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The Balance Sheet Channel of Monetary Policy : Evidence from the Panel Data of Japanese Manufacturing Firms

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Abstract

We empirically analyze the effect of monetary policy shocks on real fixed investments using the panel data of Japanese manufacturing firms to examine the existence of a balance sheet channel. We observe that the firms' investments are sensitive to their debt burden during the period of tight monetary policy. The smaller the firm size, the greater the efficacy of the contractionary monetary policy. Therefore, our estimation result is in support of the balance sheet channel. In addition, the investments of medium-sized firms are more sensitive to their net worth during the period of the quantitative monetary easing policy (QMEP). Our evidence implies that the effectiveness of the QMEP is propagated to the real economy through the balance sheet channel.

JEL classification: E51; E52; G31

Keywords: Monetary policy shock; Real fixed investment; Net worth; Debt burden

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1. Introduction

Does a monetary policy shock affect a firm's real investment? If so, how does a monetary shock influence its activity? Many researchers and economists have already argued how monetary policy shocks can significantly influence the real economy.

There are several ways in which the effects of monetary policy shocks are propagated to the real economy.[1] Among them, we focus on the efficacy of monetary policy shocks on a firm's real fixed investment, which is a crucial component of aggregate output. According to Bernanke and Gertler (1995), this route is the so-called "*balance sheet channel.*"

The underlying concept of the balance sheet channel is based on the theoretical prediction that a wedge between the cost of funds raised externally (for example, through the issuance of imperfectly collateralized debt) and the opportunity cost of internal funds occurs because of asymmetric information. This wedge is called the external finance premium. When effects such as imperfect information or costly enforcement of contracts interfere with the smooth functioning of financial markets, the size of the external finance premium should depend on the borrowers' net worth (financial position).[2] In other words, there is a negative relation between the external finance premium and net worth.

We consider that it is important to investigate the existence of the balance sheet channel, because according to credit view, the firms' real investment activities play a significant role in the transmission of monetary and financial shocks in the real economy.

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[1] See, for example, Bernanke and Gertler (1995), Mishkin (1995), and Hoshi (1997).

[2] The theoretical studies of financial propagation mechanisms that emphasize the role of borrowers' balance sheets include Bernanke and Gertler (1989), Calomiris and Hubbard (1990), Gertler (1992), and Kiyotaki and Moore (1997).

The purpose of this paper is two-fold. First, to investigate the existence of the balance sheet channel, we empirically analyze the effect of monetary policy shocks on fixed investments based on a large panel dataset of Japanese manufacturing firms from 1971 to 2006.[3] In particular, we attempt to present evidence on the differential response to contractionary monetary policy shocks according to firm size.

Second, we attempt to statistically reveal the transmission mechanism of the quantitative monetary easing policy (hereafter, QMEP), which was conducted in Japan from 2001 to 2006. While many researchers and policy makers have argued the effects of the QMEP, all the previous reported results have significant deficiencies, and this line of research provides no evidence for or against the existence of the transmission mechanism of the QMEP.[4] A major approach uses the vector autoregressive (hereafter, VAR) system, but it is difficult for the VAR system to distinguish the efficacy of the QMEP from other factors. In contrast, we estimate Tobin's q-type function by introducing the firm's asset items (proxy for positive net worth) and debt items (proxy for negative net worth) to examine the significance of the QMEP.

This paper is different from previous studies in several respects detailed in the following. Gertler and Gilchrist (1994) attempted to gain empirical evidence on the same type of financial propagation mechanism for the US economy. While they deal with the impact of net worth conditions on inventory demand, this paper shows that the balance sheet channel can explain swings in a more important aggregated demand component, which is the real fixed investment.

Ogawa (2000) investigated the existence of the balance sheet channel in the

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[3] The panel studies for examining firms' liquidity constraints begin with Fazzari, Hubbard and Peterson (1998).
[4] See Ugai (2006) for a recent survey of the empirical research of the QMEP.

Japanese economy using the quarterly time series data disaggregated by firm size for manufacturing and non-manufacturing industries. Especially, he focused on the role of land as collateral in the monetary transmission mechanism. However, his estimation results showed that the monetary policy shock decreased the investments of large firms but kept those of small firms in manufacturing industries at a high level for several quarters. This is not consistent with the balance sheet channel theory.

Then, Ogawa (2002) applied Gertler and Gilchrist (1994), *ibid.* to inventory investment of Japanese firms, but he obtained contradictory results. This may have been caused by a non-financial factor such as the Japanese subcontracting system between large and small firms being different from that in the US, or may have been contaminated by the observational equivalence problem in the reduced-form VAR system. To improve these deficiencies, we choose the real fixed investment as a dependent variable, which seems to be relatively independent of the differences in the subcontracting systems. Moreover, we do not employ the VAR system but use structural equations to avoid both small sample and observational equivalence problems.

Hosono and Watanabe (2002) also analyzed the importance of the balance sheet channel in Japan. Unfortunately, however, their *net worth* variable did not contain any debt item; hence, they reached a very misleading conclusion that the heavy debt burden in the 1990s had nothing to do with the inactive investment behavior of Japanese firms.

Nagahata and Sekine (2005) investigated how the monetary easing policy influenced the firm's investment after the collapse of the asset price in the early 1990s in Japan. Their analysis, in particular, considered the effect of the bank balance sheet on a firm's investment. They found that the monetary easing policy worked through the interest rate channel but the efficacy of the balance sheet channel was interrupted because of the deterioration in balance sheet conditions. Incidentally, they use accelerator investment functions, and not Tobin's q investment functions. Therefore, it is difficult for their evidence to support the interest rate channel without considering asset price.

Moreover, Angelopoulou and Gibson (2009) investigated the sensitivity of investments to cash flow using a panel data of UK's manufacturing firms to examine the effect of the balance sheet channel. Additionally, they constructed a dummy of tight monetary policy for the UK based on the narrative indicator of Romer and Romer (1989). They found that the investments of financially constrained firms relative to unconstrained firms became more sensitive to cash flow during the periods of the contractionary monetary policy. However, because their regression models did not include any debt item, their evidence showed that tight monetary policy shocks increased the firm investment. This is not consistent with the theoretical explanation of the balance sheet channel.

Next, there are only a few results in the field of the effectiveness of the QMEP. Kimura et al. (2002) and Fujiwara (2006) did not cover the entire period of the QMEP, while Kimura and Small (2004) and Oda and Ueda (2007) analyzed the impact of the QMEP only on financial variables. Although Honda et al. (2007, 2010) showed the possibility that the QMEP might affect industrial production by stimulating stock prices, their results were quite vulnerable since their VAR models not only suffered from small sample size but also lacked theoretical background. Furthermore, their model did not consider differences in firm-size classes, and therefore could not distinguish financial from non-financial factors. On the other hand, our analysis is based on the balance sheet channel theory (the external finance premium) and is compatible with large panel data of different firm-size classes.

Here let us briefly summarize the main results of this paper. First, we clearly succeed in extracting the effects of the monetary and financial shocks even after controlling for the omitted variable problem. Specifically, the firms' investments are sensitive to their debt burden during the period of tight monetary policy. Additionally, the smaller the firm size, the greater is the efficacy of the contractionary monetary policy.

The second contribution shows that the effects of the QMEP are transmitted to the real investments of medium-sized firms by easing their liquidity constraints, implying that the impact of the QMEP is propagated to the real economy through the balance sheet channel.

This paper is organized as follows. In Section 2, we construct a panel data set and define the firm-size classes. Section 3 presents the construction of dummy variables for monetary policy by size of firm. Section 4 shows our regression models and Section 5 reports the estimation results. In Section 6, we investigate the transmission mechanism of the QMEP. Conclusions are given in Section 7.

2. Data Description

2.1. Construction of Panel Data

The panel data set is constructed from the firm's financial database of Nikkei NEEDS Financial Quest and the sample periods range from 1970 to 2006. The dataset we use for the estimation is unbalanced because of two reasons. First, there are some firms in our panel data set that were delisted during the sample periods. Second, two firms combined together to form a new company via a merger and/or acquisition during the estimation periods.[5]

2.2. Classification of Firm Sizes

Each firm falls into one of four classes according to their level of capital *and* real interest-bearing debt amount since the external finance premium depends on debt amounts as well as capital sizes (net worth position). The largest firms in the first category have over 10 billion yen in capital and less than 20 billion yen in real interest-bearing debt amount (sample size is 147). The second largest firms with over 10 billion yen in capital and more than 20 billion yen in real interest-bearing debt amount are classified in the second category (sample size is 220). Medium-sized firms in the third category have less than 10 billion yen in capital and up to 20 billion yen in real interest-bearing debt amount (sample size is 867). The fourth category represents relatively small firms with a capital of less than 10 billion yen and debt of more than 20 billion yen (sample size is 31).

3. Construction of Dummy Variables for Monetary Policy Shocks by Firm Size

First, we concentrate on only one type of shock, which is the monetary policy shock, to exclude the influences by endogenous factors as far as possible. Kuroki (1999) analyzes in detail the historical record to isolate the monetary policy shock. During our sample period, the paper identifies three episodes in which the Bank of Japan formed a tight monetary policy to cool down the economic overheating and stabilize inflation; therefore, we adopt 1973–1974, 1979–1980, and 1989–1990 as the contractionary monetary policy periods.

5 We consider a single case of such a merger.

To precisely extract the significance of the balance sheet channel, we introduce interaction variables composed of a monetary shock dummy, the proxy variables for net worth, and a firm-size dummy. That is, we append the cross term of contractionary monetary policy dummy ("one" for the periods of contractionary policy and "zero" for other periods) to the negative net worth variable (DEBT) and the cross term of the QMEP dummy ("one" for the periods of 2001 through 2006 and "zero" for others) to the positive net worth variable (LIQ). This device is quite useful to prove the existence of the balance sheet channel, but we need an additional improvement to reach a full specification model.

Therefore, we should introduce a firm-size dummy because the more severely the channel works, the smaller the firm size, and/or lesser the firm's net worth position. Based on the category defined in the previous section, we can have the new variables, LFDUMMY1, LFDUMMY2, SMFDUMMY1, and SMFDUMMY2, which, respectively, can take the following values:

$$\text{LFDUMMY1} = \begin{cases} 1 & \text{for the largest firms} \\ 0 & \text{otherwise} \end{cases},$$

$$\text{LFDUMMY2} = \begin{cases} 1 & \text{for the second largest firms} \\ 0 & \text{otherwise} \end{cases},$$

$$\text{SMFDUMMY1} = \begin{cases} 1 & \text{for the medium-sized firms} \\ 0 & \text{otherwise} \end{cases},$$

and

$$\text{SMFDUMMY2} = \begin{cases} 1 & \text{for the relatively small firms} \\ 0 & \text{otherwise} \end{cases}.$$

Thereby, we make the cross terms to identify the balance sheet channel and the transmission mechanism of the QMEP from other factors as follows. Then, we introduce these cross terms into Tobin's q investment function.

For the contractionary monetary policy (CMP),

$$\text{CMP DUMMY} \times \text{DEBT} \times \text{FIRMSIZE DUMMY}.$$

For the QMEP,

$$\text{QMEP DUMMY} \times \text{LIQ} \times \text{FIRMSIZE DUMMY}.$$

4. Estimation Based on the Fully Specified Models

4.1. Models of Investments with Contractionary Monetary Policy Shocks

To see whether the efficacy of the balance sheet channel is significant and whether it is different with respect to firm size, we add the cross terms to Tobin's q investment functions. Then, we estimate the following fully specified real investment functions with contractionary monetary policy shocks.[6] If the balance sheet channel exists, the coefficients of DEBT and the cross terms are expected to be significantly negative.

[6] Based on the results of the Hausman test, we adopt the fixed effects model.

$$\frac{I_{it}}{K_{it}} = \delta_{1t} + \tau_{1t}q_{it} + \beta_{1t}LIQ_{it} + \gamma_{1t}DEBT1_{it} + \theta_{1t}(CMP \times DEBT1_{it} \times LFDUMMY1)$$

$$+\xi_{1t}(CMP \times DEBT1_{it} \times LFDUMMY2) + \varpi_{1t}(CMP \times DEBT1_{it} \times SMFDUMMY1)$$

$$+\phi_{1t}(CMP \times DEBT1_{it} \times SMFDUMMY2) + \varepsilon_{1t} \quad (1)$$

$$\frac{I_{it}}{K_{it}} = \delta_{2t} + \tau_{2t}q_{it} + \beta_{2t}LIQ_{it} + \gamma_{2t}DEBT2_{it} + \theta_{2t}(CMP \times DEBT2_{it} \times LFDUMMY1)$$

$$+\xi_{2t}(CMP \times DEBT2_{it} \times LFDUMMY2) + \varpi_{2t}(CMP \times DEBT2_{it} \times SMFDUMMY1)$$

$$+\phi_{2t}(CMP \times DEBT2_{it} \times SMFDUMMY2) + \varepsilon_{2t} \quad (2)$$

where

I_{it}: real fixed investment of firm i in year t, K_{it}: real capital stock of firm i in year t, and

q_{it}: Tobin's *q* of firm i in year t,

LIQ_{it}: ratio of liquid assets to total assets that firm i has in year t (proxy variable for measurement of liquidity constraints or positive net worth),

$DEBT1_{it}$: ratio of interest-bearing debt amount to net income of firm i in year t (proxy variable for debt burden or negative net worth),

$DEBT2_{it}$: real interest-bearing debt amount that firm i has in year t (proxy variable for debt burden or negative net worth)

CMP: contractionary monetary policy dummy.

δ_{1t} and δ_{2t} are constant terms, and ε_{1t} and η_{2t} are disturbances, respectively.

The interpretation of DEBT1 and DEBT2 as negative net worth in the regression models (1) and (2) is important. Masuda (2012) found that for large, small-, and medium-sized firms, there was a negative relation between the real fixed investments and debt burden in a cross section regression in each year, and it tended to be much stronger during the periods of contractionary monetary policy.

Therefore, negative net worth, which is evaluated as a measure of a firm's health, is large when a bad economic situation such as debt deflation or financial crisis occurs. Thus, as the situation is the same for the external financial premium with a net worth value, the premium is assumed to be an increasing function of negative net worth. Namely, this premium is higher in bad economic conditions, or for firms with more debt burden, than in good conditions, or for large firms with less debt burden.

4.2 Estimation Period

We construct and estimate not only full sample periods but also subsample periods. Concretely, we create two types of panel data sets: type 1 ranges from 1971 to 1996 (before the break out of the Asian financial crisis in 1997), type 2 from 1971 to 1998 (before the introduction of the zero-interest-rate policy in 1999) to remove the peculiar impact of the Asian financial crisis and the zero-interest-rate policy.[7]

5. Estimation Results: Firms' Investments and the Balance Sheet Channel

The estimated results of the regression models (1) and (2) during the periods from 1971 to 1996 are shown in Table 2 and Table 3, respectively. Panel A of Table 2 shows the estimation results of the simple investment functions (1), excluding all the four identification dummy variables. While the coefficient of LIQ is not significantly positive, the coefficients of Tobin's q and DEBT1 are of the correct signs and are

[7] We devise this type of panel data to exclude the exogenous factors as far as possible.

statistically significant at the 1% level.

Panel B of Table 2 shows the estimation results of the fully specified version model (1) introducing four cross terms. The results are quite similar to those in Panel A. Although the coefficient of LIQ is not significant, the coefficient of Tobin's q is significantly positive and DEBT1 is significantly negative. In addition, the coefficient of the cross term for the largest firms is statistically significant except for the other three. These results suggest that net income relative to debt burden has played an important role in the rate of the real investments of the largest firms.

Table 3 reports the estimation results both from the simply specified and fully specified models on the effects of DEBT2 on firms' investments. Let us focus on the estimation results based on the fully specified model (Panel D), since the simpler model, presented in Panel C, may be contaminated by the endogeneity problem. Comments on Panel D are warranted. In contrast to the results presented in Panel B of Table 2, most of the interaction dummy variables as well as DEBT2 are statistically significantly negative. This implies that the firms' investments are decidedly sensitive to debt burden, particularly during the period of the contractionary monetary policy.

Additionally, the smaller the firm sizes, the larger the estimated coefficients of the cross terms. Furthermore, the significance levels of those coefficients are also larger for the smaller firm-size classes. For instance, while the estimated coefficient for the firm category with the least amount of net worth is -0.0001190 at the 1% significance level, that for the second largest firms is -0.31×10^{-5} at the 5% level but the effect of DEBT2 on the richest firms' investments is statistically insignificant. These results are highly consistent with the theory of the balance sheet channel, and therefore, we can conclude that the balance sheet channel of monetary policy transmission operates through the debt burden.

Including the financial crises period does not modify our conclusion. Table 4 and Table 5 show the estimation results of the regression models (1) and (2) during the periods from 1971 to 1998, respectively.

Panel E and Panel F of Table 4 report the results of the regression model (1) with and without the cross terms. As shown in these Panels, the magnitude of the estimated coefficients of Tobin's q, LIQ, and DEBT1 are nearly identical with those in Panel A and Panel B of Table 2. However, as shown in Panel F, the coefficient of the cross term for the second largest firms is significantly negative except for the other three.

The results revealed in Table 5 are quite similar to those in Table 3 in terms of magnitude and statistical significance of estimated coefficients of DEBT2 and the cross terms for medium-sized firms and relatively small firms. Especially, the coefficients of the cross terms are negative at a high significance level for relatively small firms. As presented in Panel B and F, the only point we should note is that the estimation result of the cross term for the largest firms are opposite to that for the second largest firms. This may simply suggest a possibility that the financial crisis exerts some influence on the financial condition of the largest and the second largest firms. This will be a subject for further research.

In summary, we have confirmed that the effects of monetary policy shocks have been transmitted to the firms' investments through their net worth amounts. The verified evidence shows the importance of the debt burden in the monetary transmission, and as the theoretical consensus suggests, it also argues that the smaller the firm size, the larger the efficacy of monetary policy shocks via debt burden. Consequently, we can conclude that the balance sheet channel of monetary policy operates more effectively for medium-sized firms and relatively small firms.

6. Testing the Transmission Mechanism of the QMEP

6.1. The Model

The purpose of this section is to discover the transmission mechanism of the QMEP. To identify the channel of the QMEP from other factors, we estimate the Tobin's q-type regression models appending the cross terms of the QMEP dummy with LIQ and a firm-size dummy. The investment functions are as follows. [8]

$$\frac{I_{it}}{K_{it}} = \delta_{1t} + \tau_{1t}q_{it} + \beta_{1t}LIQ_{it-1} + \gamma_{1t}DEBT1_{it} + \chi_{1t}(QMEP \times LIQ_{it} \times LFDUMMY1)$$
$$+\psi_{1t}(QMEP \times LIQ_{it} \times LFDUMMY2) + \pi_{1t}(QMEP \times LIQ_{it} \times SMFDUMMY1)$$
$$+\lambda_{1t}(QMEP \times LIQ_{it} \times SMFDUMMY2) + \varepsilon_{1t} \quad (3)$$

$$\frac{I_{it}}{K_{it}} = \delta_{2t} + \tau_{2t}q_{it} + \beta_{2t}LIQ_{it-1} + \gamma_{2t}DEBT2_{it} + \chi_{2t}(QMEP \times LIQ_{it} \times LFDUMMY1)$$
$$+\psi_{2t}(QMEP \times LIQ_{it} \times LFDUMMY2) + \pi_{2t}(QMEP \times LIQ_{it} \times SMFDUMMY1)$$
$$+\lambda_{2t}(QMEP \times LIQ_{it} \times SMFDUMMY2) + \eta_{2t} \quad (4)$$

where

I_{it}: real fixed investment of firm i in year t, K_{it}: real capital stock of firm i in year t, and

q_{it}: Tobin's q of firm i in year t

LIQ_{it-1}: ratio of liquid assets to total assets that firm i has in year t − 1 (proxy variable

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[8] We introduce the lagged LIQ (LIQ_{it-1}) instead of LIQ_{it}, since the estimated coefficients of LIQ_{it} in models (1) and (2) in a previous section have insignificantly wrong signs. This seems to stem from a high correlation with LIQ_{it} and other variables.

for the measurement of liquidity constraints or positive net worth)

$\mathrm{DEBT1}_{it}$: ratio of interest-bearing debt amount to net income of firm i in year t (proxy variable for debt burden or negative net worth)

$\mathrm{DEBT2}_{it}$: real interest-bearing debt amount that firm i has in year t (proxy variable for debt burden or negative net worth)

$QMEP$: quantitative monetary easing policy dummy.

δ_{1t} and δ_{2t} are constant terms, and ε_{1t} and η_{2t} are disturbances, respectively.

Now, if the impact of the QMEP is transmitted to the firms' investments, the coefficients of LIQ and the cross terms should be statistically significantly positive. This precisely means that the QMEP could influence the real economy through the balance sheet channel.

6.2. Evidence for a Channel of the QMEP

The estimation results of regression models (3) and (4) are shown in Table 6 and Table 7, respectively. First, Panel I of Table 6 reports the results of the regression model (3) excluding the cross terms and shows that the coefficients of Tobin's q, LIQ_{it-1}, and DEBT1 have statistically significantly the correct signs. Panel J of Table 6 gives the estimated coefficients of investment function (3) introducing the interaction dummies. This panel indicates that the coefficients of Tobin's q, LIQ_{it-1}, DEBT1, and the cross term for medium-sized firms with a debt amount less than 20 billion yen are significant with the right sign. Interestingly, however, the coefficient of the cross dummy for the relatively small firms that incur heavy debts over 20 billion yen is not statistically significant. It seems that the debt burden relative to capital (firm size) is over-large for relatively small firms, and therefore, the investments of these firms do not appear to be sensitive to the target amount "changes" by the QMEP.

We obtained similar results in the estimations of the regression model (4). Panel K and Panel L of Table 7 reveal the estimated coefficients of Tobin's q, LIQ_{it-1}, and DEBT2 without and with interaction dummy variables, respectively. Panel L shows that LIQ and DEBT2, both of which are the proxy variables for net worth positions, are statistically significant at the 1% and 5% level, respectively, and the third dummy is also significant at the 1% level.

In summary, we have shown a high likelihood that the QMEP was effectively transmitted to the real fixed investments of medium-sized firms by easing their liquidity and net worth constraints. The QMEP did not independently affect the real investments of large firms, although their liquidity position itself was important; therefore, we conclude that the transmission of the QMEP indeed operates through the balance sheet channel.

7. Conclusions

The purpose of this paper was to identify the balance sheet channel of monetary policy and the transmission mechanism of the QMEP from other factors. We obtained two findings. First, the firms' investments are sensitive to their debt burden during the period of tight monetary policy. As expected, the smaller the firm size, the greater the efficacy of contractionary monetary policy shocks. Therefore, our analysis can show evidence on the existence of the balance sheet channel through the debt burden of firms.

Second, we can distinguish the transmission mechanism of the QMEP from other factors. In particular, for medium-sized firms, the investments are more sensitive to their net worth during the period of the QMEP. Thus, we can show that the effectiveness of the QMEP is propagated to the real economy through the balance sheet channel. However, the problem we need to solve remains. If the effect of the QMEP could be transmitted to firms' real investments, the coefficient of LIQ for relatively small firms must be significant with the right sign. In effect, however, we were not able to find any empirical evidence as the theoretical consideration implies. Thus, further research on this is required.

Appendix. Data Construction

This appendix describes the construction of the variables used in the estimation.

Data Source. There are three primary data sources. We obtained the company financial statements data from the Nihon Keizai Shinbun's NEEDS Financial QUEST. The price index for investment goods is taken from components of the Corporate Goods Price Index (CGPI). For the corporate tax rate calculation, we use SNA statistics.

PK_t: *Price of Capital Goods.* The three categories of capital goods are (1) buildings and structures, (2) machinery and equipment, and (3) transportation equipments. The price index for (1) is a construction material component of the CGPI in index by stage of demand and use.[9] The general machinery and equipment component of the CGPI is adopted as the index price for (2). The transportation equipment component of the CGPI is used as the index price for (3).

$NOMI_t$: *Nominal Investment.* These assets are depreciable. The calculation of a nominal investment is carried out for each category:

KTE_t = book value of tangible fixed assets at the ending of year t,

$ADEP_t$ = amount of executed depreciation during year t.[10]

The nominal investment ($NOMI_t$) is

$$NOMI_t = KTE_t - KTE_{t-1} + ADEP_t.$$

I_t: *Real investment.* We divide the nominal investment ($NOMI_t$) by the price of capital goods (PK_t) to calculate the real investment for each category as follows:

[9] The construction material is calculated from raw materials and intermediate materials.

[10] Nikkei NEEDS Financial Quest does not include the book value of the capital wastage cost for the each of the three asset types. Then, by proportionally dividing the book value of the total of capital wastage cost according to the each asset amount, we calculate the book value of the capital wastage cost for each asset.

$I_t = NOMI_t / PK_t.$

The total real investment is defined as sum of the real investment calculated for these categories.

δ: *Physical Depreciation Rates*. The depreciation rate for buildings and structures is 0.047, that for machinery and equipment is 0.09489, and that for transportation equipment is 0.147.[11]

K_t: *Real Capital Stock.* Based on Inoue and Hayashi (1991) and Fukuda (2003), we conduct the perpetual inventory method for each asset. K_t stands for the real capital stock during year t, PK_t for the price index at the ending of year t, and δ for the physical depreciation rate. The perpetual inventory calculation is given by

$$K_t = (1 - \delta)K_{t-1} + I_t.$$

We began to execute the perpetual inventory method from the end of 1971 since the data is covered from the bench mark year of 1970. For the companies that started up after 1971, we apply this method from the point at which the companies appeared on the basis of the assumption that the book value is equal to the market value. If we encounter negative K_t during the process of perpetual inventory accounting, K_t is excluded.

Proxy for Tobin's Marginal Q. Based on Suzuki (2001), we adopt the method by Suzuki (2001) for the contraction of Tobin's marginal Q.

(a) Marginal returns rate to capital = (current income + amount of executed depreciation + interest expense & discount expense) / (investment-goods price * real capital stock at the end of the previous year),

[11] Hayashi and Inoue (1991) adopt the depreciation rate of 0.0564 for structures, but we use the depreciation rate of 0.047.

(b) Debt cost = (interest expense & discount expense + amortization of bond discount) / interest-bearing debt at the end of the previous year,[12]

(c) Capital cost = (1 − corporate tax rate) * debt cost + depreciation ratio.[13][14]

Then, the definition of proxy for Tobin's marginal Q is as follows:

Q = (a) marginal return rate to capital / (c) capital cost.

LIQ: *Ratio of Liquidity Assets to Total Asset*. Liquidity assets consist of a sum of cash deposit, bills receivable, accounts receivable, and security and are divided by the total asset to get the ratio of liquidity assets to the total asset.

DEBT1: *Ratio of Interest-Bearing Debt to Current Income*. This value is calculated by dividing the interest-bearing debt by current income.

DEBT2: *Real Interest-Bearing Debt*. Simply, this variable is calculated by dividing the interest-bearing debt by aggregate average at the period of March of CGPI.

[12] Interest-bearing debt is the sum value of short-term borrowings, long-term borrowings, corporate and convertible bonds, current portion of long-term debt, current portion of corporate and convertible bonds, long-term note payable, long-term accounts payable, and deposit payable.

[13] The calculation of corporate tax rate is based on SNA statistics.

[14] We compute the value of depreciation ratio by dividing the amount of executed depreciation by the sum of the book value in the each of the three assets.

Tables

Table 1. Summary Statistics

	INV	Q	LIQ	DEBT1	DEBT2
Mean	0.1496	1.5928	0.4336	35.0606	303.2433
Median	0.0990	1.0457	0.4331	7.9060	51.8678
Std. Dev.	0.2439	5.0629	0.1297	241.1685	1019.8660
Observations	36329	34182	36331	36314	36340

Table 2 The coefficients estimated by model (1) during the period of the contractionary monetary policy through 1971 to 1996

Panel A The estimates of model (1)

Variable	q		LIQ	DEBT1	
Coefficient	0.0041	***	-0.0214	-0.0000093	***
t-Statistic	4.2629		-2.7954	-3.5911	

Adjusted R-squared	0.1393
Observations	22098

Panel **B** The effect of contractionary monetary policy on the firms' investments

Variable	q		LIQ	DEBT1		CMP×DEBT1×LFDUMMY1		CMP×DEBT1×LFDUMMY2	CMP×DEBT1×SMFDUMMY1	CMP×DEBT1×SMFDUMMY2
Coefficient	0.0043	***	-0.0221	-0.0000077	***	-0.0002130	***	-0.0000144	-0.0000028	0.0000744
t-Statistic	4.1359		-2.7536	-2.7356		-2.8058		-0.8421	-0.2180	0.2170

Adjusted R-squared	0.1407
Observations	22073

Note. 1. *** Significance at 1% level. ** Significance at 5% level. * Significance at 10% level. 2. Estimation results by OLS. 3. We adopt the fixed effect model. 4. White's heteroskedasticity-consistent standard errors are used to compute t-statistics.

Table 3 The coefficients estimated by model (2) during the period of the contractionary monetary policy through 1971 to 1996

Panel C The estimates of model (2)

Variable	q		LIQ	DEBT2	
Coefficient	0.0041	***	-0.0251	-0.0000036	***
t-Statistic	4.2644		-3.1762	-9.3199	

Adjusted R-squared	0.1398
Observations	22107

Panel D The effect of contractionary monetary policy on the firms' investments

Variable	q		LIQ	DEBT2		CMP×DEBT2×LFDUMMY1	CMP×DEBT2×LFDUMMY2		CMP×DEBT2×SMFDUMMY1		CMP×DEBT2×SMFDUMMY2	
Coefficient	0.0041	***	-0.0247	-0.0000028	***	0.0000029	-0.0000031	**	-0.0001100	***	-0.0001190	***
t-Statistic	4.2503		-3.0988	-6.1352		0.1588	-2.3655		-3.0501		-3.6611	

Adjusted R-squared	0.1410
Observations	22082

Note. 1. *** Significance at 1% level. ** Significance at 5% level. * Significance at 10% level. 2. Estimation results by OLS. 3. We adopt the fixed effect model. 4. White's heteroskedasticity-consistent standard errors are used to compute t-statistics.

Table 4 The coefficients estimated by model (1) during the period of the contractionary monetary policy through 1971 to 1998

Panel E The estimates of model (1)

Variable	q		LIQ	DEBT1	
Coefficient	0.0042	***	-0.0216	-0.0000085	***
t-Statistic	5.5892		-2.5800	-3.1611	

Adjusted R-squared	0.1410
Observations	24374

Panel F The effect of contractionary monetary policy on the firms' investments

Variable	q		LIQ	DEBT1		CMP×DEBT1×LFDUMMY1	CMP×DEBT1×LFDUMMY2		CMP×DEBT1×SMFDUMMY1	CMP×DEBT1×SMFDUMMY2
Coefficient	0.0043	***	-0.0224	-0.0000071	***	-0.0000112	-0.0002240	***	-0.0000004	0.0000537
t-Statistic	5.5092		-2.7345	-2.7610		-0.8661	-4.0154		-0.0292	0.1609

Adjusted R-squared	0.1423
Observations	24349

Note. 1. *** Significance at 1% level. ** Significance at 5% level. * Significance at 10% level. 2. Estimation results by OLS. 3. We adopt the fixed effect model. 4. White's heteroskedasticity-consistent standard errors are used to compute t-statistics.

Table 5 The coefficients estimated by model (2) during the period of the contractionary monetary policy through 1971 to 1998

Panel G The estimates of model (2)

Variable	*q*		LIQ	DEBT2	
Coefficient	0.0042	***	-0.0252	-0.0000033	***
t-Statistic	5.5857		-3.0271	-7.4065	

Adjusted R-squared	0.1415
Observations	24384

Panel H The effect of contractionary monetary policy on the firms' investments

Variable	*q*		LIQ	DEBT2		CMP×DEBT2×LFDUMMY1		CMP×DEBT2×LFDUMMY2	CMP×DEBT2×SMFDUMMY1		CMP×DEBT2×SMFDUMMY2	
Coefficient	0.0042	***	-0.0248	-0.0000027	***	-0.0000028	**	0.0000082	-0.0001140	***	-0.0001240	***
t-Statistic	5.5818		-3.0268	-5.1684		-2.1881		0.4439	-2.8577		-3.7053	

Adjusted R-squared	0.1426
Observations	24359

Note. 1. *** Significance at 1% level. ** Significance at 5% level. * Significance at 10% level. 2. Estimation results by OLS. 3. We adopt the fixed effect model. 4. White's heteroskedasticity-consistent standard errors are used to compute t-statistics.

Table 6 The coefficients estimated by model (3) during the period of the QMEP

Panel I The estimates of model (3)

Variable	q		LIQ_{t-1}		DEBT1	
Coefficient	0.0035	***	0.0138	***	-0.0000066	***
t-Statistic	6.2019		3.4803		-2.7586	

Adjusted R-squared	0.1560
Observations	30355

Panel J The impact of QMEP on the firms' investments

Variable	q		LIQ_{t-1}		DEBT1		QMEP×LIQ×LFDUMMY1	QMEP×LIQ×LFDUMMY2	QMEP×LIQ×SMFDUMMY1		QMEP×LIQ×SMFDUMMY2
Coefficient	0.0035	***	0.0126	***	-0.0000063	***	0.0214	0.0342	0.0663	***	0.0418
t-Statistic	6.2291		3.2710		-2.6579		0.2309	0.7005	3.3154		1.1795

Adjusted R-squared	0.1569
Observations	30355

Note. 1. *** Significance at 1% level. ** Significance at 5% level. * Significance at 10% level. 2. Estimation results by OLS. 3. We adopt the fixed effect model. 4. White's heteroskedasticity-consistent standard errors are used to compute t-statistics.

Table 7 The coefficients estimated by model (4) during the period of the QMEP

Panel K The estimates of model (4)

Variable	q		LIQ t-1		DEBT2	
Coefficient	0.0035	***	0.0131	***	-0.0000017	***
t-Statistic	6.2014		3.3638		-2.7591	

Adjusted R-squared	0.1559
Observations	30363

Panel L The impact of QMEP on the firms' investments

Variable	q		LIQ t-1		DEBT2		QMEP×LIQ×LFDUMMY1	QMEP×LIQ×LFDUMMY2	QMEP×LIQ×SMFDUMMY1		QMEP×LIQ×SMFDUMMY2
Coefficient	0.0035	***	0.0121	***	-0.0000015	**	0.0184	0.0284	0.0658	***	0.0421
t-Statistic	6.2284		3.1650		-2.4863		0.2012	0.6023	3.3237		1.1871

Adjusted R-squared	0.1567
Observations	30363

Note. 1. *** Significance at 1% level. ** Significance at 5% level. * Significance at 10% level. 2. Estimation results by OLS. 3. We adopt the fixed effect model. 4. White's heteroskedasticity-consistent standard errors are used to compute t-statistics.

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