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**Institut für Höhere Studien (IHS), Wien
Institute for Advanced Studies, Vienna**

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**Institut für Höhere Studien (IHS), Wien
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Abstract

The two key questions which motivate our work are: do bubbles exist (in the sense that stock market prices do not always correspond to the present value of expected future profitability) and, if bubbles exist, do they have an effect on business fixed investment? The case of Japan is particularly interesting because of the dramatic movements in the Japanese stock market and the wide perception that these were associated with a bubble.

We use a variety of techniques to analyze these questions. First, we examine financing and investment patterns to gauge firms' reactions to the 1980s stock market run-up. Second, we test subsets of the orthogonality conditions associated with the empirical first-order conditions for fixed investment. Third, we use a linear projection to decompose stock market prices into fundamental and bubble components, allowing us to carry out parametric estimates of the effect of the bubble component on fixed investment. The data strongly suggest that there was a bubble that had an economically important statistically significant effect on business fixed investment in Japan.

Keywords

Investment, financial market, bubbles

JEL-Classifications

E44, E22, G10

Comments

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In recent years, there has been a lively debate in the economics profession on whether stock market prices always equal the expected present value of future dividends. A variety of theoretical work has called the simple present value model of stock prices into question.¹ Empirical studies have provided evidence that stock prices may vary too much relative to dividends, that investors may overreact, that there may be fads in stock market prices, and that there may be a tendency to be overly optimistic about the future performance of stocks that have done well in the recent past.² Much of this theoretical and empirical work has been vigorously challenged, so the academic debate is far from over.

Among policy-makers, there is a long-standing concern that extreme movements in asset markets may adversely affect the real economy. For example, a reading of Friedman and Schwartz's Monetary History of the United States shows that the main concern of the Federal Reserve in the late 1920s was how to curb stock market speculation.³ More recently, the almost universal reaction of central bankers to the 1987 stock market crash was to inject liquidity into the system.

In this paper, we refer to deviations of actual stock market prices from the expected present value of future dividends as "bubbles." The two key questions which motivate our work are: Do bubbles exist? If bubbles exist, do they have an effect on the real economy?

We focus in particular on the possible effects of bubbles on business fixed investment. It is widely understood that business fixed investment is relatively volatile and may play an important role in economic fluctuations. To the best of our knowledge, previous research on this issue has focused exclusively on the U.S. stock market⁴, which tends to be less volatile

¹See, for example, Allen and Gale (1994), Allen and Gorton (1993), Blanchard and Watson (1982), and De Long, Shleifer, Summers, and Waldmann (1990).

²For a sampling of the large empirical literature, see Shiller (1981), Mankiw, Romer, and Shapiro (1991), DeBondt and Thaler (1986), Poterba and Summers (1988), and Lakonishok, Shleifer, and Vishny (1994).

³See especially pages 253-270.

⁴See Blanchard, Rhee, and Summers (1993), Galeotti and Schiantarelli (1994), and Morck, Shleifer, and Vishny (1990).

than many other major stock markets. As a result, tests for the effects of bubbles on investment may be less powerful.

The recent experience in Japan provides a particularly interesting case. As shown in Figure 1, the rise of the Japanese stock market in the late 1980s and its decline in the early 1990s dwarf the 1987 stock market crash in the U.S.⁵ This phenomenon was widely perceived as a bubble not only by the Japanese public (for whom the phrase "the bubble economy" has come to characterize this period), but also for many economists and policy-makers.⁶ In Japan, there was a strong perception that the bubble was an important issue for monetary policy. In fact, Yasushi Mieno, who took over as governor of the Bank of Japan in 1989, is reported to pride himself on being the man who made ending speculative excesses a primary objective of monetary policy.⁷

Higher stock prices provide firms with a potentially cheap source of finance, so we might expect firms to take advantage by issuing equity. Economic theory, however, leaves open the question of whether business fixed investment will respond to a bubble. On the one hand, firms may use the earnings-price ratio as a measure of the cost of capital so that a stock price bubble will lower the discount rate applied to future cash flows. On the other hand, firms might view stock prices as unreasonably high and issue new shares but put the proceeds into cash and securities, rather than fixed investment. These contrasting theoretical possibilities are reflected in differing interpretations of the importance of the putative bubble on real variables. Some prominent academics have concluded that the fall in equity prices had little effect on the Japanese economy (Malkiel, 1995, p.37) or that stock prices generally

⁵High and rising stock prices, however, are not necessarily indicative of a bubble. Sustained upward movements in stock prices could be attributable to falling interest rates, a rise in cash flows, or increases in the expected growth rate of cash flow. Indeed, it has been argued that the substantial equity price movements in Japan can be explained in terms of the present value model.

⁶For example, Federal Reserve Board Chairman Alan Greenspan described the plunge in the Japanese stock market as "a correction of the bubble in asset prices" [Washington Post, April 18, 1992, p. A13].

⁷The Economist, February 15, 1992, p. 91.

have little impact on Japanese firms (Porter, 1992, p.9). Alternatively, others have claimed that the bursting of the bubble has been a primary culprit in the prolonged Japanese recession (Aliber and Solomon, 1993, p.2; The Economist, July 9, 1994, p.14).

In the first section of the paper, we examine informal evidence on whether bubbles existed in Japan and, if so, whether they affected business fixed investment. We focus on the time patterns of equity issues (and equity-linked securities), changes in firms' holdings of cash and securities, and fixed investment.

In the second section of the paper, we show how the theory of fixed investment can be used to derive an innovative set of tests for whether bubbles exist and whether they affect fixed investment. These tests are based on differences in the empirical first-order conditions for fixed investment depending on whether bubbles exist and whether they affect the cost of capital. We show that when bubbles exist, they will enter the residuals associated with the empirical first-order conditions in distinct ways which are linked to interesting economic hypotheses. Two main subsets of the orthogonality conditions associated with the first-order conditions will be affected in different ways. We can therefore apply the Eichenbaum, Hansen, and Singleton (1988) econometric procedure, which is designed to assess the validity of subsets of the orthogonality conditions.

Neoclassical theory shows that investment should be linked to expected future profitability. Under standard assumptions regarding technology and market structure (including stock market efficiency), investment should therefore be linked to stock market price. However, if bubbles exist, then the stock market price will consist of a fundamental component and a bubble component. In the third section, we use a linear projection approach suggested by Abel and Blanchard (1986) to construct these two components. This allows us to parametrically estimate whether the bubble component affects investment and, if so, by how much.

The paper is organized as follows. Section 1 examines informal evidence from data about the sources and uses of funds by the principal Japanese enterprises, as well as data on aggregate investment patterns. Section 2 derives and estimates first-order conditions for fixed investment for the cases where: 1) there are no bubbles; 2) bubbles exist but do not influence the cost of capital; and 3) bubbles exist and do affect the cost of capital. Section 3

explains how we use the Abel-Blanchard (1986) linear projection technique to construct the fundamental and bubble components of stock prices and presents parametric estimates of the effect of the fundamental and bubble components on business fixed investment. In Section 4, we summarize the empirical results and present what we feel is the most convincing interpretation of the data.

1. Informal Evidence

If its shares are overvalued, a firm has an incentive to issue new shares to take advantage of the "arbitrage" opportunity.⁸ Thus, one sign of overvaluation would be a dramatic increase in new share issues.⁹ Figure 2 plots the ratio of equity issues to investment spending for Principal Enterprises.¹⁰ The plot shows a steady increase in equity issues during the latter part of the 1980s which peaks in 1988-89 at a level which is more than twice as high as the mean over the sample period. In 1990 and 1991, there is a very sharp drop in equity issues which takes them below their level in the late 1960s.

If firms suspect that there are investors with overly optimistic beliefs about their shares, it makes sense for them to take advantage of the situation by issuing bonds which include an option to purchase shares. As Malkiel (1995, p.35) notes, Japanese "corporations began to float bonds in the European markets with interest rates as low as one percent, by offering warrants to buy the companies' stock." In fact, a large proportion of the bonds

⁸Two caveats should be noted. First, debt or retained earnings could be the marginal source of finance (for tax or other reasons) and a sufficiently small overvaluation might not have an impact at the margin. Second, managers may be reluctant to issue new shares if they take into account the interests of the new shareholders, who will tend to be disappointed ex post by the performance of their shares.

⁹In their analysis of reasoned equity offerings in the U.S., Loughran and Ritter (1994) find evidence "consistent with a market in which there are swings in investor sentiment which persist for many months. Companies respond by issuing equity during these windows of opportunity."

¹⁰The data are for the period 1966 to 1991, and are drawn from the Financial Statements Of Principal Enterprises published by the Bank of Japan in Economic Statistics Annual. By focusing on Principal Enterprises (the 500-600 largest non-financial firms), we can examine the pattern of financial flows over time. Note that investment is defined as the sum of fixed and inventory investments. See the Data Appendix for details.

issued by Japanese firms in the late 1980s had an equity option. In 1987, 1988, and 1989, convertible bonds and bonds with warrants accounted for 81%, 87% and 89%, respectively, of the volume of new, publicly offered corporate bonds. By comparison, the proportions were 21% in 1979 and 39% in 1990.¹¹

Figure 3 plots the sum of Principal Enterprises' equity and bond issues (divided by fixed investment). As the figure shows, combined issues of equity and bonds were very high in the late 1980s relative to the late 1970s and early 1980s. Again, issues of equity and bonds were much lower in 1990 and 1991. The scale of the vertical axis is noteworthy: in 1989, enough funds were raised from equity and bond issues to cover more than 88% of spending on fixed investment. This was an exceptionally large amount; over the sample period, these sources covered an average of less than 30% of spending on investment.

For comparison, Figure 4 shows long-term borrowing by Principal Enterprises from banks and insurance companies (divided by fixed investment). The figure is consistent with a gradual reduction in firms' reliance on banks, but displays a time pattern during the late 1980s and early 1990s which is quite different from equity issues.

It is useful to distinguish two possibilities for what may happen when firms issue equity in response to high share prices. First, even if bubbles exist and firms issue equity to take advantage of them, this may not affect the discount rate firms use in making investment decisions. We refer to this as an inactive financing mechanism. The second case is the opposite: high stock prices lower the perceived cost of capital and, as a result, firms accept more investment projects. We refer to this as an active financing mechanism. More precisely, when the mechanism is active, the discount factor applied to next period's marginal product of capital will be $R^* + f(B)$, where R^* is determined by the market interest rate and $f(B)$ is a positive function of bubble B .¹² For example, if the market interest rate r is 3% and the bubble reduces the discount rate used by firms to 1%, $R^* = 1/(1+r) \approx .97$ and

¹¹See Yamamoto (1993), Table 6.3, p.222.

¹²As discussed in Section 3, we normalize the bubble by the replacement value of the capital stock.

$R^* + f(B) \approx .99$.¹³ If the financing mechanism is inactive, then $f(B) = 0$.

If the financing mechanism is inactive, we might expect firms to put the proceeds from new equity issues into cash and securities. Figure 5 shows changes in holdings of cash and securities (divided by fixed investment) for Principal Enterprises. This ratio rises during the late 1980s to reach a peak which coincides with the peak of the stock market in 1989 and then falls dramatically in 1990 and 1991. Again, the scale of the vertical axis is noteworthy. At the peak of the stock market, firms were putting almost as much into cash and securities as they were into fixed investment (92% in 1988 and 89% in 1989).

An alternate way to determine whether the financing mechanism was active or inactive is to look directly at the behavior of investment. If the financing mechanism was active, there should be some evidence of an investment boom during the late 1980s. Figure 6 shows that for the aggregate economy, the ratio of net investment to net output rose from 5.9% in 1984 to 11.7% by 1990, and then fell in 1991.¹⁴

Of course, the investment boom in the late 1980s could have been due to changes in market interest rates or more optimistic expectations about future demand conditions. To control for these factors, we estimated a VAR with the investment/capital ratio, the exchange rate, and the percentage changes in real interest rates, the relative price of investment goods, and real output.¹⁵ We found that the investment/capital ratio was 27% higher in 1987 than predicted by the VAR, 28% higher in 1988, 10% higher in 1989, and 11% higher in 1990, but 5% lower in 1991 and 10% lower in 1992. This pattern is consistent with the view that the putative bubble boosted investment through an active financing mechanism in the late

¹³In this example, we ignore depreciation, but in the derivations R^* is defined as $(1-d)/(1+r)$, where d is the depreciation rate.

¹⁴Data for the Principal Enterprises show a similar increase in the fixed investment to sales ratio from .9% in 1984 to 1.9% in 1990. Note that the data are not strictly comparable (but nonetheless useful for intertemporal comparisons): aggregate net output is a value added concept, while Principal Enterprises' sales is a gross value concept, hence the difference in the scale of the ratios.

¹⁵The VAR was estimated with annual aggregate data. Two lags of each variable were included. To allow for the possibility of structural changes in the late 1980's, we reestimated the VAR for each year from 1984 through 1992.

1980s.

To summarize our results, we interpret the informal evidence from financing and investment patterns as supportive of the view that there was a bubble in the Japanese stock market in the late 1980s. There was a dramatic rise in new share issues (and bonds with an equity component) during this period. The ratio of new equity and bond issues to fixed investment was exceptionally high (about three times the sample average) during the late 1980s and an exceptionally large percentage of the bonds were either convertibles or bonds with warrants. Evidence is more mixed on whether overvaluation of the stock market decreased the cost of capital for Japanese firms and therefore induced an investment boom. There is certainly some evidence of a surge of investment in the late 1980s (even after controlling for changes in interest rates, output, and the exchange rate), but there is also evidence that firms channelled substantial amounts into increases in their holdings of cash and securities.

2. Orthogonality Tests

In this section, we use an innovative approach to test whether bubbles exist and, if so, whether they affect fixed investment. Our approach is in the spirit of the orthogonality tests which have been pioneered by Hall (1978), used frequently in the asset pricing literature (e.g., Hansen and Singleton, 1983) and consumption literature (surveyed by Deaton (1992)), and applied recently in the investment literature (Hubbard and Kashyap, 1992; Whited, 1992). In our case, by exploiting information from the firm's optimization problem, we are able to distinguish hypotheses of economic interest without making strong parametric assumptions about the bubbles process.¹⁶ Unlike previous tests for the existence of bubbles, our approach uses information from the investment decisions of firms. The way in which we use orthogonality tests based on a system of first-order conditions also distinguishes our work from the previous papers which have attempted to determine whether bubbles affect

¹⁶Our orthogonality test is able to detect periodically collapsing bubbles, and thus overcomes difficulties with previous tests of bubbles noted by Evans (1991).

investment.¹⁷

In the first case we consider, we assume that there is no bubble in the stock market. The first-order conditions for optimal investment then imply that:

$$Q_t^* - C_I \left(\frac{I_t}{K_t} \right) = e_t^Q \quad (1)$$

$$(F_{K,t} - C_{K,t}) - (p_t^I + C_{I,t}) + R_{t+1}^* (p_{t+1}^I + C_{I,t+1}) = e_t^E \quad (2)$$

where Q^* is the expected present value of future marginal products of capital (relative to the replacement cost of capital)¹⁸, C_I and C_K are the first derivatives of the cost of adjusting the capital stock with respect to I and K , respectively, I is investment, K is the capital stock, e^Q and e^E are the regression errors, F_K is the marginal product of capital, p^I is the price of investment goods, and R^* is the discount factor.¹⁹ We use approximations of the marginal product of capital and marginal adjustment costs, as described in the technical appendix. We will refer to the first equation as the Q equation and the second as the Euler equation.

In the second case we consider, there are bubbles in the stock market, but the bubble has no effect on the discount factor which firms use in evaluating investment projects. In the terms we used in the previous section, the financing mechanism is inactive, so $f(B)=0$. In this case, the Q equation becomes:

$$Q_t^{SM} - C_I \left(\frac{I_t}{K_t} \right) = e_t^Q + B_t \quad (3)$$

where Q^{SM} is stock market Q ; i.e., the market value of the firm (based on the stock market) divided by the replacement value of its capital stock. Intuitively, the reason B_t appears on the right hand side is because stock market Q now equals $Q^* + B$, so we need to add B to both sides of (1) to express the relationship between investment and stock market Q (which,

¹⁷See the references in footnote 4.

¹⁸In the empirical work, Q is normalized to zero and multiplied by p^I , the latter reflecting the valuation of adjustment costs in terms of foregone output.

¹⁹For an example of a standard investment model from which equations of this form can be derived, see Chirinko (1993, Section III).

unlike Q^* , is directly observable). The Euler equation is unchanged. Note that the bubble now appears on the right hand side of the Q equation but not the Euler equation.

In the third case, there are bubbles in the stock market and they affect the discount factor. In other words, the financing mechanism is active, so $f(B) \neq 0$. The Q and Euler equations become:

$$Q_t^{SM} - C_t \left(\frac{I_t}{K_t} \right) = e_t^Q + B_t - \lambda_t^B(B_t) \quad (4)$$

$$\begin{aligned} (F_{K,t} - C_{K,t}) - (p_t^I + C_{I,t}) + R_{t+1}^*(p_{t+1}^I + C_{I,t+1}) \\ = e^{E_t} - f(B_t)(p_{t+1}^I + C_{I,t+1}) \end{aligned} \quad (5)$$

where $\lambda_t^B(B)$ is the wedge between the present value of future profitability (evaluated at the market interest rate) and the present value evaluated at the lower discount rate induced by a bubble. This wedge (the difference between the two present values) is a function of the bubble because an active financing mechanism implies that firms use the discount factor $R^* + f(B)$ in evaluating future cash flows. When the financing mechanism is active, the bubble appears on the right-hand side of both the Q and Euler equations.²⁰

The econometric procedure we use is designed to detect correlation between variables in the time $t-1$ information set and the right-hand side of the Q and Euler equations. More precisely, the tests described by Eichenbaum, Hansen, and Singleton (1988) can determine which subsets of the orthogonality conditions associated with the Q or Euler equations are suspect. The orthogonality tests can therefore be used to distinguish between the three economically interesting cases we have described. If there are no bubbles in the stock market, both the Q and Euler equations will pass the specification test. If the Q equation is rejected but the Euler equation passes, this is consistent with the existence of bubbles but provides no evidence that bubbles have an effect on investment. If both the Q and Euler equations are rejected, this is consistent with the existence of bubbles and an effect of bubbles on the discount rate and therefore on investment.

²⁰It is straightforward to show that $\partial[B - \lambda^B(B)]/\partial B > 0$, so, if the financing mechanism is active, the correlation between the bubble and the Q residual should be positive.

B. Test Results

Table 1 presents the orthogonality tests for non-linear least squares estimates of the base model.²¹ For all choices of instrument sets, the orthogonality tests strongly reject the Q equation.²² The Euler equation is also rejected at standard significance levels. The mean marginal product of capital is economically reasonable for all of the instrument sets. The marginal adjustment costs are not very precisely estimated but the confidence interval around the mean includes economically sensible values.

Much recent theoretical and empirical research has emphasized the possibility that at least some firms face finance constraints.²³ Table 2 allows for capital market imperfections which could affect firms' ability to borrow. The orthogonality tests continue to reject the Q equation, suggesting the existence of bubbles, but fail to reject the Euler equation.

C. Residual Analysis

If there are bubbles in the stock market, the residual from the Q equation will contain the bubble term, as shown in equations (3) and (4). This implies that there should be a positive correlation between the Q equation residual and the bubble. In fact, there is strong

²¹The NL3SLS estimator is chosen instead of Hansen's (1982) Generalized Method of Moments (GMM) estimator, which allows for conditional heteroscedasticity, because the covariance matrix of orthogonality conditions is nearly singular, as indicated by its condition number. The condition number is the ratio of the largest to the smallest eigenvalue for the covariance matrix. A matrix is ill-conditioned if the condition number is large relative to the inverse of the precision of the algorithm, equal to 12 in the case of double precision. For the base model, the condition numbers equalled or exceeded 12 for all three instrument lists.

²²We consider three sets of instruments. The "short" instrument set includes a constant, time, time squared, the first lags of Q, I/K, and output (normalized by K), and the second lags of the real interest rate, the change in the real price of investment goods, and the change in I/K. The "money" instrument set includes the short instrument set plus three lags of the growth rate of M1. The "long" instrument set includes the short instrument set plus the second lags of Q, I/K, and output (normalized by K).

²³For surveys, see Gertler (1988) and Bernanke (1993). For empirical evidence on Japan, see Hoshi, Kashyap, and Scharfstein (1990, 1991) and Hayashi and Inoue (1991).

correlation between the Q residual and the bubble²⁴; for the base specification (using the long instrument set), the correlation is .930, as shown in Table 3. Alternative measures of the bubble show the same positive correlation.²⁵ This is considerably higher than the correlation of the Q residual with other macroeconomic variables. For example, the correlations with output growth, M1 growth, and the real interest rate are -.203, -.392, and .370, respectively. The strong positive correlation of the Q residual with the bubble provides an additional piece of evidence that the reason for the rejection of the Q equation is the existence of bubbles in the stock market.

A further way to check the interpretation of the orthogonality tests is to plot the Q residuals. If there is a bubble in the stock market which is reflected in the Q residual, we might expect the residual to be rising during the 1980s, as the stock market headed towards its peak, and declining in the early 1990s. Figure 7 plots the Q residuals and shows exactly this pattern.²⁶

D. A Second Battery of Tests

We now consider a second battery of tests which do not use stock market prices. Instead, we use a procedure (to be described in more detail in the next section) based on Abel and Blanchard (1986) to construct a linear projection of the present value of expected

²⁴To calculate the correlation obviously requires a measure of the bubble (which is not required for the orthogonality tests). B^1 is the market value of firms (based on the stock market) less a linear projection of the present value of future profitability (all normalized by the replacement value of the capital stock). It is discussed in more detail in Section 3.A.

²⁵ B^2 is constructed in the same way as B^1 , except using a marginal product of capital series based on the national accounts. (More precisely, $B^2 = Q^{SM} - Q^{NA}$; Q^{SM} and Q^{NA} are described in greater detail in the next section.) B^3 is based on a Lucas (1978) asset pricing model in which earnings are a random walk with drift. The fundamental stock price is then a multiple of current earnings: $P^* = \rho_F E$, where $\rho_F = 28.983$, the sample mean of the price-earnings ratio for the Nikkei 225. $B^3 = (P - P^*)/P = 1 - \rho_F(E/P)$, where P is the actual stock price.

²⁶If $B \neq 0$ and $f(B) \neq 0$, then B will enter the Euler equation residual in the form $f(B)[p^1 + C_1]$. Thus, if the financing mechanism is active, the Euler residuals will fluctuate both due to bubbles and due to variations in the price of investment goods and marginal adjustment costs. This makes correlations between the bubble measures and the Euler residuals harder to analyze than correlations between the bubble measures and the Q residuals.

profitability.

Suppose that there is a bubble, but the financing mechanism is inactive, so $B \neq 0$ and $f(B)=0$. It is then possible to show that the Q equation becomes:

$$Q_t^{LP} - C_I \left(\frac{I_t}{K_t} \right) = e_t^{Q^*} \quad (6)$$

where Q^{LP} is the present value of future profitability (relative to the replacement cost of capital) calculated from the linear projection. Intuitively, (6) is like (1). Even though there is a bubble in the stock market, B does not appear on the right hand side of (6) because Q^{LP} , linear projection Q, is not contaminated by stock market prices and therefore corresponds to Q^* . The Euler equation is the same as shown in (2) above. Thus when the financing mechanism is inactive and we measure the present value of future profitability with a linear projection, the bubble will not appear on the right hand side of either the Q or Euler equations.

However, if the financing mechanism is active, so $f(B) \neq 0$, the Q equation (estimated with linear projection Q) becomes:

$$Q_t^{LP} - C_I \left(\frac{I_t}{K_t} \right) = e_t^{Q^*} - \lambda_t^B(B_t) \quad (7)$$

and the Euler equation corresponds to (5). The bubble term will now appear on the right-hand side of the Q equation with a negative sign (unlike equation (3) above where it enters with a positive sign). Thus if the financing mechanism is active, the orthogonality tests will tend to reject the Q equation estimated with Q^{LP} . In contrast to the first battery of tests, the correlation between the bubble and the Q residual should be negative. Table 4 shows these orthogonality tests; for all three instrument sets, the Q equation is strongly rejected. The correlation between the bubble measures and the Q residual are -.592, -.626, and -.372 for the long instrument set, as reported in the last row of Table 3.

To sum up, the orthogonality tests all point to the existence of bubbles. On balance, they also suggest that the financing mechanism was active.

3. Parametric Estimates

In this section, we focus exclusively on the question of whether bubbles affect investment. Our empirical strategy is straightforward: we regress investment on the expected present value of future profitability (the fundamental component) and the deviation of stock market prices from the expected present value of future profitability (the bubble component). The resulting parameters provide a direct estimate of the relative importance of shocks to the fundamental and bubble components.²⁷

This section is divided into four parts. First we compute the fundamental and bubble components using a linear projection technique. Second, we present the main empirical estimates. Third, we examine the robustness of the empirical results to alternative definitions of fundamentals, the introduction of liquidity, and the use of instrumental variables. Finally, we use a completely different specification, based on a Jorgensonian neoclassical investment equation, to estimate the effect of bubbles on fixed investment.

A. Fundamentals and Bubbles

Under standard assumptions, it can be shown that investment is a linear function of the expected present value of future profitability:

$$\lambda_t = E \left[\sum_{j=0}^{\infty} \prod_{s=0}^j R_{t+s} M_{t+j} | \Omega_{t-1} \right] \quad (8)$$

where $M = (F_K - C_K)(1-\delta)^{-1}$ (i.e., the marginal product of capital, including the reduction in adjustment costs due to increased capital), r is the real interest rate, δ is the depreciation rate,

$$R_{t+1} = \frac{1-\delta}{1+r_{t+1}} \quad (9)$$

E is the expectations operator, and Ω_{t-1} is the information set at time $t-1$. The ratio λ_t/p_t^I is often referred to as "marginal Q." Much empirical work on investment is based on a result

²⁷If there was no bubble, then the measured bubble component should be statistical noise and should not affect investment.

from Hayashi (1982), that under specified conditions²⁸, marginal Q corresponds to the financial market value of the firm:

$$\frac{\lambda_t}{p_t^I} = \frac{V_t}{(1-\delta)p_t^I K_t} = Q_t^{SM} \quad (10)$$

where V is the value of the firm as determined by financial markets. We refer to this as Q^{SM} to emphasize that it is based on the stock market value of the firm. If there are bubbles in the stock market, then they will be included in V and thus in Q.

When there is a bubble in the stock market, $V_t = V_t^* + V_t^B$, where V_t^* and V_t^B are the fundamental and the bubble components of stock market value. In order to measure the fundamental component of Q, we forecast the discount rates and marginal products directly, following the procedure described by Abel and Blanchard (1986). Let $\tilde{\lambda}_t$ be the ex post realization of the RHS of (8). Linearizing $\tilde{\lambda}_t$ around $R_{t+j} = \bar{R}$ and $M_{t+j} = \bar{M}$, where a bar indicates the sample mean:

$$\tilde{\lambda}_t \approx \bar{M}\bar{R}(1 - \bar{R})^{-1} + \bar{M}(1 - \bar{R})^{-1} \sum_{j=0}^{\infty} \bar{R}^j (R_{t+j} - \bar{R}) + \sum_{j=0}^{\infty} \bar{R}^{j+1} (M_{t+j} - \bar{M}) \quad (11)$$

We then assume that R_t and M_t have a vector autoregressive structure, specifically of the form:

$$z_t = \begin{bmatrix} z_t^1 \\ z_t^2 \\ z_t^3 \\ z_t^4 \\ z_t^5 \end{bmatrix} = \begin{bmatrix} A^{11}(L) & \dots & A^{15}(L) \\ A^{21}(L) & \dots & A^{25}(L) \\ \vdots & & \vdots \\ A^{51}(L) & \dots & A^{55}(L) \end{bmatrix} \begin{bmatrix} z_{t-1}^1 \\ z_{t-1}^2 \\ z_{t-1}^3 \\ z_{t-1}^4 \\ z_{t-1}^5 \end{bmatrix} + \begin{bmatrix} u_t^1 \\ u_t^2 \\ u_t^3 \\ u_t^4 \\ u_t^5 \end{bmatrix} \quad (12)$$

where z_t^1 is the marginal product of capital (i.e., M_t), z_t^2 is the discount factor, z_t^3 is the relative price of investment goods, z_t^4 is the inflation rate, z_t^5 is real output growth, and the

²⁸These conditions include stock market efficiency, linear homogeneity of the profit function, and price-taking behavior by the firm. See Hayashi (1982) for a formal statement.

$A^j(L)$ are polynomials in the lag operator.²⁹ The previous equation can be rewritten in companion matrix form as:

$$z_t = Az_{t-1} + u_t \quad (13)$$

where $z_t = (z_{1,t}, z_{1,t-1}, \dots, z_{1,t-m}, z_{2,t}, z_{2,t-1}, \dots, z_{2,t-m}, \dots, z_{5,t}, \dots, z_{5,t-m})'$ and $u_t = (u_{1,t}, 0, \dots, 0, u_{2,t}, 0, \dots, 0, \dots, u_{5,t}, 0, \dots, 0)'$. It is then possible to construct the expected present value of future profitability without using the stock market and thus exclude the bubble component.

We refer to this as Q^{LP} since it is formed as a linear projection on a subset of the variables in the information set Ω_{t-1} :

$$Q_t^{LP} = (\overline{MR}(1-\overline{R})^{-1} + \overline{M}(1-\overline{R})^{-1}e_2(I-A\overline{R})^{-1}Az_{t-1} + \overline{R}e_1(I-A\overline{R})^{-1}Az_{t-1})/p_t' \quad (14)$$

where e_i is a vector whose i^{th} element is 1 and all the other elements of which are 0.³⁰

Since $V_t = V_t^* + V_t^B$:

$$\frac{V_t^B}{(1-\delta)p_t'K_t} = \frac{V_t - V_t^*}{(1-\delta)p_t'K_t} = Q_t^{SM} - Q_t^{LP} \quad (15)$$

This is the (appropriately normalized) bubble component, which we refer to as B^1 .

Figure 8 plots Q^{SM} and Q^{LP} . The plot of Q^{SM} is consistent with the hypothesis of a stock market bubble which began during the 1980s, reached a peak in 1989, and deflated during the early 1990s. Q^{LP} shows no similar pattern during the 1980s and 1990s.

B. Main Empirical Results

Before discussing the parameter estimates, we digress briefly to address issues of dynamic specification. Under standard assumptions, only current values of investment and Q should appear in the specification. Intuitively, investment depends only on current Q because Q is a forward-looking variable which captures the impact of expected future conditions. A

²⁹ $z^i, i=1, \dots, 5$, are expressed as deviations from their sample means. The marginal product of capital is based on the approximation described in the technical appendix. The VAR was initially computed with lag lengths of one, two, and three. The increment to the adjusted R^2 for each element in the VAR was sizeable in moving from one to two lags, but very modest in moving from two to three lags. Consideration of degrees of freedom led us to use the two-lag specification for all of the results reported in the paper.

³⁰As in equation (10), λ is divided by p^1 .

variety of previous research has shown that the data sometimes prefer a more general dynamic specification, perhaps because of the timing issues discussed by Summers (1981).³¹ To allow for this possibility, we select the dynamic specification based on a series of likelihood ratio tests.³² In subsequent tables, we report two dynamic specifications - the standard Q equation with no lags and an alternative dynamic specification which includes the lagged dependent variable.³³

To make the parameters easier to interpret, we have standardized all variables (i.e., divided by their standard deviations). The estimates in columns (1) and (2) of Table 5 therefore imply that a one-standard-deviation shock to the bubble component has an effect that is about one-third to one-half as large as the shock to the fundamental component. The effect of the fundamental component (Q^{LP}) is highly statistically significant for both the standard specification and the alternative dynamic specification.

The parameter estimates imply that the bubble component had an economically important effect on investment in Japan, especially during the late 1980s. According to the estimates, more than 20% of business fixed investment is attributable to the high value of the

³¹See, for example, Bernanke, Bohn and Reiss (1988), Blanchard and Wyplosz (1981), Chirinko (1987), Clark (1979), von Furstenberg (1977), Poterba and Summers (1983), and Schaller (1990). Note that all the variables in these regressions should be stationary since all enter in ratio form with the capital stock in the denominator.

³²In Table 5, we first compare the general lag specification in column (4) to a relatively parsimonious specification with a common factor restriction in column (5). If lagged variables enter because of an autoregressive term in the error, then a comparison of column (5) and (4) will fail to reject the common factor restriction. The Japanese data reject the restriction at the .01 level. Next, we test whether the lagged dependent variable can be excluded by comparing columns (4) and (3); this restriction is also rejected at the .01 level. Finally, we test whether it is possible to exclude lags of the independent variables by comparing columns (4) and (2); the likelihood ratio test fails to reject this restriction.

³³Note that the LM_1 statistic indicates that residual serial correlation is not a concern in either specification. Performing a t-test with LM_1 is asymptotically equivalent to the Durbin h-test. However, LM_1 can be calculated for all possible values of the estimated parameters, and has performed better than the h-statistic in Monte Carlo experiments. See Breusch and Godfrey (1981, Section 3.3) and Harvey (1981, pp. 275-276) for further discussion.

stock market bubble in each of the years 1987, 1988, and 1989.³⁴ This is equivalent to approximately 4% of GDP in each of these three years.³⁵

C. Additional Empirical Results

In the following three tables, we investigate the robustness of our key results to modifications in variable definitions and estimation techniques. In Table 6, we present estimates which use the average product of capital from the national accounts to construct z^1 ; we refer to the resulting measure of Q as Q^{NA} .³⁶ As in the previous table, we present both the standard and the alternative dynamic specifications. The main results we obtained earlier are robust. The parameters on both the fundamental and bubble components are statistically significant. The main difference between the results based on Q^{LP} and Q^{NA} is the greater relative importance of the bubble component when we use the national accounts to construct the fundamental component.

We adopt two approaches to control for finance constraints (or any other situations which lead to a link between liquidity and investment). First, we include liquidity (in place of inflation) in the set of variables in the linear projection which is used to construct Q ; we refer to the resulting measure of Q as Q^{LQ} . Second, we add liquidity as an additional variable in the investment equation. Table 7 shows that the main results in previous tables are not affected by these changes. Shocks to both the fundamental and bubble components are economically important and statistically significant. Shocks to the bubble component have an effect slightly more than one-half as large as shocks to the fundamental component. When we include liquidity in the investment equation directly, we find that it also has

³⁴These calculations are based on the estimated parameter of the bubble component in column (1) of Table 1 and the value of B_t in each year, compared to $B_t=0$.

³⁵Japanese observers have suggested that the stock market was depressed in the mid-1960s. Interestingly, the parameter estimates imply that investment was about 9% lower than it would have been if B_t had been equal to zero at this time.

³⁶Under commonly used assumptions (specifically, homogeneity of degree one of the production function and price-taking behavior), the average product of capital will equal the marginal product of capital. Under more general assumptions, the two will still tend to move together but the link may be weaker.

economically important and statistically significant effects. However, the inclusion of liquidity does not have a dramatic effect on the coefficients associated with either the fundamental or bubble components, as can be seen by comparing columns (5) and (6) with columns (1) and (2).³⁷

Table 8 presents instrumental variable estimates based on three different instrument sets: "LP first lags" and "LP second lags" represent the t-1 and t-2 values, respectively, of the elements of z , the variables used in the linear projection; the "short" instruments are listed in Section 2. The results are quite similar to those in previous tables. Both the fundamental and bubble components are economically important and statistically significant. Shocks to the bubble component have an effect which is roughly one-third to one-half as great as shocks to the fundamental component.

D. Neoclassical and Flexible Accelerator Models

It is also possible to estimate a completely different investment specification based on a Jorgensonian neoclassical investment model. This model relates the investment/capital ratio to current and lagged values of the percentage changes in output and the cost of capital and the lagged value of the dependent variable.³⁸ To conserve on degrees of freedom (and because the data are annual), lags for only one period are included. The estimates are presented in Table 9. Column 2 presents estimates which include liquidity. Regardless of whether or not liquidity is included, the bubble has a highly significant effect on investment. As in previous tables in this section, the variables have been divided by their standard

³⁷This contrasts with Blanchard, Rhee, and Summers (1993), who find that when a liquidity variable (current profits) is included, the fundamental component is no longer statistically significant and the effect of market valuation is small and only marginally significant. It is possible that we find stronger effects for both the fundamental and bubble components because we use the Abel and Blanchard (1986) linear projection approach to construct the components. It is also possible that the stronger effects of the bubble component that we find arise because fluctuations in the stock market were larger and more important in Japan than in the U.S.

³⁸See Chirinko (1993, Section II) for a derivation and discussion of the Jorgensonian investment model with rational lags. The cost of capital is composed of three multiplicative terms: the price of investment relative to the price of output, the financial cost of capital (a real interest rate plus the economic depreciation rate), and tax parameters. We were unable to locate time series of sufficient length to measure the effects of tax parameters.

deviations. The estimated effects of the bubble on investment are comparable to the point estimates in Column 2 of Table 5 and Column 4 of Table 7, which include a lagged dependent variable.

If the cost of capital variable is omitted, the specification can be interpreted as a flexible accelerator model. Columns 3 and 4 of Table 9 report flexible accelerator specifications with and without liquidity. In both cases, the bubble is highly significant and the point estimates are similar to those for the neoclassical investment model.

4. Conclusion

If firms perceive an overvaluation of their stock, they have an incentive to issue equity and equity-linked securities. Figure 3 shows that issues of equity and bonds surged in the late 1980s and fell precipitously in the early 1990s. At the peak in 1989, the funds raised from these security issues were enough to cover almost 90% of the expenditures on business fixed investment by the principal Japanese enterprises, roughly three times the usual proportion.

The stock market boom of the late 1980s coincided with high levels of business fixed investment. The ratio of net investment to output rose from .06 in the mid-1980s to .12 at the peak. When we use a VAR to control for macroeconomic factors which might have affected investment (such as interest rates, output, the price of investment goods, and the exchange rate), we find that the investment/capital ratio was 10-30% higher than predicted by these factors in the years 1987-89, but 5-10% lower in the years following the crash.

When we turn from informal evidence to tests based on the first-order conditions for investment, the Eichenbaum, Hansen, and Singleton (1988) tests reject the orthogonality conditions which would hold if there were no bubbles. This rejection seems to be driven by the existence of bubbles. The correlation between various measures of bubbles and the residual to a standard first-order condition (which assumes no bubbles) ranges from .71 to .93.

The orthogonality tests can also be used to examine whether bubbles affected fixed investment, specifically by lowering the cost of capital. (We refer to this as an "active financing mechanism".) The strongest evidence comes from our second battery of

orthogonality tests, which are based on the fact that an active financing mechanism will lead to a wedge between the present value of future profitability based on the market interest rate and the present value based on the lower discount rate induced by a bubble. Our derivations show that this wedge, which is a function of the bubble, will enter the residual with a negative sign and lead to the rejection of the orthogonality conditions. The orthogonality conditions are rejected and the correlation between the residual and various measures of bubbles, is, in fact, negative.

In the third section of the paper, we directly estimate the effect of the fundamental and bubble components on business fixed investment using the Abel-Blanchard (1986) linear projection technique. We find that the bubble component has a statistically significant effect on fixed investment. The parametric estimates suggest that a one-standard-deviation shock to the bubble component has an effect which is one-third to the one-half as large as a comparable shock to the fundamental component. The estimates imply that the bubble boosted business fixed investment by more than 20% in the years 1987-89. This amounts to approximately 4% of GDP in each of these three years.

A variety of types of evidence therefore suggests that there were bubbles in Japanese equity markets and that the bubbles affected business fixed investment. This means that the long-standing debates over whether asset prices sometimes deviate from present value are relevant to economists whose focus is on the real (as opposed to financial) side of the economy.

References

- Abel, Andrew B., and Olivier J. Blanchard (1986), "The Present Value of Profits and Cyclical Movements in Investment," Econometrica, 54, 2, pp. 249-73
- Aliber, Robert Z., and Solomon, Robert, "The Speculative Bubble in Japan," International Economic Letter, Vol. XIII, No. 2 (February 10, 1993).
- Allen, Franklin, and Douglas Gale (1994), "Limited Market Participation and Volatility of Asset Prices," American Economic Review, 84, 4, pp. 933-955
- Allen, Franklin, and Gary Gorton (1993), "Churning Bubbles," Review of Economic Studies, 60, pp. 813-36
- Bernanke, Benjamin S. (1993), "Credit in the Macroeconomy," Federal Reserve Bank of New York Quarterly Review, 18, pp. 50-70
- Bernanke, Benjamin S., Henning Bohn, and Peter Reiss (1988), "Alternative Nonnested Specification Tests of Time Series Investment Models," Journal of Econometrics, 37, pp. 293-326
- Blanchard, Olivier J., Changyong Rhee, and Lawrence Summers (1993), "The Stock Market, Profit and Investment," Quarterly Journal of Economics, CVIII, 1, pp. 115-34
- Blanchard, Olivier J., and Mark Watson (1982), "Bubbles, Rational Expectations and Financial Markets," in P. Wachtel (ed.), Crises in the Economic and Financial Structure (Lexington, MA: Lexington Books)
- Blanchard, Olivier J., and Charles Wyplosz (1981), "An Empirical Structural Model of Aggregate Demand," Journal of Monetary Economics, 7, pp. 1-28
- Breusch, Trevor S., and L. G. Godfrey (1981), "A Review of Recent Work on Testing for Auto-Correlation in Dynamic Simultaneous Models," in D. Curie, R. Nobay, and D. Peel (eds.), Macroeconomic Analysis: Essays in Macroeconomics and Econometrics (London: Croom and Helm), pp. 63-110
- Chirinko, Robert S. (1987), "Tobin's Q and Financial Policy," Journal of Monetary Economics, 19, pp. 69-87
- Chirinko, Robert S. (1993), "Investment, Tobin's Q, and Multiple Capital Inputs," Journal of Economic Dynamics and Control, 17, pp. 907-28
- Chirinko, Robert, and Huntley Schaller (1995), "Why Does Liquidity Matter in Investment

- Equations?" Journal of Money, Credit, and Banking, forthcoming
- Clark, Peter K. (1979), "Investment in the 1970s: Theory, Performance, and Prediction," Brookings Papers on Economic Activity: 1, pp. 73-124
- Deaton, Angus (1992), Understanding Consumption. Oxford: Clarendon.
- DeBondt, Werner F. M., and Richard H. Thaler (1986), "Does the Stock Market Overreact?" Journal of Finance, XL, 3, pp. 793-807
- De Long, J. Bradford, Andrei Shleifer, Lawrence H. Summers, and Robert J. Waldmann (1990), "Noise Trader Risk in Financial Markets," Journal of Political Economy, 98, pp. 703-38
- Eichenbaum, Martin S., Lars Peter Hansen, and Kenneth J. Singleton (1988), "A Time Series Analysis of Representative Agent Models of Consumption and Leisure Choice Under Uncertainty," Quarterly Journal of Economics, 103, pp. 51-78
- Evans, George W. (1991), "Pitfalls in Testing for Explosive Bubbles in Asset Prices," American Economic Review, 81, pp. 922-930
- Friedman, Milton, and Anna Jacobson Schwartz (1963), A Monetary History of the United States, 1867-1960 (Princeton University Press: Princeton, NJ)
- Galeotti, Marzio, and Schiantarelli, Fabio (1994), "Stock Market Volatility and Investment: Do Only Fundamentals Matter?" Economica, 61, 147-165.
- Gertler, Mark (1988), "Financial Structure and Aggregate Economic Activity: An Overview," Journal of Money, Credit, and Banking, 20, 3, pp. 559-588
- Hall, Robert E. (1978), "Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence," Journal of Political Economy, 86, 6, pp. 971-87
- Hansen, Lars Peter (1982), "Large Sample Properties of Generalized Method of Moments Estimators," Econometrica, 50, 4, pp. 1029-1054.
- Hansen, Lars Peter, and Kenneth J. Singleton (1983), "Stochastic Consumption, Risk Aversion, and the Temporal Behavior of Asset Returns," Journal of Political Economy, 91, 2, pp. 249-65
- Harvey, Andrew C. (1981), The Econometric Analysis of Time Series (New York: Halsted Press)

- Hayashi, Fumio (1982), "Tobin's Marginal q and Average q : A Neoclassical Interpretation," Econometrica, 50, pp. 1029-54
- Hayashi, Fumio and T. Inoue (1991), "The Relation Between Firm Growth and Q with Multiple Capital Goods: Theory and Evidence from Panel Data on Japanese Firms," Econometrica, 59, 3, 731-53.
- Hoshi, Takeo, Anil Kashyap, and David Scharfstein (1990), "The Role of Banks in Reducing the Costs of Financial Distress in Japan," Journal of Financial Economics, 27, pp. 67-88
- Hoshi, Takeo, Anil Kashyap, and David Scharfstein (1991), "Corporate Structure, Liquidity, and Investment: Evidence from Japanese Industrial Groups," Quarterly Journal of Economics, 106, pp. 33-60
- Hubbard, R. Glenn and Kashyap, Anil, "Internal Net Worth and the Investment Process: An Application to U.S. Agriculture, 1910-1987," Journal of Political Economy 100 (June 1992), 506-534.
- Lakonishok, Josef, Andrei Shleifer, and Robert W. Vishny (1994), "Contrarian Investment, Extrapolation, and Risk," working paper
- Loughran, Tim, and Jay R. Ritter (1994), "The New Issues Puzzle," University of Illinois working paper
- Lucas, Robert E. Jr. (1978), "Asset Prices in an Exchange Economy," Econometrica, Vol. 66, 429-45.
- Malkiel, B. (1995), A Random Walk Down Wall Street (New York: Norton), forthcoming
- Mankiw, Gregory N., David Romer, and Matthew D. Shapiro (1991), "Stock Market Forecastability and Volatility: A Statistical Appraisal," Review of Economic Studies, 58, pp. 455-77
- Morck, Randall, Andrei Shleifer, and Robert W. Vishny (1990), "The Stock Market and Investment: Is the Market a Sideshow?" Brookings Papers on Economic Activity, 2, pp. 157-202
- Porter, Michael E., Capital Choices: Changing The Way America Invests In Industry (Washington: Council on Competitiveness, 1992).
- Poterba, James M., and Lawrence H. Summers (1988), "Mean Reversion in Stock Prices: Evidence and Implications," Journal of Financial Economics, 22, 1, pp. 27-59

- Poterba, James M., and Lawrence H. Summers (1983), "Dividend Taxes, Corporate Investment, and 'Q'," Journal of Public Economics, 22, pp. 135-67
- Schaller, Huntley (1990), "A Re-examination of the Q Theory of Investment Using U.S. Firm Data," Journal of Applied Econometrics, 5, pp. 309-325
- Shiller, R. J. (1981), "Do Stock Prices Move Too Much to Be Justified by Subsequent Changes in Dividends?" American Economic Review, 71, pp. 421-36
- Summers, Lawrence H. (1981) "Taxation and Corporate Investment: A q-Theory Approach," Brookings Papers on Economic Activity: 1, pp. 67-140
- von Furstenberg, George M. (1977), "Corporate Investment: Does Market Valuation Matter in the Aggregate?" Brookings Papers on Economic Activity, pp. 347-97
- Whited, Toni M., "Debt, Liquidity Constraints, and Corporate Investment: Evidence from Panel Data," Journal of Finance 47 (September 1992), 1425-1460.
- Yamamoto, Shigeru, "The Japanese Bond Market," in Shinji Takagi (ed.), Japanese Capital Markets: New Developments in Regulations and Institutions (Oxford: Blackwell, 1993), 215-248.

Technical Appendix

This appendix presents the parametric specifications for Section 2. The Euler and Q equations rely on two technological functions -- the marginal product of capital and marginal adjustment costs. These functions are parametrized by the following second-order Taylor expansions:

$$MPK_t = (F_{K,t} - C_{K,t}) = \sum_{j=0}^2 \beta_j y_t^j + \gamma_j i_t^j + \nu_t^p \quad (A1)$$

$$C_{I,t} = \sum_{j=0}^2 \alpha_j i_t^j + \nu_t^q \quad (A2)$$

where i is investment divided by the capital stock, y is output (divided by capital stock), and ν^q and ν^p are white noise approximation errors.

Marginal adjustment costs are evaluated by the MAC statistic, defined below as the ratio of the marginal adjustment costs to the sum of purchase price and marginal adjustment costs:

$$MAC_t = \frac{C_{I,t}}{p_t^I + C_{I,t}} \quad (A3)$$

Liquidity constraints are modeled by assuming that the interest cost on external funds is sensitive to balance sheet variables and that, when procuring external funds, firms incur flotation costs reflecting either transactions costs or information problems similar to those affecting the interest cost. The effects of these liquidity constraints are capitalized into Q, except for marginal flotation costs ($MFC(\cdot)$), which we assume are a function of the flow of outside finance relative to the capital stock (o_t) (see the derivation in Chirinko and Schaller (1995)):

$$MFC(o_t) = \sum_{j=0}^2 \psi_j o_t^j + \nu_t^f \quad (A4)$$

where ν^f is a white noise approximation error. In the Euler equation, the net marginal product of capital is expanded to reflect the dependence of flotation costs on the capital stock, and the following terms are added to the marginal product of capital approximation

(equation (A1)):

$$FC_{K,t} = \sum_{j=0}^2 \phi_j o_t^j \quad (\text{A5})$$

In computing the tests reported in Table 4, the VAR forming Q^{LP} (which uses the MPK series, z^1 in the VAR, equation (12)) and the coefficients in Table 4 (which include the MPK parameters) are iterated until the MPK series converges. Convergence was rapid (no longer than five iterations, and the converged value was nearly attained after two iterations), and completely insensitive to starting values for the MPK series.

Table 1 Orthogonality Tests Base Model			
	Instruments		
	Long (1)	Money (2)	Short (3)
Specification Tests:			
Test System (p-value)	39.822 (.001)	39.400 (.001)	32.347 (.000)
Test Q (p-value)	39.761 (.000)	39.036 (.000)	32.331 (.000)
Test Euler (p-value)	18.759 (.009)	19.289 (.007)	12.567 (.014)
MPK:			
Mean Standard Deviation	.190 [.047]	.187 [.050]	.206 [.067]
MAC:			
Mean Standard Deviation	-.011 [.071]	-.011 [.072]	-.001 [.104]

Non-linear three stage least squares estimates for 1966-1992; the instrumental variables are listed in footnote 22. "Test System" is the Hansen (1982) test statistic of overidentifying restrictions; "Test Q" and "Test Euler" are the test statistics of Eichenbaum, Hansen, and Singleton (1988) for the validity of the Q and Euler equations, respectively. See the text for further discussion of these statistics. P-values are in parentheses. MPK is the net marginal product of capital, and MAC is the marginal adjustment cost stated as a percentage of purchase and adjustment costs. For MPK and MAC, the means and standard deviations are calculated over the sample period.

Table 2 Orthogonality Tests Allowing for the Role of Liquidity		
	Instruments	
	Long (1)	Money (2)
Specification Tests:		
Test System (p-value)	18.402 (.073)	16.949 (.109)
Test Q (p-value)	18.335 (.032)	16.907 (.050)
Test Euler (p-value)	2.706 (.745)	2.962 (.706)
MPK:		
Mean Standard Deviation	.026 [.038]	-.017 [.035]
MAC:		
Mean Standard Deviation	5.259 [3.749]	2.324 [.314]
Marginal Flotation Cost:		
Mean	1.430	1.953
Standard Deviation	[.279]	[.296]

Non-linear three stage least squares estimates for 1966-1991. Marginal flotation costs are defined in the technical appendix. See the footnote to Table 1 for further information.

Table 3 Residual Analysis						
	B ¹	B ²	B ³	Y	M	r
Base Model (Table 1)						
	.930	.770	.715	-.203	-.392	-.370
Allowing for Liquidity (Table 2)						
	.557	.500	.431	.120	-.288	.269
Linear Projection Q (Table 4)						
	-.592	-.626	-.372	.108	.162	-.341

The entries represent the correlation between the variable shown at the top of the column and the Q equation residual for each specification. B¹, B², and B³ are three measures of bubbles, Y is output growth, M is M1 growth, and r is the real interest rate. All residuals come from system estimates using the long instruments; the results are very similar for estimates based on the other instrument sets. All correlations are for 1966-92, except those using B² which are for 1966-91.

Table 4 Orthogonality Tests Using Linear Projection Q			
	Instruments		
	Long	Money	Short
Specification Tests:			
Test System (p-value)	42.245 (.000)	38.344 (.001)	30.390 (.001)
Test Q (p-value)	42.037 (.000)	37.252 (.000)	30.334 (.000)
Test Euler (p-value)	18.165 (.011)	14.940 (.037)	7.733 (.102)
MPK:			
Mean Standard Deviation	.121 [.027]	.119 [.031]	.125 [.032]
MAC:			
Mean Standard Deviation	.018 [.102]	.020 [.096]	.024 [.095]

Non-linear three stage least squares estimates for 1966-1992. Linear projection Q is described in detail in Section 3.A. See the footnote to Table 1 for further information.

Table 5 Parametric Estimates Alternative Dynamic Specifications					
	(1)	(2)	(3)	(4)	(5)
Q_t^{LP}	1.208 (.130)	.667 (.147)	.810 (.175)	.656 (.159)	.501 (.165)
Q_{t-1}^{LP}			.523 (.173)	.070 (.214)	
B_t	.454 (.130)	.308 (.099)	.186 (.284)	.314 (.249)	.271 (.249)
B_{t-1}			.376 (.276)	.020 (.267)	
$(I/K)_{t-1}$		.529 (.111)		.489 (.166)	
ρ					.850 (.091)
Constant	4.022 (.089)	1.852 (.459)	3.975 (.082)	2.005 (.672)	4.184 (.390)
\bar{R}^2	.817	.904	.859	.896	.872
LOGL	-13.830	-4.512	-9.095	-4.423	-9.714
SSR	4.403	2.208	3.101	2.194	3.161
LM_1	.998	.452	1.182	.864	2.314
DW	1.577	1.801	1.522	1.773	1.345

Ordinary Least Squares estimates for 1966-1992. Standard errors are in parentheses. The dependent variable is $(I/K)_t$. All model variables are divided by their standard deviations, thus standardizing the reported coefficients. Q_t^{LP} is the linear projection of Q as discussed in the text; B_t is B^1 , a measure of the stock market bubble; ρ is the coefficient on the lagged dependent variable; LOGL is the log likelihood; SSR is the sum of squared residuals; LM_1 is a modified Lagrange Multiplier statistic that evaluates the null hypothesis of no first-order residual serial correlation; see footnote 31 for further discussion.

	(1)	(2)	(3)	(4)
Q_t^{LP}	1.208 (.130)	.667 (.147)		
Q_t^{NA}			3.020 (.881)	1.782 (.438)
B_t	.454 (.130)	.308 (.099)	2.342 (.881)	1.543 (.426)
$(I/K)_{t-1}$		.529 (.111)		.724 (.079)
Constant	4.022 (.089)	1.852 (.459)	4.292 (.127)	1.145 (.348)
\bar{R}^2	.817	.904	.576	.905
LOGL	-13.830	-4.512	-25.130	-4.336
SSR	4.403	2.208	10.170	2.180
LM_t	.998	.452	5.498	1.716
DW	1.577	1.801	.511	1.424

Ordinary Least Squares estimates for 1966-1992. See the notes to Table 5 for further information. Q_t^{NA} is the linear projection of Q constructed with a marginal product of capital series derived from the National Income and Product Accounts. See Section 3 for further details.

Table 7 Parametric Estimates Accounting for the Role of Liquidity						
	(1)	(2)	(3)	(4)	(5)	(6)
Q^{LQ}_t	1.446 (.137)	.790 (.209)			1.241 (.123)	.703 (.156)
Q^{LP}_t			.981 (.128)	.466 (.125)		
LIQ_t			.316 (.099)	.247 (.065)	.288 (.079)	.248 (.059)
B_t	.748 (.137)	.480 (.131)	.447 (.114)	.313 (.077)	.715 (.110)	.488 (.097)
$(I/K)_{t-1}$		.496 (.135)		.526 (.096)		.429 (.101)
Constant	3.651 (.092)	1.789 (.511)	3.320 (.220)	1.326 (.390)	3.180 (.167)	1.575 (.382)
\bar{R}^2	.860	.912	.860	.943	.911	.952
LOGL	-8.897	-2.697	-8.254	3.133	-2.831	5.173
SSR	2.949	1.759	2.795	1.082	1.779	.913
LM_1	1.132	1.171	.317	.357	1.047	1.206
DW	1.461	1.513	1.816	1.861	1.495	1.466

Ordinary Least Squares estimates for 1968-1991. See the footnotes to Table 5 for further information. Q^{LQ}_t is the linear projection of Q in which LIQ_t replaces inflation as an argument in the VAR that defines the linear projection of Q . LIQ_t is liquidity, normalized by the capital stock. See the data appendix for the construction of LIQ_t and Section 3 for further details.

Table 8 Parametric Tests Instrumental Variable Estimation						
	Instruments					
	LP First Lags		LP Second Lags		Short	
	(1)	(2)	(3)	(4)	(5)	(6)
Q_t^{LP}	1.224 (.149)	.856 (.209)	1.570 (.223)	1.267 (.329)	1.330 (.091)	.848 (.177)
B_t	.412 (.164)	.314 (.134)	.782 (.224)	.650 (.221)	.543 (.140)	.391 (.112)
$(I/K)_{t-1}$		.349 (.165)		.225 (.203)		.423 (.126)
Constant	4.021 (.092)	2.596 (.681)	3.928 (.112)	3.024 (.819)	3.991 (.091)	2.270 (.517)
\bar{R}^2	.815	.890	.796	.852	.815	.899
SSR	4.480	2.523	5.912	3.887	4.567	2.354
LM_1	1.301	.783	-.429	-.430	1.083	-.110
DW	1.615	1.873	1.767	1.912	1.759	1.981

Instrumental variable estimates for 1966-1992. See the footnotes to Table 5 for further information. The instrument lists are given in Section 2 (for "short") and Section 3 (for "LP").

Table 9
Parametric Estimates
Neoclassical and Flexible Accelerator Models

	Neoclassical		Flexible Accelerator	
	(1)	(2)	(3)	(4)
ΔY_t	.398 (.034)	.395 (.049)	.349 (.038)	.320 (.050)
ΔY_{t-1}	.249 (.051)	.244 (.052)	.271 (.053)	.261 (.055)
ΔC_t	.041 (.027)	.043 (.032)		
ΔC_{t-1}	.076 (.027)	.079 (.027)		
$(I/K)_{t-1}$	.565 (.043)	.560 (.044)	.585 (.047)	.585 (.048)
LIQ_t		.020 (.045)		.051 (.051)
B_t	.251 (.062)	.253 (.068)	.262 (.075)	.283 (.080)
Constant	.765 (.137)	.757 (.142)	.711 (.160)	.676 (.168)
\bar{R}^2	.986	.986	.979	.979
LOGL	23.24	22.63	16.61	16.14
SSR	.283	.267	.462	.440
LM	.591	.718	1.476	1.260
DW ¹	1.698	1.657	1.391	1.472

Ordinary Least Squares estimates for 1966-1992 (columns 1 and 3) and 1966-1991 (columns 2 and 4). ΔY_t is the percentage change in real output. ΔC_t is the percentage change in the cost of capital, defined as the relative price of investment goods multiplied by the sum of the real interest rate and economic depreciation, the latter equal to .10. B_t is a measure of the stock market bubble normalized by the capital stock (specifically, B^1 as defined in the text). LIQ_t is liquidity normalized by the capital stock.

Figure 1
Stock Price Indexes for Japan and the U.S.

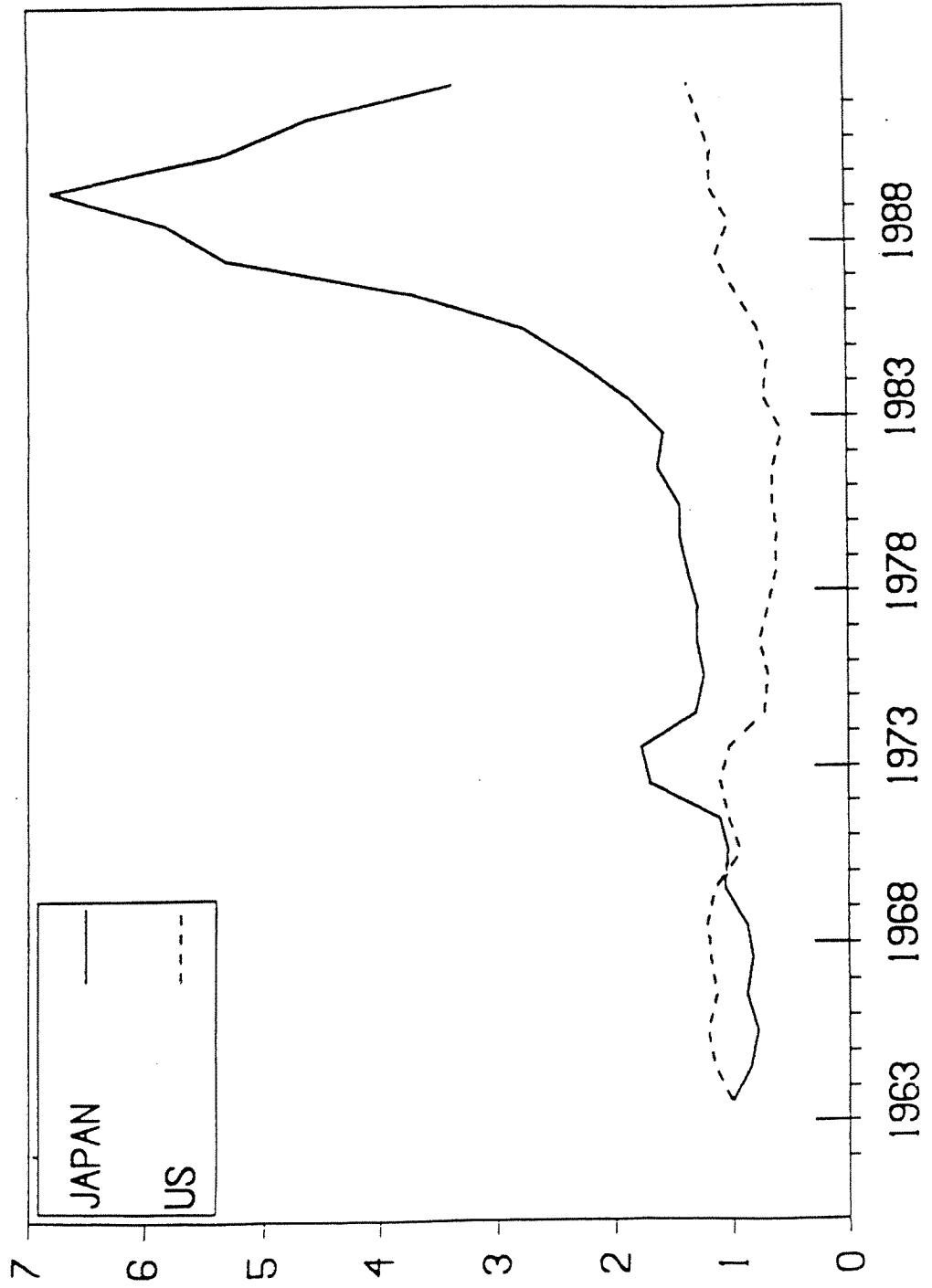


Figure 2
Equity Issues
(Normalized by Fixed Investment Expenditures)
Japanese Principal Enterprises

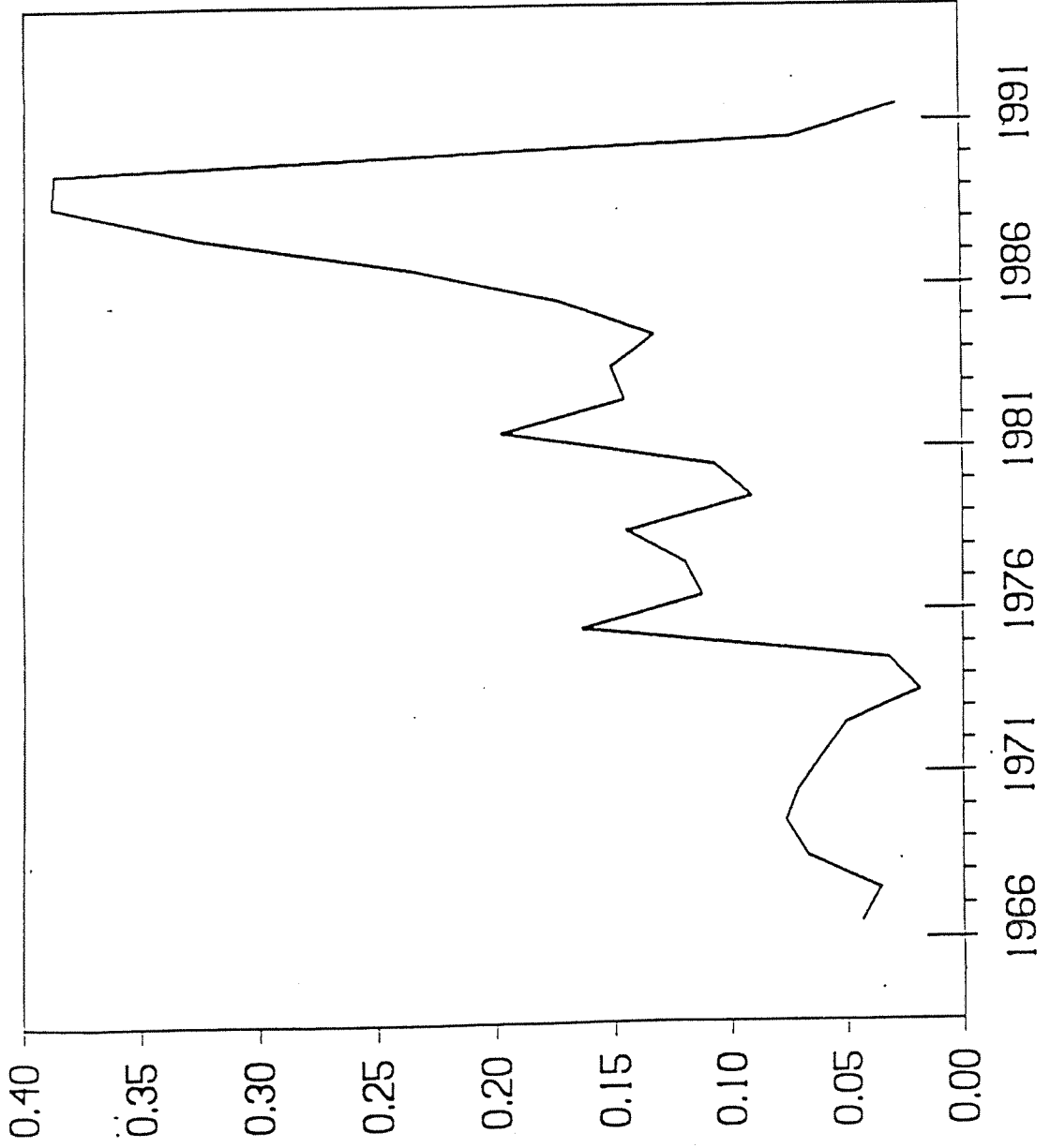


Figure 3
Equity Plus Bond Issues
(Normalized by Fixed Investment Expenditures)
Japanese Principal Enterprises

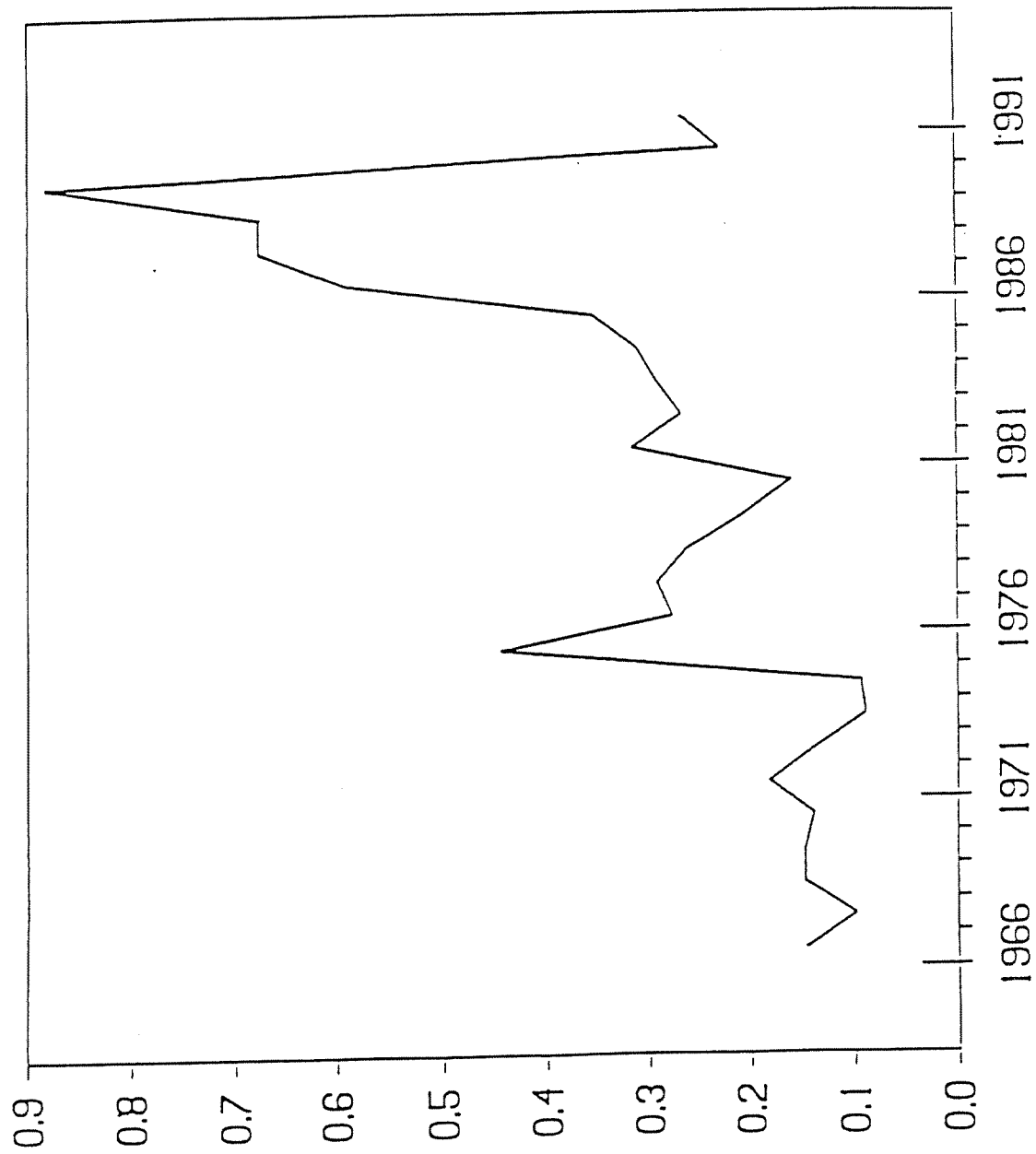


Figure 4
Long-Term Borrowing
(Normalized by Fixed Investment Expenditures)
Japanese Principal Enterprises

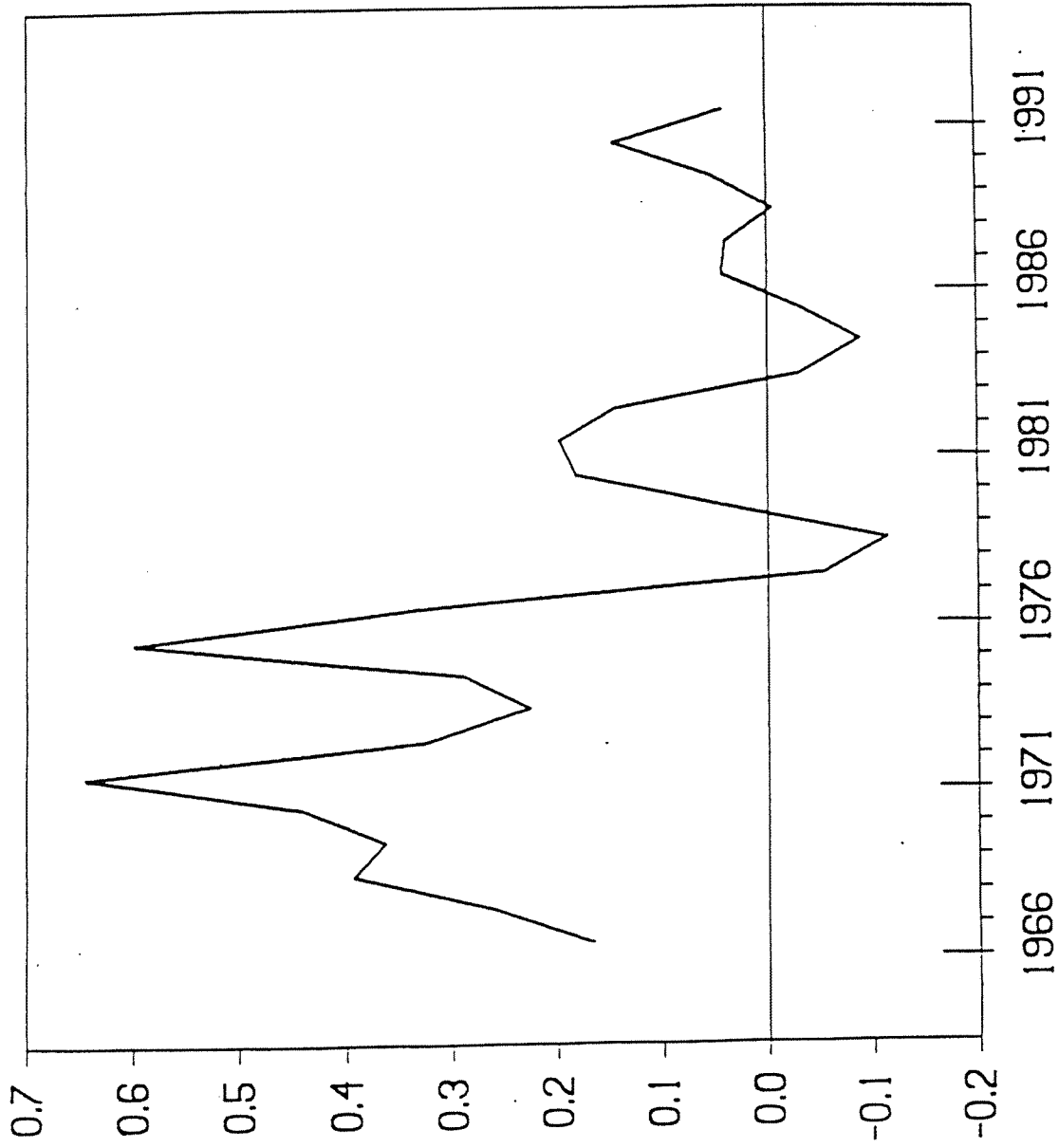


Figure 5
Changes in Holdings of Cash and Securities
(Normalized by Fixed Investment Expenditures)
Japanese Principal Enterprises

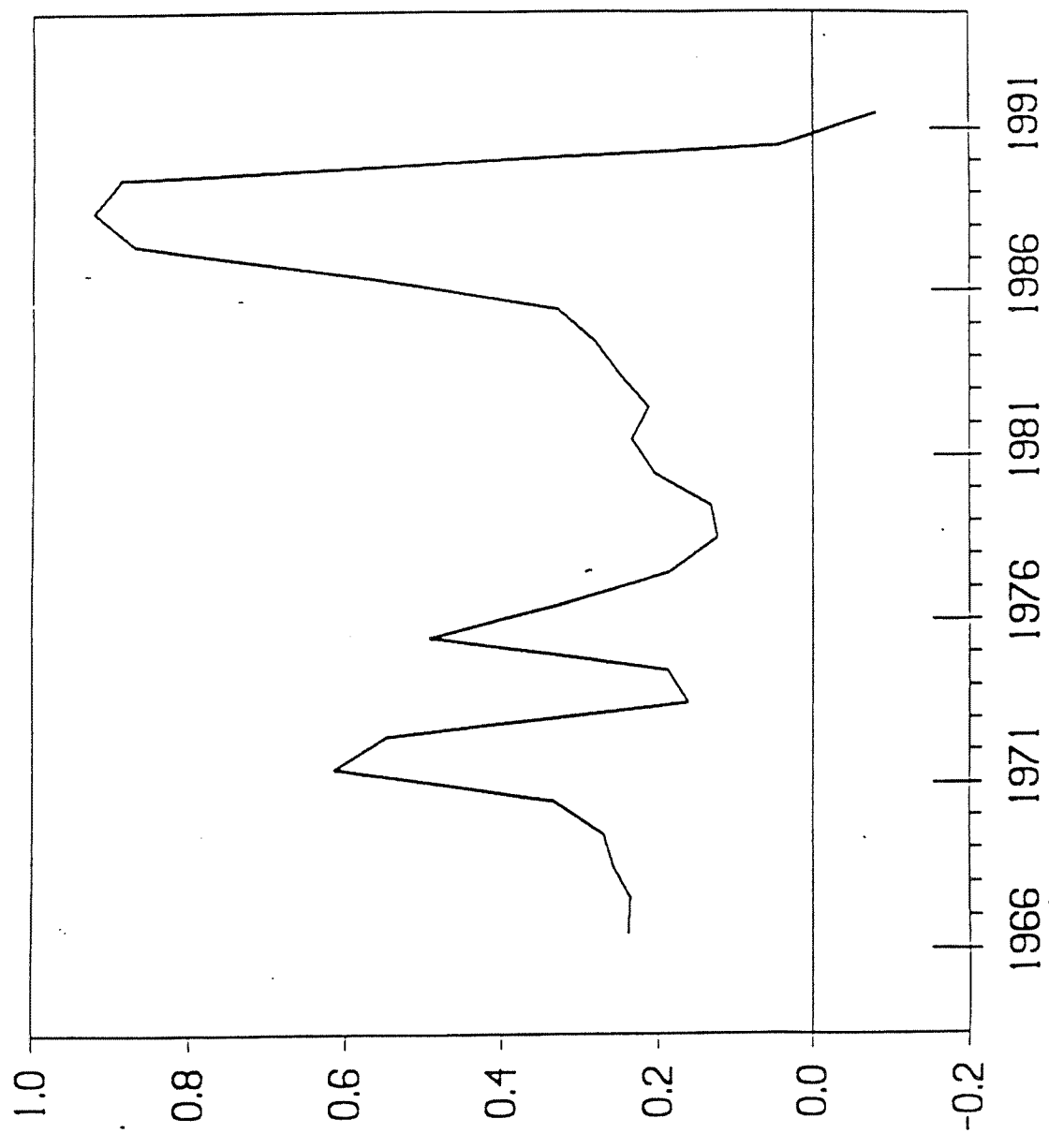


Figure 6
Net Investment as a Share of Japanese Output

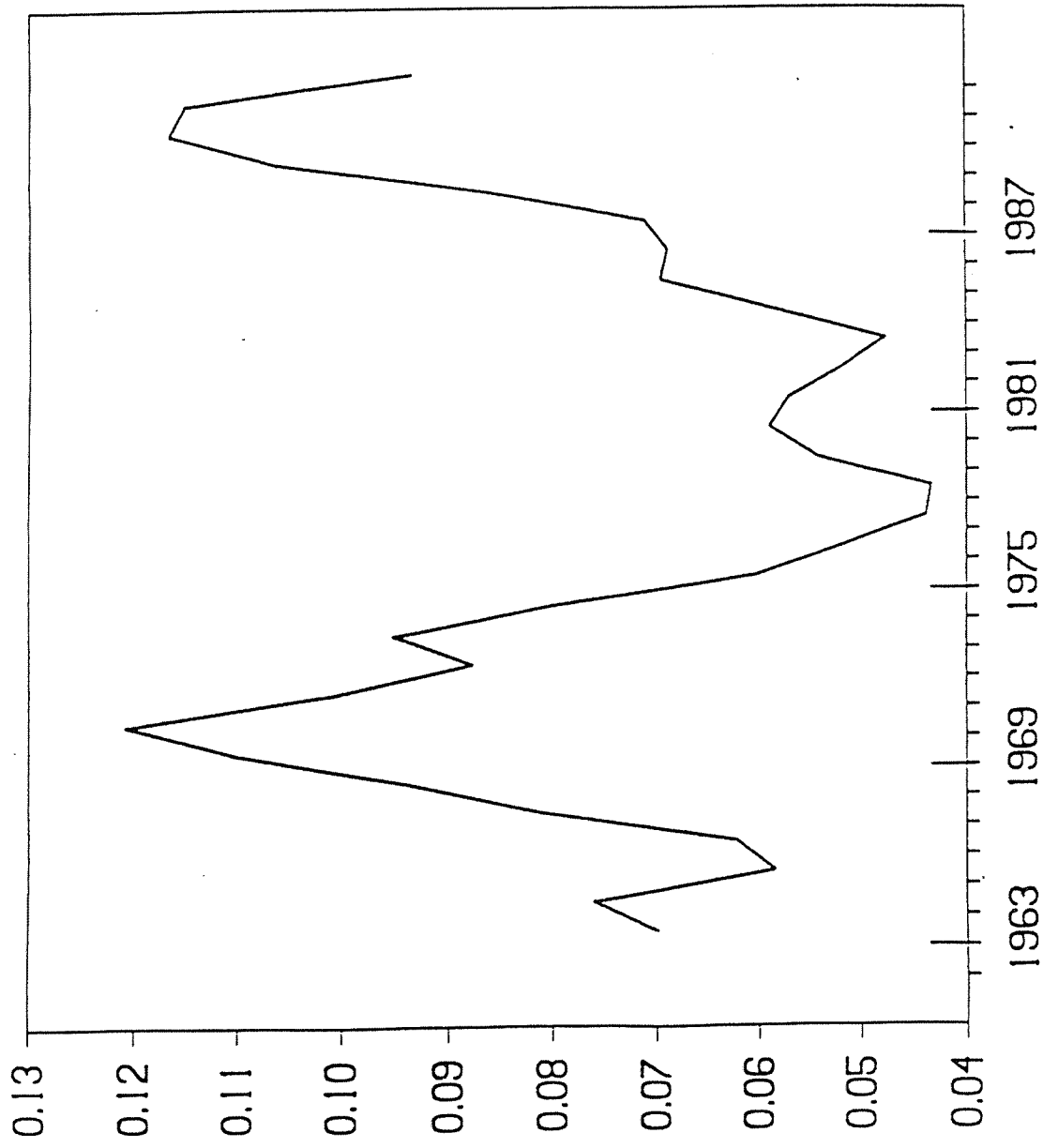


Figure 7
Q Equation Residuals

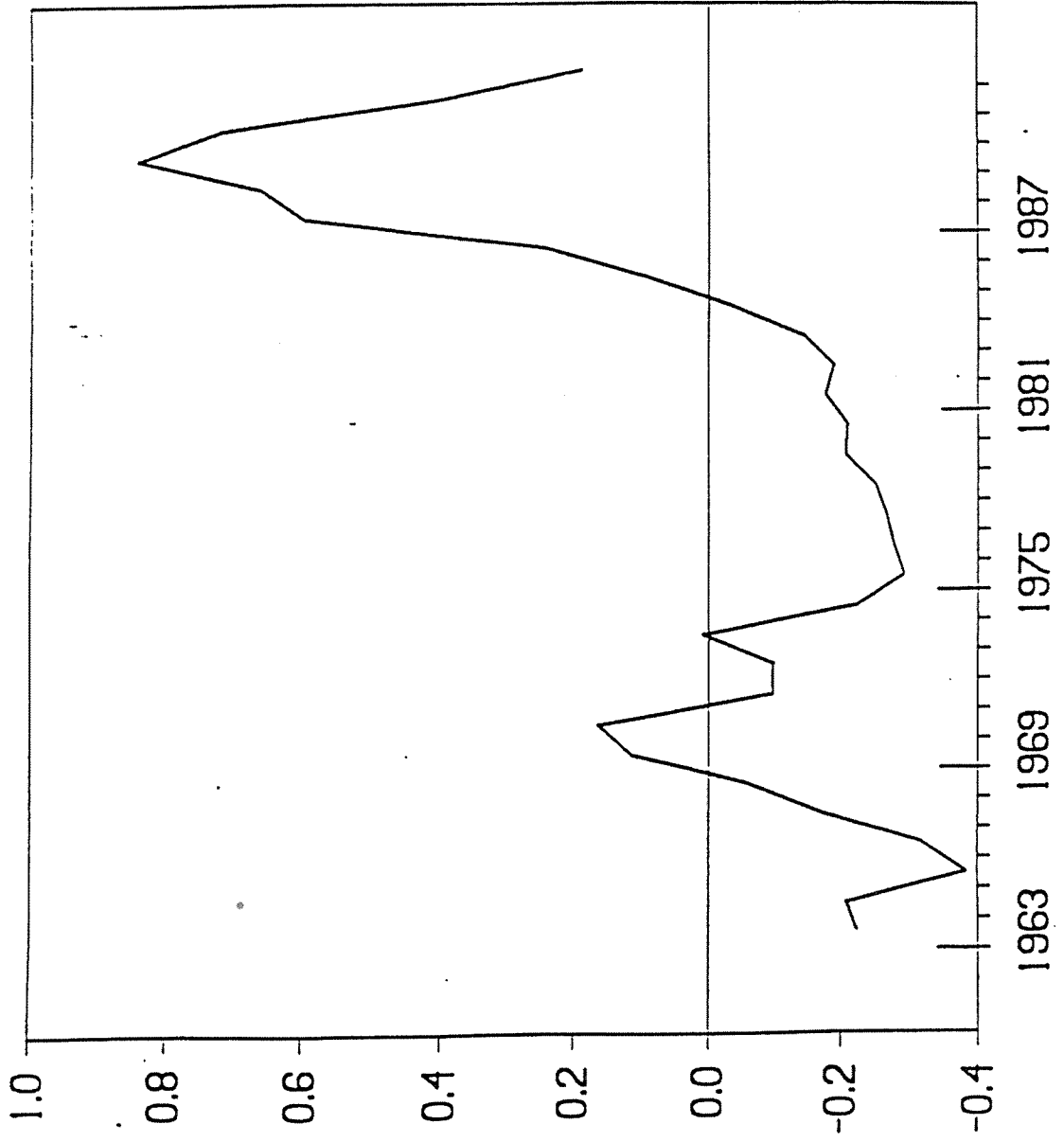
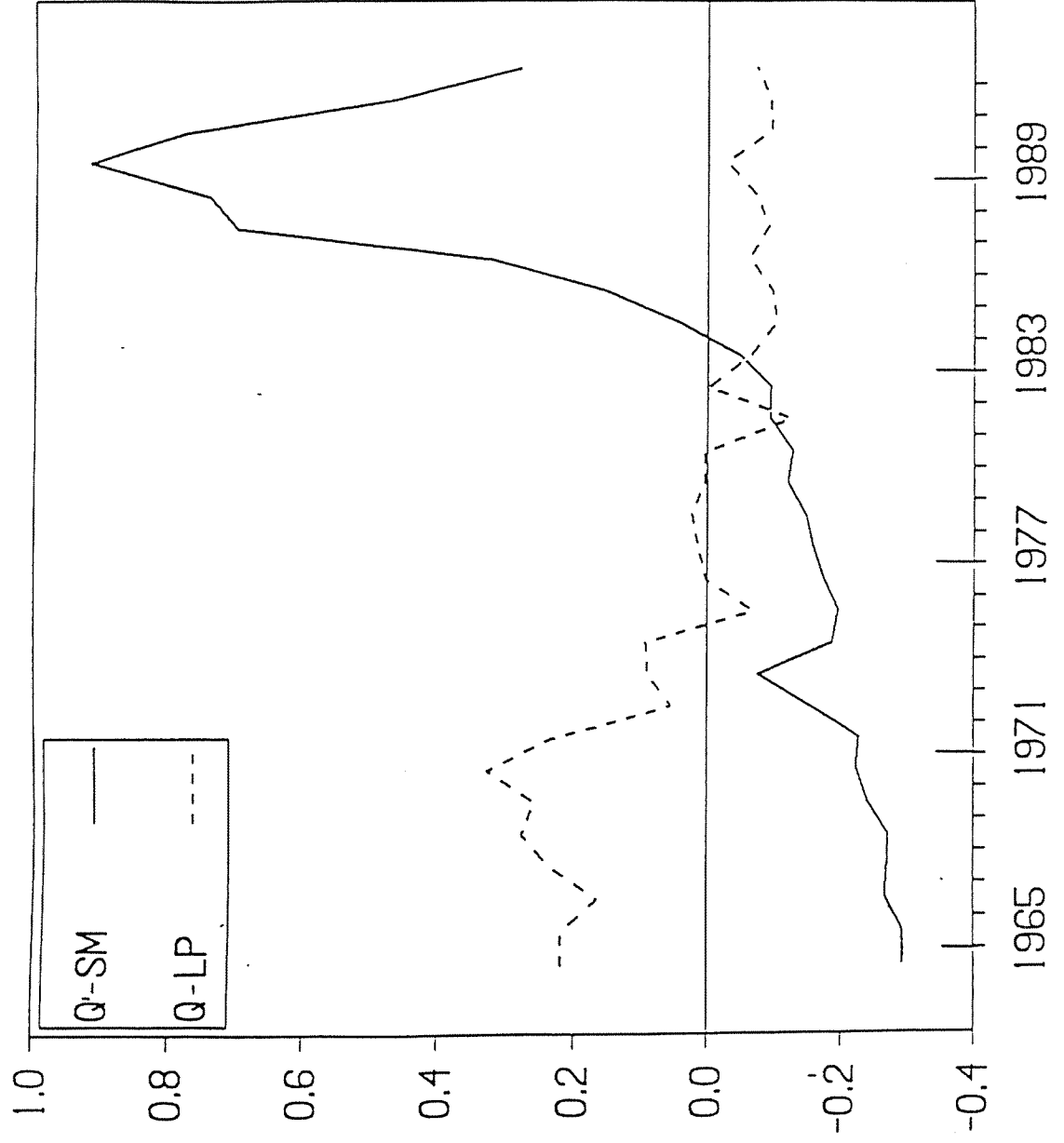


Figure 8
Stock Market Q and Linear Projection Q



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