .05, .25, .50, .75 and .95. Panels A and B of Table 53.2 reports the results of the original sample with outliers and without outliers, respectively.[6] Both panels present the results of OLS and quantile regressions. We find that although there have no significant differences in the quantile regressions with and without outliers, the OLS results are significantly different. Some of the coefficients in OLS regression turn out to be significant after deleting the outliers, while the results are not significant when the outliers are included. Furthermore, the R squared improves much after deleting the outliers in both OLS and quantile regressions. Finally, the values of coefficients on both OLS and quantile regressions turn out to be more clearly interpretable after deleting the outliers.

53.4.2.1 The Original Sample

We discuss the results of original sample first. Although OLS Models (1) and (2) in Panel A show that neither R&D investment (RD_TA) nor leverage (LEV) or main bank relationships (MB_D) have significant impacts on a firm's Tobin's Q,

[6] Panel A uses the original sample, while Panel B uses the sample where Tobin'Q less than 1% or larger than 99% has been deleted.

Table 53.2 Results of OLS and quantile regression

Panel A: The original sample

	OLS		Quantile regression				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
COEFFICIENTS			q5	q25	q50	q75	q95
RD_TA	437.7	1128	−0.0000326	−0.712	20.53***	110.3***	579.4***
	(4635)	(4838)	(0.00023)	(0.68)	(6.60)	(40.2)	(210)
LEV	−209.3	−66.43	1.000***	0.680***	−2.507***	−5.874***	−12.30***
	(258)	(261)	(0.000016)	(0.10)	(0.19)	(0.42)	(3.14)
MB_D	−53.36	−29.86	0.0000247***	0.0993***	0.0456	−0.0264	0.658
	(143)	(144)	(0.0000051)	(0.024)	(0.036)	(0.074)	(0.58)
LOG_TA	−39.95	−22.60	0.0000297***	0.176***	0.131***	−0.104***	−3.379***
	(66.7)	(67.2)	(0.0000098)	(0.024)	(0.021)	(0.033)	(0.72)
CAPEX_TA	0.165	0.174	0.000115	−0.000707*	−0.000771	0.000394	0.0131
	(2.25)	(2.25)	(0.000080)	(0.00036)	(0.00054)	(0.00080)	(0.018)
CF_TA	0.161	0.108	−0.000208	−0.000515	−0.00139*	−0.00108	0.00171
	(1.76)	(1.76)	(0.00020)	(0.00048)	(0.00072)	(0.00084)	(0.0092)
EBIT_VOLA	0.00306	−0.00154	−0.00000236**	−0.00000717	0.0000542	0.000227	0.000269
	(0.17)	(0.17)	(0.0000012)	(0.000022)	(0.00014)	(0.00023)	(0.0024)
DIV_TA	9495	9151	0.000297	−1.025**	17.51***	24.94*	357.1*
	(8057)	(8078)	(0.00052)	(0.51)	(6.53)	(12.8)	(186)
LEV*RDTA	2532	−247.6	0.000310	2.339*	−27.86***	−142.6***	−681.0**
	(8552)	(8740)	(0.00039)	(1.38)	(8.53)	(35.4)	(321)
MB*RDTA	−2843	−2656	−0.000656***	14.14***	10.07***	1.750	−83.83
	(5101)	(5129)	(0.00022)	(1.09)	(1.80)	(6.28)	(74.3)
IND_D1		−29.00	−0.00000420	0.000875	0.0640	0.0783	−2.237***
		(201)	(0.000012)	(0.052)	(0.064)	(0.85)	(0.47)
IND_D2		433.3	−0.00000546	0.0776	9.146	1055***	2475***
		(526)	(0.000017)	(0.88)	(23.3)	(368)	(665)
IND_D3		360.4**	0.0000107***	−0.0501***	0.181***	0.988	9.220*
		(147)	(0.0000032)	(0.019)	(0.058)	(0.86)	(5.30)
IND_D4		−28.72	−0.00000597	−0.0141	0.150	−0.0570	10.17
		(235)	(0.0000045)	(0.031)	(0.11)	(1.04)	(8.44)
IND_D5		35.58	−0.0000138***	−0.0525	0.558** 0.675	137.4	
		(344)	(0.0000051)	(0.039)	(0.22)	(1.18)	(565)
IND_D6		−80.36	−0.00000369	0.936***	1.207***	2.617	−2.220
		(297)	(0.0000060)	(0.16)	(0.27)	(2.16)	(2.48)
IND_D7		650.8***	−0.00000724	−0.0973***	−1.177***	1.746**	616.2***
		(201)	(0.0000079)	(0.029)	(0.17)	(0.69)	(181)
Constant	351.6	129.1	−0.000113***	−0.473***	2.670***	7.155***	31.47***
	(344)	(351)	(0.000036)	(0.049)	(0.17)	(0.39)	(3.95)
Observations	13674	13674	13674	13674	13674	13674	13674
R-squared/Psedo			.0.0027	0.0009.	0.0014	0.0068.	.0.0294
R-squared	0.001	0.001					

(continued)

Table 53.2 (continued)

Panel B: Sample after deleting the outliers (Tobin's Q less than 1% or larger than 99%)							
RD_TA	64.57	97.83**	−0.000185	−1.458*	19.53***	103.5***	509.9***
	(43.4)	(45.3)	(0.00014)	(0.83)	(4.01)	(12.2)	(81.2)
LEV	−13.00***	−10.53***	1.000***	0.482***	−2.710***	−5.986***	−13.92***
	(2.40)	(2.41)	(0.000014)	(0.11)	(0.15)	(0.34)	(2.40)
MB_D	1.828	2.641**	0.0000102	0.0983***	0.0457	−0.0283	0.147
	(1.29)	(1.29)	(0.0000063)	(0.035)	(0.032)	(0.073)	(0.44)
LOG_TA	−4.461***	−3.951***	0.0000178*	0.207***	0.135***	−0.0730**	−2.065***
	(0.61)	(0.61)	(0.000010)	(0.023)	(0.020)	(0.031)	(0.40)
CAPEX_TA	0.0175	0.0225	0.000115	−0.000964***	−0.000838	0.0000200	0.00964
	(0.020)	(0.020)	(0.00010)	(0.00037)	(0.00060)	(0.00099)	(0.025)
CF_TA	0.00676	0.00230	−0.000208	−0.000466	−0.00134	−0.00111	−0.00200
	(0.016)	(0.016)	(0.00023)	(0.00070)	(0.0012)	(0.00078)	(0.012)
EBIT_VOLA	0.0000481	0.00000523	−0.00000236**	−0.00000434	0.0000583	0.000233	0.000270
	(0.0015)	(0.0015)	(0.0000010)	(0.000017)	(0.000071)	(0.00020)	(0.00026)
DIV_TA	−147.6**	−185.4**	0.000144	−2.005***	11.12*	18.91*	146.6*
	(74.8)	(74.6)	(0.00057)	(0.68)	(5.68)	(10.7)	(80.3)
LEV*RDTA	18.29	−26.60	0.000411	3.641**	−27.38***	−136.8***	−600.1***
	(79.6)	(81.0)	(0.00029)	(1.48)	(5.27)	(15.6)	(132)
MB*RDTA	−110.5**	−114.6**	0.000195	13.52***	10.55***	4.734	−36.45
	(46.1)	(46.1)	(0.00024)	(1.79)	(2.40)	(3.21)	(61.1)
IND_D1		−2.727	0.00000528	−0.000278	0.0807	0.150	−1.379***
		(1.80)	(0.0000091)	(0.035)	(0.061)	(0.10)	(0.47)
IND_D2		60.27***	−0.0000209	−0.0386	2.255	17.64	554.2***
		(5.44)	(0.000021)	(0.27)	(1.43)	(32.3)	(187)
IND_D3		2.383*	0.00000153	−0.0475*	0.217***	0.981***	7.174**
		(1.33)	(0.0000029)	(0.027)	(0.048)	(0.10)	(3.57)
IND_D4		−0.0775	−0.000000202	−0.00747	0.198*	0.0601	10.24
		(2.12)	(0.0000023)	(0.032)	(0.10)	(0.14)	(6.94)
IND_D5		3.535	−0.00000594*	−0.0719*	0.560***	0.546**	−0.226
		(3.14)	(0.0000033)	(0.041)	(0.19)	(0.23)	(2.55)
IND_D6		−2.018	−0.00000341	0.908***	1.237***	2.897***	−0.295
		(2.68)	(0.0000047)	(0.17)	(0.26)	(0.88)	(2.16)
IND_D7		12.29***	-0.00000733	−0.138***	−1.098***	0.948*	16.60
		(1.88)	(0.0000057)	(0.036)	(0.15)	(0.51)	(61.0)
Constant	34.07***	29.20***	−0.0000627*	−0.451***	2.822***	7.113***	26.10***
	(3.17)	(3.20)	(0.000038)	(0.070)	(0.16)	(0.35)	(2.71)
Observations	13401	13401	13401	13401	13401	13401	13401
R-squared/Psedo			0.0406	0.0135	0.0235	0.0469	0.0830
R-squared	0.01	0.02					

This table presents the OLS and quantile regression results from 1994 to 2004. Dependent variable is Tobin's Q, which is measured by the sum of market value of firms' equity and book value of total liabilities divided by total assets; RD_TA is R&D expenditure divided by total assets; LEV represents leverage measured by total debt to total assets; MB_D is the main bank dummy, which is given a 1 or 0; LOG_TA is size measured by the log of firm's total assets; CAPEX_TA is capital expenditure divided by total assets; CF_TA is the ratio of net cash flow to total assets; EBIT_VOLA is the volatility of earnings before interest and taxes, measured by the standard deviation of first differences of earnings before interest and tax divided by total assets; DIV_TA is the cash dividend payout ratio; LEV*RDTA is the interaction of LEV and RD_TA; MB*RDTA is the interaction of MB_D and RD_TA. IND_D1-IND_D7 are industry dummies. Standard errors in parentheses, $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

they all show significant quantile effects on Tobin's Q in Models (3)–(7). We find that for firms with higher quantiles ($q = .50$–$.95$), RD_TA is monotonically increasing with Tobin's Q (with coefficients of 20.53, 110.3, and 579.4 at $q = .50$, .75, and .95, respectively). However, for lower quantile firms ($q = .05$–$.25$), R&D investment is monotonically decreasing with Tobin's Q (with negative coefficients of −.000003 and −.712 at $q = .05$ and .25, respectively). This implies R&D expenditures add value to high quantiles firms, while destroying value on low quantiles firms. Leverage (LEV) exhibits the opposite signs as R&D increases across various quantiles. LEV is monotonically decreasing with firm value for high q firms (with coefficients of −2.507, −5.874 and −12.30 at $q = .50$, .75, and .95, respectively); however, it is increasing with firm value for low q ($q = .05$–.25) firms. This result may be explained by optimal capital structure theory: leverage may increase value for low Q firms; and destroy value for high Q firms.

The interaction effect of R&D investment and leverage (LR*RDTA) is significantly negative for high quantiles firms, while positive for low quantiles firms. This finding demonstrates that leverage and R&D substitute each other in high Q firms, but complement each other in low Q firms. Main bank (MB_D) significantly adds value for lower quantile firms ($q = .05$–$.25$), positively but insignificantly influences firm values at $q = .50$, then turns to destroy value in higher quantile firms ($q = .75$). Hence, main banks help reduce asymmetric information and provide efficient monitoring only for firms with relatively lower quantiles. The interaction effect of R&D investment and main bank effect (MB*RDTA) is increasing with firm value for firms in the medium range of quantiles ($q = .25$–$.50$), implying that main bank relationships may increase value with increasing R&D investment for firms with median Q. However, in the presence of extremely low or high quantile ($q = .05$ or $q = .95$), main bank effect on firm value is destroyed with increasing R&D investment. This finding sounds reasonable; main bank clients have a potential information leakage cost after reporting their financial statement to their largest banks. For firms with an extremely high Q, this cost of R&D information leakage on firm value is expected to be high and may even outweigh the benefit from main bank in reducing information asymmetry.

Although LOG_TA shows a significantly positive impact on Tobin's Q for lower quantile firms ($q = .05$–$.50$), the impact is significantly negative for higher quantile firms ($q = .75$–$.95$). This demonstrates the size effect is nonlinear rather than linear. It is positive in low Q firms, while negative in high Q firms. This finding is different from most of the extant literature, which documents a negative relationship by way of using traditional OLS regression. Capital expenditure (CAPEX_TA) positively influences Tobin's Q in higher quantiles and insignificantly in lower quantiles. Higher dividend payout (DIV_TA) adds value for high quantiles firms ($q = .50$–$.95$) but destroys value in lower quantile firms ($q = .25$).

The coefficients on the industry dummies (IND_D1-IND_D7) in Models (3)–(7) show that industry dummies do have quantile effects on Tobin's Q. Although the coefficients on industry dummies in OLS Model (2) are not highly significant, the coefficients in quantile Models (3)–(7) turn from negative to positive while firms' quantiles increase. This implies that the impact of industry on firm value depends on the firm's quantile membership within its industry rather than the industry to which the firms belong. We find that as quantile of Q increases, the industry impact tends to positively affect Tobin's Q regardless of industry types. This finding is different from Acs and Isberg (1996) demonstrating that the impact of R&D on growth opportunity depends on industry type. We formally document that industry quantile effect is larger than the industry effect itself: when firms get into a high quantile membership, most of the industry impacts gradually turns out to be significantly positive no matter what industry it is. Finally, Models (3)–(7) of Panel A show the true intercepts are higher at higher quantiles, demonstrating errors are positive on average at $q = 0.5$, 0.75 and 0.95.

Figure 53.2 exhibits the quantile effects of all variables on Tobin's Q. It shows most of the relationships with Q are nonlinear. For example, RD_TA shows a convex relation with Q, LEV is concave related to Q, and MB_D is nonlinear to Q without specific pattern.

53.4.2.2 Sample Without Outliers

We now discuss the Panel B sample after deleting the outliers. Interestingly, the coefficients of Model (2) on leverage, size, dividend payout, and interactions of main bank with R&D expenditures turn out to be significantly negatively related to Tobin's Q after deleting the outliers (with coefficients of −10.53, −3.95, −185.4, and −114.6, respectively), while showing insignificant results when they are included (with coefficients of −66.4, −22.6, 9151, and −2656, respectively). Main bank turns out to have a significantly positive impact on Tobin's Q (with coefficient of 2.64) with significance level of 0.05. These findings document high-levered, large size, and high payout firms tend to have lower Tobin's Q. Moreover, main bank effects on Tobin's Q are expected to be worse when firms' R&D expenditure is high. Although the impact of outliers is indifferent on various quantiles, it is significantly different in OLS regression. This finding suggests OLS may lead to misleading conclusions with the inclusion of outliers, while quantile regression is impervious to either inclusion or exclusion outliers.

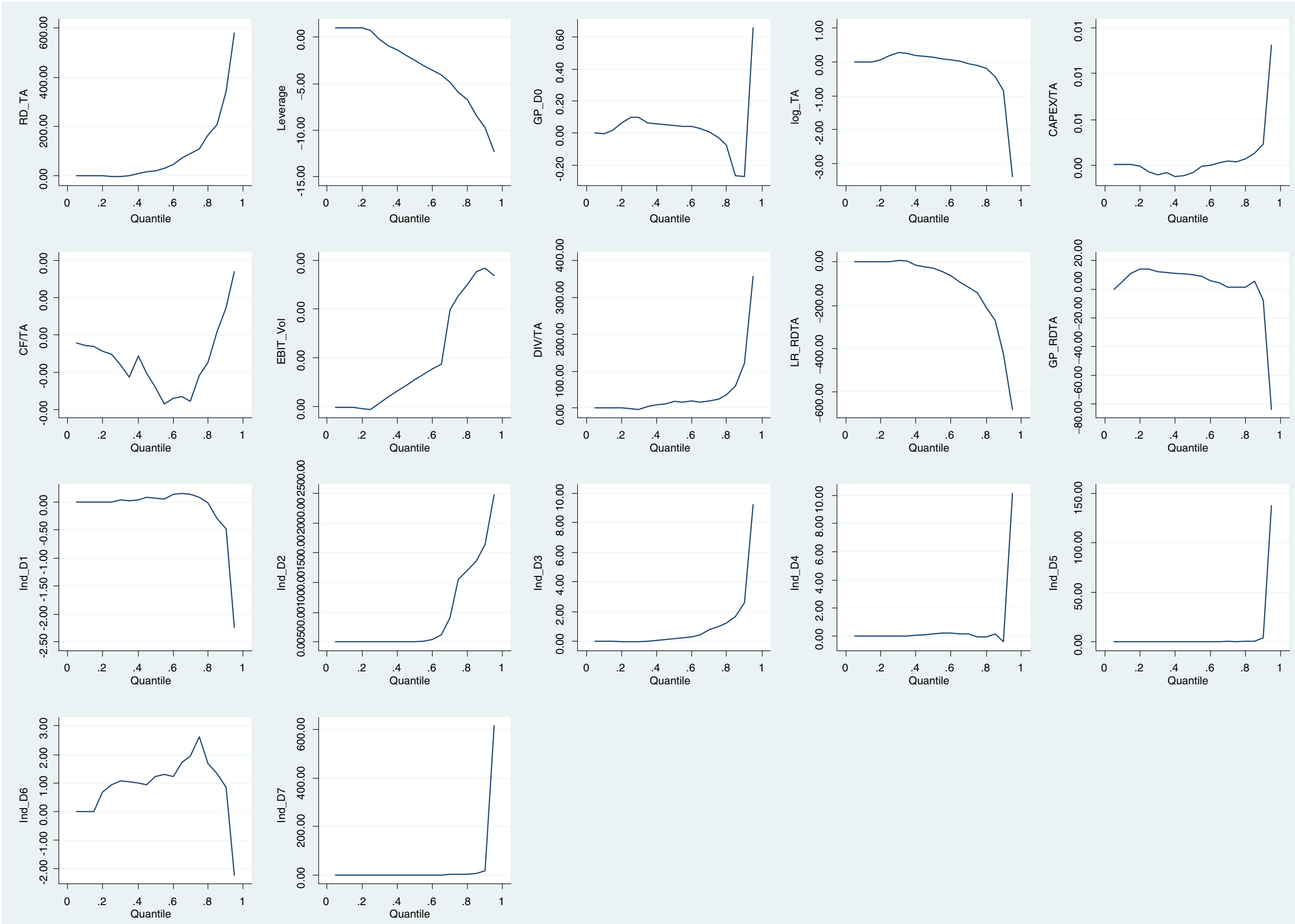

Fig. 53.2 The quantile effects of all variables on firms' Tobin's Q

53.5 Conclusions and Discussion

The quantile approach has advantages over conventional mean-based approachs in estimating the effects of R&D, leverage, and main bank relationship on Tobin's Q. The targeting quantiles from middle of the error distribution can reduce the outlier bias and improve the sample description based on targeted quantiles. Using quantile regression, our results provide explanations for the inconsistent findings that are derived utilizing conventional OLS regression in the extant literature. We also find the results of OLS are seriously influenced by outliers. In stark contrast, quantile regression effects are impervious to either inclusion or exclusion outliers. Thus, it appears quantile regression is superior to OLS when analyzing data garnered from a volatile period.

When taken as a whole, our results also have implications for understanding the effects of *Keiretsu* style banking or industry characteristics on borrowers within the economy. First, recent studies find that the impact of R&D investment on firm performance depends on industry characteristics (see, for example, Ho et al. 2006) and size (Acs and Isberg 1996). We also note from our findings that systematic (or consistent industry) effects do not always exist, and that most of the firms in our study gain from industry effects while in higher quantile Q, thus providing policy guidance for governments in their attempts to stimulate R&D. Second, our finding that the presence of main banking relationships do not always lead to higher Q scores suggests a segmented role for *Keiretsu* style banking and helps explain why only 19.5% of the sample firms actually participate in this type of banking. Additionally, the impact of main bank on firm performance depends on firm's performance itself rather than its main bank: thus for firms entering into a high quantile membership, the main bank impact turns out to be positive.

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