Testing the *Ex Ante* Relationship between Asset and Investment Returns in Japan: An Application of the P-CAPM to Japanese Asset Returns

Naohiko Baba

This article provides an empirical investigation into the validity of the production-based capital asset-pricing model (P-CAPM) in the Japanese asset markets during the period 1980–97. Several methodologies are used to test the P-CAPM, which include the generalized method of moments (GMM) test of the Euler equations, the volatility bound test, the mispricing test, and the test of the ability of stock and investment returns to forecast future economic activity. The empirical results basically support the P-CAPM. For example, the GMM test of the Euler equations strongly favors the P-CAPM in terms of the statistical significance level of the estimated parameter and the overidentification test. In addition, statistical inference of the volatility bound test cannot significantly reject the P-CAPM. On the other hand, the estimation result of the mispricing coefficients suggests that the so-called risk-free rate puzzle is a more significant phenomenon than the so-called equity premium puzzle in Japan during this period.

Key words: Asset pricing; P-CAPM; GMM; Equity premium puzzle; Risk-free rate puzzle; Volatility bound test; *q* theory of investment

Research Division 1, Institute for Monetary and Economic Studies, Bank of Japan (E-mail: naohiko.baba@boj.or.jp)

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I. Introduction

According to Cochrane and Hansen (1992), asset prices can provide us with the intertemporal general equilibrium reflection of theories about consumption, production, and demography, and thus offer a useful insight into the validity of theoretical representations of the economy.

In fact, there is a tremendous quantity of literature that studies the interaction between the U.S. capital market and its underlying economic activity. The number of studies that examine the relationship between the Japanese capital market, which is the second largest in the world, and its fundamental economic activity, however, has been quite limited and the few existing studies generally use *ad hoc* factor-pricing-type models or the consumption-based capital asset-pricing model (C-CAPM) as their basic analytical framework.

For example, Chan, Lakonishok, and Hamao (1991) explored the relationship between U.S. capital market fundamentals and stock market returns in a cross-sectional context. Also, Campbell and Hamao (1992) studied the degree of integration between the U.S. and Japanese capital markets. These studies use factor-pricing models, which are thought to be extensions of the traditional CAPM.

On the other hand, Hamori (1992, 1994) was the first to apply the C-CAPM to the Japanese stock market and consumption data, concluding that it performed well over the period from the 1970s to the 1980s in terms of the generalized method of moments (GMM)-based overidentifying restrictions test, which was proposed by Hansen (1982). However, Hori (1996) rejects the C-CAPM in terms of Hansen and Jagannathan's (1991) volatility bound test[1] despite the fact that Hamori (1992, 1994) and Hori (1996) used very similar data sets. Since both types of test frequently reject the C-CAPM in the case of the U.S. data,[2] the coexistence of these competing results has been said to be characteristic of Japanese asset markets.

Another direction for testing asset-pricing relationship is to use the production-based capital asset-pricing model (P-CAPM), which characterizes intertemporal marginal rates of substitution using physical investment data, not consumption data, in the belief that investment should reflect variations in stock returns more significantly than consumption, as suggested by Mehra and Prescott (1985).

Theoretically, however, the P-CAPM shares many features with the C-CAPM. Just as the latter model derives its asset-pricing implications from the consumers' first-order Euler conditions regarding the intertemporal marginal rate of substitution of consumption, the former model relies on the firm's Euler conditions regarding the intertemporal marginal rate of transformation, and in fact, both models coincide in a special case.

More specifically, the return on investment is defined as the marginal rate at which a firm can transfer resources through time by increasing investment in the

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1. Recently, Bakshi and Naka (1997) examined the empirical performance of various specifications in the class of the C-CAPM using these methods. The empirical results indicate that habit-forming preferences provide a relatively good characterization of the Japanese security market data.
2. For example, see Singleton (1990) and Cochrane and Hansen (1992).

current period and decreasing it in the future period, leaving its production plan unchanged in all later periods. In this paper, I examine whether the variation in expected stock returns can be explained by the investment return, which is derived from investment data via a production function interacting with an adjustment cost function.

Most previous empirical studies on the relationship between Japanese stock prices and physical investment rely on the q theory of investment posited by Tobin (1969). Although its theoretical basis is robust, measures of the q index are often empirically inappropriate for testing whether stock prices reflect their fundamental values. Typically, in computing the numerator of q, one is obliged to use either (1) firm value evaluated in the stock market or (2) the present discounted value of a stream of firm profits with some interest rate as its discount rate.

However, it is difficult to appropriately measure (1) the market value of equity net of cross-holdings[3] in the former method, and to choose or estimate (2) the discount rate in the latter method. Further, *ex post* stock prices have a lot of noisy components, which, by definition, do not reflect fundamental firm decisions about intertemporal investment and production. In this regard, the use of the P-CAPM enables us to avoid such problems because it concentrates on the *ex ante* relationship between asset and investment returns, although from the theoretical perspective, the two models are closely related to each other.

Motivated by the above discussion, this paper tries to examine the relationship between asset and physical investment returns within the framework of the P-CAPM using the industry-level data that consist of the firms listed on the Tokyo, Osaka, and Nagoya stock exchanges, as well as the over-the-counter (OTC) market.[4] To my knowledge, there are only a few existing studies that examine the validity of the P-CAPM using detailed Japanese stock market data.[5]

On the one hand, Bakshi, Chen, and Naka (1995)[6] found supporting evidence for the P-CAPM. However, their analysis is not complete because they did not examine their results within a framework of Hansen and Jagannathan's volatility bound test. On the other hand, Hori (1997) tried to estimate the parameter of the adjustment cost function by GMM using industry-level data, but failed to find evidence supporting the P-CAPM. However, he applied GMM to the Euler

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3. For example, Kiyotaki and West (1996) state that in Japan q was almost always negative during the period between the 1960s and the 1980s, reflecting a negative numerator (equity value net of cross-holding). They point out that one possible cause is a mismeasurement of equity values caused by the use of book value for non-traded corporations. Hoshi and Kashyap (1990) also point out this kind of problem, finding that a substantial fraction of firms with equity valued at market has a negative value of q.

4. In fact, this is the most extensive coverage of the stock returns of firms of all the previous studies, which typically cover only the stock returns of the firms listed on the first section of the Tokyo Stock Exchange. It is important to include as many stock returns as possible since investment and production data available reflect not only large-scale leading firms but also small ones.

5. Kasa (1997) compares the ability of two competing asset-pricing models, C-CAPM and P-CAPM, to explain cross-sectional and time-series variation of national stock returns in the United States, Japan, the United Kingdom, Germany, and Canada. The result shows that the P-CAPM performs better than the C-CAPM.

6. In their GMM estimation, they estimate the parameter of the marginal productivity, which plays a role in determining the mean value of the investment return, not the parameter of adjustment costs, which plays a decisive role in determining the variation of the investment return.

equations only for the stock returns in excess of the risk-free interest rate, which might incur a serious bias in his estimation results.[7]

In fact, there are several ways of deriving the testable form of the P-CAPM. The differences between them largely depend upon how the stochastic discount factor (pricing kernel) or the intertemporal marginal rate of substitution is specified. Following Cochrane (1991, 1996), this paper characterizes it as a function of the return on physical investment.

Thus, this paper can be thought to be an application of the methodologies used by Cochrane (1991, 1996) to the Japanese industry-level stock return data, but the following modifications have been made.

(1) I focus on manufacturing industries because (a) in the 1980s, there was large-scale privatization in some non-manufacturing industries, so that there are big jumps in the investment and capital stock data for such industries, and (b) in evaluating the marginal productivity of capital that is one of the essential elements of investment return, it is much more appropriate if one adjusts capital stock for the corresponding operating ratio, which is available only for manufacturing industries.

(2) Although Cochrane (1996) treats the marginal productivity of capital as a constant parameter given *a priori* under the assumption that the variation in the investment return depends solely upon the adjustment cost function, not on the production function, I use the specification such that the marginal productivity of capital is also time-varying.

(3) Relating to this point, Cochrane (1991, 1996) also gives an arbitrary value to a parameter of the adjustment cost function and tests whether the constructed investment return can be regarded as a pricing factor of the stochastic discount factor. But I try to directly estimate this parameter within the framework of GMM.

(4) In evaluating the values of the parameter estimated by GMM in terms of the volatility bound test, I construct a confidence region to perform a proper statistical inference taking into account possible sampling and measurement errors.

The rest of the paper is organized as follows. Chapter II outlines a basic theoretical framework of the P-CAPM, referring to the link with the *q* theory of investment. Then I discuss the testable implications of the P-CAPM. Chapter III describes the empirical methodologies. First, I briefly discuss the thrust of the GMM estimation, followed by the method of Hansen and Jagannathan's volatility bound test and its statistical inference, the estimation of mispricing coefficients that have an implication for equity premium and risk-free rate puzzles, and the ability of stock and investment returns to forecast future economic activity. Chapter IV describes the data and reports the empirical results. Chapter V concludes the paper.

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7. In other words, he ignored the Euler equation for the risk-free interest rate itself. I will discuss this point in Chapter II. Also, he estimated the quarterly industry GDP under the assumption that the output of each industry has the same pattern of quarterly variation as has total output. This treatment might cause another bias.

II. Theoretical Framework

A. Basic Model[8]

1. Maximization problem for a firm

This section derives the formula of the investment return from the production and investment technologies and then shows that a firm's first-order conditions imply that the firm tries to make decisions so as to remove arbitrage opportunities between asset and physical investment returns.

Now, consider the following production economy similar to those of Lucas and Prescott (1981), Abel and Blanchard (1986), and Cochrane (1996).[9] Any security markets are assumed to be frictionless. By frictionless markets, I mean that agents are able to buy and sell any securities at a given price without paying any transaction costs.

Different securities correspond to different technologies. There are numerous investors in the asset markets and their belief is assumed to be homogeneous. Also, let me assume that shareholders can choose an optimal physical investment plan directly or delegate managers to do the task perfectly. Every agent takes the price as given under perfect competition.

Given the technology and the capital accumulation rule, a representative firm chooses investment I_{t+j} and the labor input L_{t+j} in order to maximize its present discounted value. Thus, the maximization problem for the firm can be written as

$$V_t \equiv \max_{\{I_{t+j}, L_{t+j}\}} E_t \left[\sum_{j=0}^{\infty} M_{t,t+j} D_{t+j} \right], \tag{1}$$

$$\text{s.t. } D_{t+j} = Q_{t+j} - I_{t+j}, \tag{2}$$

$$Q_{t+j} = F(K_{t+j}, L_{t+j}) v_{t+j} - C(I_{t+j}, K_{t+j}) - w_{t+j} L_{t+j}, \tag{3}$$

$$\text{and } K_{t+j+1} = (1 - \delta)(K_{t+j} + I_{t+j}), \tag{4}$$

where E_t denotes the expectation operator conditional on the information set available at the beginning of period t, D_{t+j} the dividend in period $t + j$, and $M_{t,t+j}$ the stochastic discount factor (pricing kernel) or the intertemporal marginal rate of substitution from period t to $t + j$,[10] which is assumed to be common to every investor. In a complete market, the present value (1) is equal to the firm's period t contingent claims value.

Equation (2) states that the firm is assumed to pay the dividend D_{t+j} that is equal to the cash flow Q_{t+j} netting out investment expenditures I_{t+j}. Equation (3) depicts the cash flow identity, where $F(K_{t+j}, L_{t+j})$ is the concave production function,

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8. Description of the basic model follows Hori (1997).
9. These works are descended from Breeden (1979).
10. In general, $M_{t,t+j}$ is defined as $M_{t,t+j} = \rho^j U'(c_{t+j})/U'(c_t)$, where ρ is the time discount factor, c_{t+j} the investor's consumption in period $t + j$, and $U(c_{t+j})$ the period utility of consumption in period $t + j$. By definition, $M_{t,t+j}$ can be transformed as $M_{t,t+j} = M_{t,t+1} \times M_{t+1,t+j}$.

$C(I_{t+j}, K_{t+j})$ the adjustment cost function, K_{t+j} the capital stock, w_{t+j} the wage rate, and v_{t+j} the exogenous shock. The adjustment costs indicate deadweight costs incurred by installing and transforming investment goods into capital stock. Lastly, Equation (4)[11] is the capital accumulation rule, where δ is the constant depreciation rate.

The first-order conditions and a transversality condition can be written as

$$F_L(t)v_t = w_t, \tag{5}$$

$$-C_I(t) - 1 + (1 - \delta)E_t[M_{t,t+1}V_K(K_{t+1}, v_{t+1})] = 0, \tag{6}$$

$$\text{and} \lim_{j\to\infty} E_t\left[M_{t,t+j}\left(\frac{\partial D_{t+j}}{\partial K_{t+j}}\right)K_{t+j}\right] = 0. \tag{7}$$

Equation (5) states that at optimum the marginal product of labor should be equal to the wage rate, and equation (6) states that the cost of one unit of investment good should be equal to the marginal gain of the firm value. Equation (7) is the transversality condition that is necessary to rule out the speculative bubbles. Now equation (6) can be rewritten as

$$(1 - \delta)E_t\{M_{t,t+1}[1 + F_K(t + 1)v_{t+1} + C_I(t + 1) + C_K(t + 1)]\} = 1 + C_I(t). \tag{8}$$

Thus, the one-period investment return $R_{t,t+1}^I$[12] can be defined as

$$R_{t,t+1}^I \equiv (1 - \delta)\frac{1 + F_K(t + 1)v_{t+1} + C_I(t + 1) - C_K(t + 1)}{1 + C_I(t)}. \tag{9}$$

Combining the definition of the investment return (9) and the transformed first-condition (8) yields the following Euler equation:

$$E_t[M_{t,t+1}R_{t,t+1}^I] = 1. \tag{10}$$

The pricing condition (10) states that the time variation in the investment return that is predictable based on the information set is removed when the investment return is multiplied by an appropriate stochastic discount factor.

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11. One alternative specification is that adjustment costs are included in the capital accumulation rule instead of the cash flow identity such that $K_{t+1} = (1 - \delta)K_t + I_t - C(I_t, K_t)$. As will be shown later, it turns out that the results are qualitatively very similar. For more details, see Cochrane (1991), Bakshi, Chen, and Naka (1995), and Arroyo (1996).
12. Here, as emphasized by Cochrane (1996), it should be noted that for some production technologies it is not possible to summarize the price versus present value relation (6) in a single-period investment return. For example, if the adjustment costs depend upon p lags of investment, then a p-period investment strategy must be considered.

2. Specification of the production function and the adjustment cost function

To estimate the investment return (9) within the framework of the Euler equation (10), one needs to specify a concrete form of the investment return $R^I_{t,t+1}$, which in turn requires the specification of the production function and the adjustment cost function. As for the production function, the following Cobb-Douglas form is used:

$$F(K_t, L_t) = K_t^\alpha L_t^{1-\alpha} v_t \text{ and } 0 < \alpha < 1. \tag{11}$$

Here, the marginal productivity of capital can be derived as $F_K(K_t, L_t) = \alpha(Y_t/K_t)$, where under the assumption of perfect competition the parameter α indicates the ratio of capital income to total income.

Next, I will specify the adjustment cost function as[13]

$$C(I_t, K_t) = \frac{\beta}{2} \frac{I_t^2}{K_t} \text{ and } \beta > 0, \tag{12}$$

where β denotes the adjustment cost parameter to be estimated.

This functional form has the properties such that $C_I(t) \equiv \partial C(I_t, K_t)/\partial I_t = \beta(I_t/K_t) \geq 0$, $C_{II}(t) \equiv \partial C_I(t)/\partial I_t = \beta(1/K_t) \geq 0$, and $C_K(t) \equiv \partial C(I_t, K_t)/\partial K_t = -(\beta/2)(I_t/K_t)^2 \leq 0$.

Now the investment return (9) can be rewritten as

$$R^I_{t,t+1} \equiv (1-\delta)\frac{1 + \alpha(Y_{t+1}/K_{t+1}) + \beta(I_{t+1}/K_{t+1}) + (\beta/2)(I_{t+1}/K_{t+1})^2}{1 + \beta(I_t/K_t)}. \tag{13}$$

This expression states that basically, the output-capital ratio and the depreciation rate determine the mean value of the investment return, while the investment-capital stock ratio plays a role in determining the variation of the investment return around its mean value.[14]

3. Relation with marginal *q*

Here, the so-called envelope condition is given by

$$V_K(K_t, v_t) = F_K(t)v_t - C_K(t) + (1-\delta)E_t[M_{t,t+1}V_K(K_{t+1}, v_{t+1})]. \tag{14}$$

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13. This form is used in Cochrane (1996) and Hori (1997). The adjustment cost function of this form is often used when one tries to prove the equality of marginal *q* and average *q*. For more details, see Obstfeld and Rogoff (1996).

14. In the case in which the alternative specification of the capital accumulation rule is used as in Cochrane (1991) and Bakshi, Chen, and Naka (1995), other things being equal, the following expression for the investment return can be obtained:

$$R^I_{t,t+1} \equiv \left[\alpha(Y_{t+1}/K_{t+1}) + \frac{(1-\delta) + \beta(I_{t+1}/K_{t+1})^3}{1 - 1.5\beta(I_{t+1}/K_{t+1})^2}\right]\left[1 - 1.5\beta(I_t/K_t)^2\right].$$

This specification has the same qualitative characteristics as investment return (13), and empirically, almost the same results are obtained.

Let q denote an increase in the value of the firm when another unit of capital stock is installed, that is, $q_t \equiv V_K(K_t, v_t)$. Combining equations (6) and (14) gives the following equilibrium condition:

$$q_t \equiv V_K(K_t, v_t) = 1 + F_K(t)v_t + C_I(t) - C_K(t) = 1 + \alpha \frac{Y_t}{K_t} + \beta \frac{I_t}{K_t} + \frac{\beta}{2} \left(\frac{I_t}{K_t}\right)^2. \quad (15)$$

Equation (15) states that as adjustment costs asymptotically approach to zero—that is, when $\beta \to 0$—marginal q is getting more independent of the investment-to-capital ratio (I/K) and thus, solely a function of the marginal productivity of capital. In addition, as suggested by the literature, marginal q is increasing in the investment-to-capital ratio (I/K) and β. A positive technology shock, $v_t > 1$, for instance, increases the marginal productivity of capital, and as a result, increases the incentive to invest. This assertion is consistent with the conventional wisdom that marginal q varies systematically over business cycles.

In terms of marginal q, the investment return (9) can be rewritten as

$$R_{t,t+1}^I = (1 - \delta) \frac{q_{t+1}}{q_t - F_K(t)v_t - C_K(t)}. \quad (16)$$

Therefore, other things being equal, the investment return will be positively correlated with current marginal q and negatively correlated with one-period-lagged marginal q. Since, to a reasonably close approximation, the investment return is proportional to the (gross) rate of growth in the investment-capital ratio (I/K), the period t investment depends upon both current and one-lagged values of marginal q. This finding is consistent with the literature on q including Hayashi (1982) and Abel and Blanchard (1986).

B. Testable Implication of the P-CAPM
The literature states that any asset-pricing model with homogeneous belief is characterized by

$$E_t[M_{t,t+1}R_{t,t+1}] = 1,^{15} \quad (17)$$

where $M_{t,t+1}$ is the stochastic discount factor from period t to $t + 1$ and $R_{t,t+1}$ is any asset return. Hence, equations (10) and (17) jointly suggest that *ex ante* asset returns should be equal to the *ex ante* investment return state by state if there are no arbitrage

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15. Although it seems easiest to derive this equation by reference to the intertemporal choice problem of a representative investor, it can be derived merely from the absence of arbitrage, without assuming that the investor maximizes a well-behaved utility function. That is, without the arbitrage opportunity,

$$1 = \sum_{s=1}^{S} p_s R_s = \sum_{s=1}^{S} \pi_s M_{t,t+1}^s R_s = E_t[M_{t,t+1}R_{t,t+1}],$$

where p_s is the state price and π_s is the probability of state s occurring. For more details, see Campbell, Lo, and MacKinlay (1997).

opportunities between asset and physical investment. This is the most important testable implication of the P-CAPM.

C. Testable Form of the P-CAPM

As stated by Ross (1978), Hansen and Richard (1987), and Hansen and Jagannathan (1991), if there are no arbitrage opportunities, then a stochastic discount factor $M_{t,t+1}$ can be uniquely characterized by any asset return $R_{t,t+1}$. The preceding discussion suggests that the following condition sufficiently guarantees the satisfaction of the asset-pricing condition:

$$M_{t,t+1} = \frac{1}{R_{t,t+1}^I}. \tag{18}$$

This condition can also be obtained by some types of the general equilibrium model under the assumption of log utility and Cobb-Douglas production, as shown by Cochrane (1996).[16] For reference, let me sketch the model. Consider the following simplified version of the one-sector stochastic growth model:

$$\max_{\{C_s\}} E_t\left[\sum_{s=t}^{\infty} \rho^{s-t} \ln(c_s)\right], \tag{19}$$

subject to $c_s + I_s = Y_s = \gamma_s I_{s-1}^{\tau}$ and $\ln\gamma_s = \chi \ln\gamma_{s-1} + \varepsilon_s$, where Y_s denotes the income and ε_s denotes white noise.

Then, the investment return can be computed as $R_{t,t+1}^I = \tau\gamma_{t+1}I_t^{\tau-1} = \tau Y_{t+1}/I_t$. The solution to the model gives $c_t = (1 - \tau\rho)Y_t$ and $I_t = \tau\rho Y_t$. Substituting this solution into the investment return yields

$$R_{t,t+1}^I = \frac{1}{\rho}\frac{c_{t+1}}{c_t} = \frac{1}{M_{t,t+1}}. \tag{20}$$

Thus, one can obtain the condition (18).

Now let me restate the system of equations to be estimated:[17]

$$E_t[M_{t,t+1}R_{t,t+1}^b] = 1 \quad \text{for the bond return,} \tag{21}$$

and $\quad E_t[M_{t,t+1}R_{t,t+1}^i] = 1 \quad$ for i-th stock return ($i = 1, 2, \ldots n$). $\tag{22}$

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16. As a matter of fact, Cochrane (1996) does not use this specification of the stochastic discount factor, but uses a more general form such that $M_{t,t+1} = b_0 + b_R R_{t,t+1}^I + \ldots$. That is, following the factor-pricing tradition, he estimates the loading of the investment return factor as a free parameter. Since, approximately, one can write $M_{t,t+1} = (1/R_{t,t+1}^I) \approx 2 - R_{t,t+1}^I$, the restriction in this paper implies that $b_0 = 2$ and $b_R = -1$ in terms of his formulation.
17. He and Modest (1995) and Luttmer (1996) independently show that, for example, when there are short-sale constraints for some assets, it follows that $E_t[M_{t,t+1}R_{i,t+1}^i] = 1$ for $i \subseteq A^c$ and $E_t[M_{t,t+1}R_{i,t+1}^i] \leq 1$ for $i \subseteq A$, where A denotes the subset of assets that cannot be sold short and A^c the complement set. That is, the returns on assets with no short-sale constraints satisfy the same equality first-order Euler conditions. Also, the inequality restriction for the rest might be strict since in equilibrium the investor may hold a zero amount in these assets. This is a typical example of the corner solution.

Of course, the system that consists of $E_t[M_{t,t+1}R^b_{t,t+1}] = 1$ and $E_t[M_{t,t+1}(R^i_{t,t+1} - R^b_{t,t+1})]$ = 0 is equivalent to the system consisting of conditions (21) and (22), since either set of moments is a linear combination of the others. But it should be noted that to apply GMM only to $E_t[M_{t,t+1}(R^i_{t,t+1} - R^b_{t,t+1})]$ = 0, as done by Hori (1997), is problematic because this treatment allows the right-hand side of each Euler equation to differ from one. That is, even if it is equal to some constant other than one, if and only if it is the same constant across all the Euler equations, is the relationship $E_t[M_{t,t+1}(R^i_{t,t+1} - R^b_{t,t+1})]$ = 0 satisfied.

III. Empirical Methodologies

A. GMM Tests of the Euler Equations

As emphasized by Cochrane (1996), GMM proposed by Hansen (1982) is particularly convenient when it comes to testing the dynamic properties of a stochastic discount factor model, that is, when assessing a model's ability to capture variation over time in expected rates of return.[18]

In this case, all one has to do is scale the period $t + 1$ returns by any variables that are presumed to be observable in period t. To see how it works, let me define an N-dimensional error vector $\mathbf{e}_{t+1}$ such that $E(\mathbf{e}_{t+1}|\mathbf{Z}_t) = 0$ from the moment conditions such as (21) and (22), where $\mathbf{Z}_t$ is the R-dimensional vector of instrumental variables. Next, let me define an $N \times R$-dimensional vector $\mathbf{g}_t$ such that $\mathbf{g}_t = \mathbf{e}_{t+1} \otimes \mathbf{Z}_t$, where $\otimes$ denotes the Kronecker product. By the law of iterated expectation, it follows that

$$E(\mathbf{g}_t) = E[E_t(\mathbf{g}_t)] = E[E_t(\mathbf{e}_{t+1} \otimes \mathbf{Z}_t)] = E[E_t(\mathbf{e}_{t+1}) \otimes \mathbf{Z}_t] = 0. \tag{23}$$

This is the orthogonality condition in GMM. Lastly, define the sample average of $\mathbf{g}_t$ as

$$\bar{\mathbf{g}}_T = \frac{1}{T}\sum_{t=1}^{T}\mathbf{g}_t. \tag{24}$$

Here, the GMM estimates $\hat{\theta}$ are obtained by

$$\hat{\theta} = \underset{\theta}{\mathrm{argmin}}\ \bar{\mathbf{g}}'_T\mathbf{W}_T\bar{\mathbf{g}}_T, \tag{25}$$

where $\mathbf{W}_T$ denotes a weight matrix. Hansen (1982) shows that if one chooses a consistent estimate of the covariance matrix of the sample pricing errors $\bar{\mathbf{g}}_T$ as $\mathbf{W}_T$, the GMM estimator is optimal or efficient in the sense that this variance matrix is the smallest of all the possible cases.

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18. For example, Hamilton (1994) explains this point as follows:

> People's behavior is often influenced by their expectations about the future. Unfortunately, however, we do not have direct information on these expectations. But, it is still possible to test behavioral models if people's expectations are formed rationally in the sense that the errors in forecasting are uncorrelated with information available at the time of the forecast. As long as the econometrician observes a subset of the information people have actually used, the rational expectations hypothesis suggests orthogonality conditions that can be used in the GMM framework.

In practice, however, for computational facility, let me start with an identity weight matrix, $\mathbf{W}_T = \mathbf{I}$, which forms the first-stage estimates. I use the first-stage estimates to form an estimate of the covariance matrix of the sample pricing errors denoted $\mathbf{S}_T$ and then use $\mathbf{S}_T^{-1}$ as the weight matrix for the second-stage estimates. I iterate this procedure, finding third- and fourth-stage estimates, and so on. This procedure does not change the asymptotic distribution theory. On the contrary, Ferson and Foerster (1994) find that it gives a better small-sample performance.

When the number of orthogonality conditions exceeds the number of parameters to be estimated, the model is overidentified in the sense that more orthogonality conditions are used than are needed for the estimation. In this regard, Hansen (1982) has shown that the minimized value of the quadratic form $\bar{\mathbf{g}}_T' \mathbf{W}_T \bar{\mathbf{g}}_T$ times the number of observations T, denoted the J_T-statistic, is χ^2 distributed under the null hypothesis that the model is properly specified with degrees of freedom equal to the number of orthogonality conditions net of the number of parameters to be estimated. In simple terms, the J_T-statistic tests whether the estimated error of an investor's forecast is uncorrelated with any instrumental variables in the information set available at the time of the forecast. A high value of this statistic indicates a high probability that the model is misspecified.[19]

Strictly speaking, the parameters to be estimated in the model are α and β in equation (13), but it turns out that when the data set described below is analyzed, a consistent estimate of the covariance matrix of the orthogonality conditions cannot be obtained since the matrix does not converge properly. Thus, I follow the estimation procedure proposed by Ferson and Constantinides (1991), who suggest that one parameter be estimated while the other is fixed at some plausible value. Fortunately, as mentioned earlier, α indicates the share of capital in the value added under the assumption of the Cobb-Douglas production function, hence one can get its estimate from the historical data. That is, one can compute it as one minus the labor share, which is conventionally calculated by the labor income divided by the value added. The sample mean value of labor share during the period from 1980 to 1996 is 0.52, so one can concentrate on estimating the value of β by setting the value of α at 0.48.

Although GMM is a standard testing method for estimating the Euler equations, the test results tend to be sensitive to the choice of instrumental variables. Hansen (1985) discusses how to select optimal instrumental variables, but his methodology is difficult to implement in practice.[20]

In this paper, I follow the usual *ad hoc* procedure of picking out a small list of instrumental variables. The following two sets of instrumental variables are used. The first one, denoted $\mathbf{Z}1$, includes a constant and one-lagged values of the investment-capital ratio, the output-capital stock ratio, and the weighted average of industry stock returns in excess of the government bond rate. The second one, denoted $\mathbf{Z}2$, includes a constant and two-lagged values of the same variables.

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19. Unfortunately, however, as shown by Newey (1985), Hansen's J_T-statistic can easily fail to detect a misspecified model. It is therefore often advisable to supplement this test with others.

20. One's first thought might be that, the more orthogonality conditions are used, the better the estimates might be. However, Monte Carlo simulations by Tauchen (1986) and Kocherlakota (1990) assert that one should be quite parsimonious in the selection of the conditioning information set.

In theory, components of $\mathbf{Z}1$ should be available at the beginning of the period, but due to time aggregation problems associated with the time-averaged investment and production data, in reality $\mathbf{Z}1$ might not be available to investors at that time. So in this paper, $\mathbf{Z}2$ is also used.

B. Hansen and Jagannathan's Volatility Bound Test [21]

1. Basic framework

Hansen and Jagannathan (1991) proposed a set of restrictions in terms of a volatility bound derived from equation (17). Let me review its basic framework. Consider the least squares projection of a stochastic discount factor M [22] onto the space spanned by a vector of asset returns $\mathbf{R}$ and a constant as

$$M = \tilde{\mathbf{R}}'\Theta_0 + \mu, \tag{26}$$

where $\tilde{\mathbf{R}}' = (1 \ \mathbf{R}')$ and $E[\tilde{\mathbf{R}}' \mu] = \mathbf{0}$. This implies that

$$\Theta_0 = \{E[\tilde{\mathbf{R}}\tilde{\mathbf{R}}']\}^{-1}E[\tilde{\mathbf{R}}M]. \tag{27}$$

If the second-moment matrix of the vector of asset returns, $E[\tilde{\mathbf{R}}\tilde{\mathbf{R}}']$, is denoted $\mathbf{M_R}$, then equation (27) can be rewritten as

$$\Theta_0 = \mathbf{M}_R^{-1}\begin{pmatrix} E[M] \\ \mathbf{1} \end{pmatrix}, \tag{28}$$

where $\mathbf{1}$ is a vector of ones conformable with $\mathbf{R}$.

Since μ is orthogonal to $\tilde{\mathbf{R}}$ by construction, and must have nonnegative variance, the following inequality holds:

$$\mathrm{Var}(M) \geq (\mathbf{1} - E[M]E[\mathbf{R}])'\sum_R^{-1}(\mathbf{1} - E[M]E[\mathbf{R}]), \tag{29}$$

where $\sum_R$ is the covariance matrix of $\mathbf{R}$.

An equivalent approach proposed by Cochrane and Hansen (1992) is to construct a bound on the second moment of M centered around zero. From the projection, it is clear that

$$E[M^2] \geq \Theta_0'E[\tilde{\mathbf{R}}'\tilde{\mathbf{R}}]\Theta_0 = (E[M] \ \mathbf{1}')\mathbf{M}_R^{-1}\begin{pmatrix} E[M] \\ \mathbf{1} \end{pmatrix}. \tag{30}$$

Here let me form the estimate:

$$\hat{\mathbf{M}}_R = \frac{1}{T}\sum_{t=1}^{T}\tilde{\mathbf{R}}_t\tilde{\mathbf{R}}_t', \tag{31}$$

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21. Craig (1994) provides an excellent survey on this topic. In what follows, basically I follow his explanation.
22. In this section, both M and M_t indicate $M_{t,t+1}$.

which allows the formation of an estimated bound such that

$$(E[M] \ \mathbf{1}')\hat{\mathbf{M}}_R^{-1}\begin{pmatrix} E[M] \\ \mathbf{1} \end{pmatrix}. \tag{32}$$

An informal test of a candidate stochastic discount factor involves checking whether a sample pair $(\bar{M} \ \hat{M}_m)$ lies above or below the estimated bound, where

$$\bar{M} = \frac{1}{T}\sum_{t=1}^{T} M_t \text{ and } \hat{M}_m = \frac{1}{T}\sum_{t=1}^{T} M_t^2. \tag{33}$$

Now define the vertical distance to the second-moment volatility bound as follows:

$$\varsigma = \hat{M}_m - (\bar{M} \ \mathbf{1}')\hat{\mathbf{M}}_R^{-1}\begin{pmatrix} \bar{M} \\ \mathbf{1} \end{pmatrix}. \tag{34}$$

Clearly, the population value of ς must be nonnegative.

Figure 1 plots both (1) the second-moment volatility bounds[23] computed by the actual data of the Japanese asset returns, and (2) sample pairs of $(\bar{M} \ \hat{M}_m)$ implied by the P-CAPM for given values of β. Evidently, any sample pair of $(\bar{M} \ \hat{M}_m)$ cannot satisfy the volatility bound, but the larger the parameter β becomes, the smaller the distance.[24] In this situation, statistical inference should play a role.

Figure 1 The Second-Moment Volatility Bound and the Pair of $\bar{M}$ and $\hat{M}_m$ Implied by the Japanese Data

Notes: 1. Two versions of the second-moment volatility bound are computed. One is derived from the bond return and 12 individual industry stock returns, and the other is from the bond return and the weighted average of these industry stock returns.
2. ◆ indicates the implied pair of the mean $\bar{M}$ and the second moment centered around zero $\hat{M}_m$ of the candidate stochastic discount factor calculated given each value of β.

23. For details of the data set used to construct volatility bounds, see Chapter IV.
24. Actually, I changed the value of β from zero to 10,000, but in any case this result still holds.

2. Statistical inference of the volatility bound test

In this paper, I conduct a statistical inference based on the volatility bound test. The purpose is to construct a statistical confidence region for the parameter ς. According to Cecchetti, Lam, and Mark (1994), two sources of uncertainty emanate when one makes a comparison between the mean standard deviation (or equivalently, second moment centered around zero) pairs on the volatility bound and the stochastic discount factor counterparts.

First, the computation of the mean standard deviation pair for each stochastic discount factor is influenced by the estimated sample moments of the investment process. Second, volatility bounds must be constructed from the asset return data. That is, both the moments of the stochastic discount factor and the volatility bound are data specific and sample dependent, which means that the test is influenced by measurement and sampling errors.

In what follows, let me briefly describe the method of the statistical inference originally proposed by Cochrane and Hansen (1992).[25] The sample distance measure $\hat{\varsigma}$ can be obtained using GMM. They showed that an exactly identified GMM framework which exploits the $k + 2$ moment conditions

$$E\left[\binom{M_t}{\mathbf{1}} - \mathbf{\bar{R}}_t\mathbf{\bar{R}}_t'\Theta\right] = 0, \tag{35}$$

and $\quad E[M_t^2 - (M_t \ \mathbf{1}')\Theta - \varsigma] = 0, \tag{36}$

can be used to obtain the estimate $\hat{\varsigma}$. These moment restrictions can be written in generic form as $E[f(\boldsymbol{x}_t, \boldsymbol{a})] = \mathbf{0}$, where $\boldsymbol{a}$ is the combined vector $\boldsymbol{a} = (\Theta' \ \varsigma)'$. In this case, the corresponding sample moments are given by

$$\mathbf{\bar{g}}_t(\boldsymbol{a}) = \begin{pmatrix} \dfrac{1}{T}\sum_{t=1}^{T}\left[\binom{M_t}{\mathbf{1}} - \mathbf{\bar{R}}_t\mathbf{\bar{R}}_t'\Theta\right] \\ \dfrac{1}{T}[M_t^2 - (M_t \ \mathbf{1}')\Theta - \varsigma] \end{pmatrix}. \tag{37}$$

Since the estimator is exactly identified, the sample moments can be set exactly to zero by the estimates

$$\hat{\Theta} = \left[\frac{1}{T}\sum_{t=1}^{T}\mathbf{\bar{R}}_t\mathbf{\bar{R}}_t'\right]^{-1}\frac{1}{T}\sum_{t=1}^{T}\binom{M_t}{\mathbf{1}} = \mathbf{\hat{M}}_R \ \bar{M}, \tag{38}$$

and $\quad \hat{\varsigma} = \dfrac{1}{T}\sum_{t=1}^{T}M_t^2 - \dfrac{1}{T}\sum_{t=1}^{T}(M_t \ \mathbf{1}')\hat{\Theta} = \hat{M}_m - \bar{M}'\hat{\Theta}. \tag{39}$

The asymptotic covariance matrix of the vector $\sqrt{T}(\hat{\boldsymbol{a}} - \boldsymbol{a}_0)$ is given by

$$\mathbf{Var}(\hat{\boldsymbol{a}}) = [\mathbf{D}_0{}'\mathbf{S}_0^{-1}\mathbf{D}_0]^{-1}, \tag{40}$$

where $\mathbf{S}_0 = \sum_{i=-\infty}^{\infty} E[f(\boldsymbol{x}_i, \boldsymbol{a}_0)f(\boldsymbol{x}_i, \boldsymbol{a}_0)']$ and $\mathbf{D}_0 = E[\partial f(\boldsymbol{x}_i, \boldsymbol{a}_0)/\partial \boldsymbol{a}]$.[26] These quantities are estimated by $\widehat{\mathbf{Var}}(\hat{\boldsymbol{a}}) = [\mathbf{D}_T{}'\mathbf{S}_T^{-1}\mathbf{D}_T]^{-1}$, where

$$\mathbf{S}_T = \frac{1}{T}\sum_{t=1}^{T}f(\boldsymbol{x}_t, \hat{\boldsymbol{a}})f(\boldsymbol{x}_t, \hat{\boldsymbol{a}})' + \sum_{i=1}^{n}\left[1 - \frac{i}{n+1}\right]$$

$$\times\left[\frac{1}{T}\sum_{t=1+i}^{T}f(\boldsymbol{x}_t, \hat{\boldsymbol{a}})f(\boldsymbol{x}_{t-i}, \hat{\boldsymbol{a}})' + \frac{1}{T}\sum_{t=1}^{T-i}f(\boldsymbol{x}_t, \hat{\boldsymbol{a}})f(\boldsymbol{x}_{t+i}, \hat{\boldsymbol{a}})'\right], \tag{41}$$

and $\quad \mathbf{D}_T = \dfrac{1}{T}\sum_{t=1}^{T}\dfrac{\partial f(\boldsymbol{x}_t, \hat{\boldsymbol{a}})}{\partial \boldsymbol{a}}. \tag{42}$

This method is due to Newey and West (1987). $n = 4$ is used throughout the paper. Finally, the statistic Z[27] is given by

$$Z = \sqrt{T}\frac{\hat{\varsigma}}{[\widehat{\mathbf{Var}}(\hat{\boldsymbol{a}})_{k+2,k+2}]^{\frac{1}{2}}}, \tag{43}$$

where $\widehat{\mathbf{Var}}(\hat{\boldsymbol{a}})_{k+2,k+2}$ corresponds to the variance of $\hat{\varsigma}$. Under the null hypothesis of $\varsigma = 0$, the statistic Z follows the property of $Z \xrightarrow{d} N(0, 1)$, given the properties of the GMM estimators.

C. Estimation of Mispricing Coefficients

The next econometric methodology is an informal version of the diagnostic test used in Ferson and Constantinides (1991). To gauge the implication of the P-CAPM for the Japanese equity premium and risk-free rate puzzles, let me add parameters η^i to the asset-pricing Euler equations:

$$E_t[M_{t,t+1}(R_{t,t+1}^b + \eta^b)] = 1 \text{ for the bond return}, \tag{44}$$

and $\quad E_t[M_{t,t+1}(R_{t,t+1}^i + \eta^i)] = 1$ for the i-th stock return $(i = 1, 2, \ldots n)$, (45)

where each η can be interpreted as a mispricing coefficient or a pricing error similar to Jensen's alpha.[28] Using the same set of assets as before, the restrictions imposed by equations (44) and (45) are tested via GMM given the value of the adjustment cost parameter β. Since the system is exactly identified, the sample moments can be set

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26. χ_t denotes the data.
27. Cochrane and Hansen (1992) proposed a second optimal test statistic that is designed to minimize the sampling error involved in measuring distance to the bound. But Craig (1994) shows that Cochrane and Hansen's statistic and the statistic Z in this paper lead to identical probability values.
28. Bakshi and Naka (1997) use this method to compare the pricing performance of several types of C-CAPM specifications.

exactly at zero. The asymptotic covariance of the parameters ηs is given by Newey and West's (1987) method as in the preceding section.

It is easier to understand the role of those parameters in detecting the puzzles if the system consisting equations (44) and (45) can be restated as

$$E_t[M_{t,t+1}(R^b_{t,t+1} + \eta^b)] = 1, \tag{46}$$

and

$$E_t[M_{t,t+1}(R^i_{t,t+1} - R^b_{t,t+1} + \varphi^i)] = 0, \tag{47}$$

where $\varphi^i = \eta^i - \eta^b$.

If φ^is are found to be significantly negative given the value of β, then it implies that the representative agent can gain at the margin by borrowing at the government bond rate and then investing in stocks. This is the so-called equity premium puzzle. Similarly, if η^b is found to be significantly positive, then it implies that the representative agent can gain at the margin by transferring consumption from the future to the present (that is, reducing his or her savings rate). This is the so-called risk-free rate puzzle. One can employ a *t*-statistic computed from the parameter values and standard deviations derived from the GMM estimation of the system consisting of equations (46) and (47).

D. Testing the Ability of Stock and Investment Returns to Forecast Future Economic Activity

Among others, Cox, Ingersoll, and Ross (1985), Lucas (1978), and Brock (1982) have modeled the relationship between stock returns and real economic activity as a function of production technology. A typical intuition behind it is that a negative productivity shock induces a fall in output and consumption, which results in an increase in the market risk premium. These technology shocks get propagated over time via the consumers' willingness to intertemporally smooth their consumption profiles. Due to the lumpiness of investment expenditures and the presence of the adjustment costs, however, investment tends to be more volatile than output.

Also, Chen (1991) points out that since financial assets are claims to future real output, changes in real economic activity will also cause the financial opportunity set to change. Since the discount rate that prices cash flows is likely to be correlated with stock market risk premiums, such variables as GDP and investment ought to be predictable using stock returns. Motivated by these arguments, I check whether stock and investment returns can forecast future economic activity by the usual regression model.

IV. Data Set

A. Sample Period and Industry Classification

The data set includes the variables described below for 12 manufacturing industries covering the period between 1980/I and 1997/I due to the availability of the data. This period covers noteworthy episodes of the "bubble" economy from the mid-1980s to the early 1990s and the post-"bubble" economic sluggishness.

Concerning the industries, let me concentrate on the following 12 manufacturing industries: textiles; pulp, paper, and paper products; chemicals; petroleum and coal products; nonmetallic mineral products; iron and steel; nonferrous metals and products; fabricated metal products; general machinery; electric machinery; transportation equipment; and precision instruments. The reasons for this choice are that (1) there was large-scale privatization in some non-manufacturing industries so that there are big jumps in the investment and production data in these industries, and (2) there are no quarterly data on the operating ratio and production for the food industry in manufacturing and non-manufacturing industries.

Table 1 reports the capitalization weight of each industry in the stock market. Evidently, electric machinery, transportation equipment, and chemicals have a remarkable share in the Japanese stock market.

Table 1 Industry Portfolio

Portfolio	Industry	Capitalization weight (percent)	
		1980/I	1997/I
E1	Textiles	4.83	3.66
E2	Pulp, paper, and paper products	1.87	1.46
E3	Chemicals	16.41	18.54
E4	Petroleum and coal products	7.19	2.17
E5	Nonmetallic mineral products	3.83	3.11
E6	Iron and steel	9.91	5.76
E7	Nonferrous metals and products	3.83	3.14
E8	Fabricated metal products	1.35	2.17
E9	General machinery	9.90	9.10
E10	Electric machinery	23.01	30.57
E11	Transportation equipment	15.24	18.30
E12	Precision instruments	2.61	2.02
TOTAL	Weighted average	100.00	100.00

Note: The capitalization weights are computed from the NIKKO Stock Performance Index (NIKKO SPI) issued by Nikko Securities Co., Ltd. It covers all the firms listed on the Tokyo, Osaka, and Nagoya stock exchanges, and the over-the-counter (OTC) market. It is adjusted for cross-shareholdings by *keiretsu* firm group.

B. Data Description
1. Investment, capital stock, and depreciation rate
The data on investment and capital stock are taken from *Gross Capital Stock of Private Enterprises* issued by the Economic Planning Agency (EPA). They cover all enterprises in the above-mentioned 12 manufacturing industries, which consist of both incorporated and unincorporated businesses. Both the investment and capital stock data include nonresidential buildings, structures, machinery, transportation equipment, and instruments and tools, but they do not cover land and inventories. They are expressed in real terms at 1990 market prices. In computing the investment-capital ratio (I/K), I use the total values of investment and capital stock across 12 industries instead of using individual industry data. This is

because the stochastic discount factor $M_{t,t+1}$ is assumed to be common in asset markets so that it is more suitable if it reflects the variation in the investment return in a macro sense.

On the other hand, the mean value of the depreciation rate[29] for these industries is about 1.07 percent on a quarterly basis. However, its depreciation value is estimated using the method of diminishing balance depreciation instead of straight-line depreciation. It is often said that the former method overestimates the value of depreciation. Also, to be exact, it is a gross rate of depreciation, because it includes the acquisition of the secondhand goods. Taking into account these points, I use an *ad hoc* constant quarterly depreciation rate of 0.7 percent[30] instead of the estimated 1.07 percent.

2. Output and operating ratio

Preceding studies including Hori (1996) and Bakshi, Chen, and Naka (1995) use GDP or GNP as output data.[31] The problem here is that individual industry data can be obtained only on an annual basis. One alternative is industrial production data[32] reported by the Ministry of International Trade and Industry (MITI). This is not a value, but an index series, hence I use it to capture fluctuations in output and tie its level to the 1996 value of real industry GDP.[33]

Further, I believe that one should adjust capital stock for the corresponding operating ratio when one evaluates the marginal productivity of capital because the operating ratio reflects the business cycle much more than capital stock itself. Hence, I multiply capital stock by the corresponding operating ratio divided by 100 (since it is an index that is standardized at 100 in 1995) in computing the marginal productivity of capital. The data of the operating ratio are issued by MITI and available from the Nikkei NEEDS tape.

3. Industry stock and government bond period returns

In this paper, I use the NIKKO Stock Performance Index (NIKKO SPI) issued by Nikko Securities Co., Ltd. It is a stock performance index weighted by market capitalization value. In order to maintain continuity, individual rates of return are adjusted for dividends and rights issues. Also, the NIKKO SPI has two types of indices, a cross-shareholding adjusted index and an unadjusted index. The crossholding of shares among publicly traded companies is one of the essential characteristics of the Japanese stock market, which results in inflated market capitalization figures by means of double counting. That is why I use the cross-shareholding adjusted series. In terms of the coverage, it reflects all the stock returns of the firms that are listed on the Tokyo, Osaka, and Nagoya stock exchanges as well as the OTC market.

For the bond return, I use the rate of return on the 10-year Japanese government bond. It is taken from various issues of *Economic Statistics Monthly* published by the

29. These data are also available in *Gross Capital Stock of Private Enterprises* issued by the EPA.
30. For example, in the case of the 10-year depreciation period, at the end of the fifth year, the accumulated value of depreciation by the diminishing balance depreciation is about 1.54 times larger than the corresponding value by the straight-line depreciation method. Thus, the mean value of the depreciation rate in the case of the diminishing balance depreciation (1.07 percent) divided by 1.54 is equal to about 0.7 percent.
31. Hori (1997) estimates quarterly industry GDP under the assumption that the seasonal fluctuation of GDP in each industry is the same as that in total GDP.
32. These are value-added data in real terms, taken from the Nikkei NEEDS tape.
33. As the formula of the investment return suggests, the output-capital ratio is important in determining the mean value of the investment return. Hence this adjustment is essential.

Bank of Japan.[34] Similarly to Cochrane (1996),[35] I follow the method of Fama and Gibbons (1982, 1984) to construct an expected inflation series.[36]

C. Coping with Seasonality, Trading-Day Effects, and Trends
1. Seasonality and trading-day effects
In this paper, every datum is adjusted for seasonality and trading-day effects by the program named "Decomp," whose main idea was originally developed by Kitagawa and Gersch (1984). "Decomp" can be accessed on the Ministry of Education's Institute of Statistical Mathematics web site.[37] By this method, one can decompose any time-series data into not only trend, seasonal, and autoregressive (AR) components, but also into the component of trading-day effects, which cannot be estimated by other methods like X-11 despite the fact that it is sometimes an important component, particularly in the case of stock returns.[38]

2. Linear trend
One of the maintained assumptions of GMM is that all the observable variables are strictly stationary. Hence, if the raw data appear to be trending over time,[39] one needs to take necessary steps to remove the trend. In this paper, I remove the linear trend from every variable while preserving its mean value.

D. Properties of the Data
1. Summary statistics
Table 2 [1] on the following page reports summary statistics of the data set, which is adjusted for seasonality, trading-day effects, and linear trends (preserving mean values). All asset returns are in real terms. As can readily be expected, the mean value of every stock return is higher than that of the government bond return and the standard deviation (S.D.) of any stock return is much higher than that of the government bond return. Also, the output-capital stock ratio Y/K has a larger mean value and a lower standard deviation than the investment-capital stock ratio I/K.

The sixth and seventh columns in Table 2 [1] report skewness and excess kurtosis (Ex-Kurt). The estimation result shows that skewness for quarterly Japanese asset returns tends to be negative, and kurtosis tends to be positive, indicating that returns have more mass in the tail areas than would be predicted by a normal distribution. This result shows that Japanese asset returns have almost the same characteristics as U.S. returns in this regard.[40] In contrast, skewness of both the investment-capital stock ratio I/K and the output-capital stock ratio Y/K is positive and their kurtosis is negative.

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34. I also tried the collateralized overnight call rate, but estimation results are very similar to those in the case of the return on the government bond.
35. Although it is not an application of the P-CAPM, Chen, Roll, and Ross (1986) also use this formula of the expected inflation series.
36. As for the moving average parameter λ (MA[1]) in the difference between the real interest rates for time $t + 1$ and t, I use the value $\lambda = 0.5$.
37. We can access "Decomp" at http://ssnt.ism.ac.jp/inets/inets_eng.html.
38. For example, two early studies (French [1980] and Gibbons and Hess [1981]) found that the return on Monday was quite different from those on other days in the United States.
39. It turns out that the investment-capital ratios and the government bond rate, in particular, have deterministic trends that are statistically significant.
40. For a detailed analysis of the U.S. asset returns, see Campbell, Lo, and MacKinlay (1997).

Table 2 Properties of the Data Set (1980/I–1997/I)

[1] Summary Statistics

	Mean	S.D.	Min	Max	Skewness	Ex-Kurt	$\rho(1)$	$\rho(4)$	$\rho(8)$	$Q(1)$	$Q(4)$	$Q(8)$
TOTAL	1.0211	0.0984	0.6764	1.2194	−0.5570	1.1835	−0.0960	−0.1542	−0.0910	0.66 [0.417]	2.41 [0.661]	5.65 [0.686]
E1	1.0168	0.1029	0.6995	1.2072	−0.6027	0.3089	−0.1028	−0.1337	0.1278	0.74 [0.390]	1.98 [0.739]	3.50 [0.899]
E2	1.0164	0.1049	0.7856	1.2465	0.0436	−0.5867	0.0435	−0.0337	−0.2220	0.13 [0.718]	2.77 [0.597]	7.31 [0.504]
E3	1.0191	0.0956	0.6889	1.1782	−0.7265	1.1281	−0.1661	−0.1856	−0.0749	1.95 [0.163]	4.88 [0.300]	6.68 [0.572]
E4	1.0109	0.1292	0.6069	1.1905	−0.9002	0.7097	−0.1777	−0.1077	−0.0396	2.15 [0.143]	3.29 [0.511]	5.10 [0.747]
E5	1.0168	0.1032	0.6256	1.2008	−1.0072	2.0023	−0.0688	−0.0950	−0.0350	0.33 [0.566]	1.09 [0.896]	3.01 [0.934]
E6	1.0218	0.1437	0.6628	1.4658	0.4596	1.5233	0.0311	−0.0597	−0.1129	0.07 [0.791]	7.03 [0.134]	8.28 [0.407]
E7	1.0209	0.1120	0.6840	1.2730	−0.5680	0.8947	−0.1296	−0.1143	−0.0390	1.20 [0.273]	2.52 [0.641]	3.03 [0.932]
E8	1.0188	0.0976	0.7241	1.1920	−0.2967	−0.0714	0.1095	−0.1321	−0.0047	0.81 [0.368]	3.76 [0.439]	7.04 [0.532]
E9	1.0163	0.1120	0.6329	1.2979	−0.2334	1.0169	−0.0628	−0.0891	−0.0237	0.28 [0.597]	0.78 [0.941]	4.60 [0.799]
E10	1.0237	0.1236	0.6955	1.3289	−0.1145	0.1616	−0.0954	−0.1543	−0.0741	0.64 [0.424]	2.49 [0.602]	6.25 [0.619]
E11	1.0226	0.1121	0.6735	1.3325	0.0707	1.2582	−0.0904	−0.0966	−0.0709	0.58 [0.446]	1.96 [0.743]	5.84 [0.665]
E12	1.0234	0.1238	0.6335	1.2441	−0.4235	0.4666	−0.0906	−0.1518	−0.0806	0.59 [0.442]	2.20 [0.699]	6.70 [0.569]
BOND	1.0100	0.0078	0.9855	1.0254	−0.9631	1.5376	−0.0238	−0.0546	−0.1146	0.04 [0.841]	4.52 [0.340]	7.21 [0.514]
I/K	0.0238	0.0035	0.0184	0.0321	0.7820	−0.1983	0.9714	−0.0806	−0.2699	67.2 [0.000]	210 [0.000]	257 [0.000]
Y/K	0.0514	0.0009	0.0495	0.0532	0.1541	−0.6637	0.6104	−0.1507	−0.1328	26.5 [0.000]	64.3 [0.000]	74.1 [0.000]

Notes: 1. TOTAL is the weighted average of 12 industry real returns (E1–E12). BOND is the real return on the 10-year Japanese government bond. I/K is the ratio of investment to capital stock. Y/K is the ratio of output to capital stock, which is adjusted for the corresponding operating ratio. All variables are adjusted for seasonality and trading-day effects by the web-based program "Decomp."
2. ρ(L) is the partial-autocorrelation coefficient and Q(L) is Ljung and Box's (1979) Q-statistic at lag length of L. The Q(L) statistic is distributed χ^2(L) under the null hypothesis of no serial correlation. The p-values are reported in brackets.

[2] Correlation Matrix

	TOTAL	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	BOND	I/K	Y/K
TOTAL	1.0000															
E1	0.7892	1.0000														
E2	0.6889	0.7066	1.0000													
E3	0.8746	0.8470	0.6726	1.0000												
E4	0.6375	0.7233	0.6837	0.7425	1.0000											
E5	0.9080	0.8576	0.7787	0.8990	0.7386	1.0000										
E6	0.7068	0.7836	0.6918	0.5820	0.5295	0.7082	1.0000									
E7	0.8252	0.8243	0.6908	0.7705	0.7587	0.8383	0.6920	1.0000								
E8	0.7365	0.6727	0.7278	0.7584	0.6616	0.7988	0.4855	0.6180	1.0000							
E9	0.9152	0.7791	0.7357	0.8083	0.6507	0.8700	0.6723	0.7843	0.8234	1.0000						
E10	0.8867	0.4785	0.4278	0.6665	0.3595	0.6937	0.4149	0.6026	0.5619	0.7503	1.0000					
E11	0.8912	0.6623	0.5656	0.6859	0.4507	0.7567	0.7120	0.7049	0.5629	0.7626	0.7772	1.0000				
E12	0.8782	0.5164	0.4572	0.6752	0.3985	0.7161	0.4392	0.6059	0.6153	0.8029	0.9254	0.7355	1.0000			
BOND	0.0132	0.1468	0.1589	0.0957	0.0304	0.0729	0.0928	0.0814	0.0149	0.0213	−0.0090	0.0692	−0.1258	1.0000		
I/K	−0.1925	−0.1536	−0.1872	−0.1544	0.0101	−0.1359	−0.1625	−0.1987	0.0192	−0.0879	−0.2045	−0.1688	−0.1582	−0.0169	1.0000	
Y/K	0.2133	0.1579	0.1421	0.1563	0.1055	0.1442	0.2113	0.1862	0.1938	0.2830	0.1661	0.2330	0.1696	−0.0760	−0.0058	1.0000

Note: TOTAL is the weighted average of 12 industry real returns (E1–E12). BOND is the real return on the 10-year Japanese government bond. I/K is the ratio of investment to capital stock. Y/K is the ratio of output to capital stock, which is adjusted for the corresponding operating ratio. All variables are adjusted for seasonality and trading-day effects by the web-based program "Decomp."

In addition, to investigate the autocorrelation pattern of the data set, Table 2 [1] also reports the partial-autocorrelation coefficient and Ljung and Box's (1979) Q-statistic. The estimation result suggests that the investment-capital stock ratio I/K and the output-capital stock ratio Y/K are significantly serially correlated for all patterns of lags. On the other hand, the stock returns and the bond return are not found to be significantly serially correlated, which suggests that there are no significant predictable components in Japanese asset returns as far as this period is concerned.

2. Correlation matrix

Table 2 [2] reports coefficients of correlation between these variables. It shows that there is a very high positive correlation between the various stock returns themselves, and between the stock returns and the output-capital stock ratio Y/K, which is a source of the variation in the marginal productivity of capital under the assumption of the Cobb-Douglas production function. On the other hand, there is a negative correlation between the stock returns and the investment-capital stock ratio I/K, which captures the growth rate of capital stock. However, the bond return does not seem to be highly correlated with any indices of the stock returns, the investment-capital stock ratio I/K, and the output-capital stock ratio Y/K.

V. Empirical Results

A. GMM Test of the Euler Equation and the Corresponding Volatility Bound Test

Table 3 [1] and [2] reports estimation results of the coefficient β of the adjustment cost function by GMM and the statistical inference of the corresponding volatility bound test, which is based on the vertical distance between the raw second-moment volatility bound calculated from actual asset return data and the implied value of the second-moment $\hat{M}_m$ for the given value of β.

Table 3 The GMM Estimation Results of the Euler Equations and the Corresponding Volatility Bound Tests (1980/III–1997/I)

$E_t [M_{t,t+1} R_{t,t+1}^b] = 1$ for the bond return,

and $E_t [M_{t,t+1} R_{t,t+1}^i] = 1$ for the i-th stock return ($i = 1, 2, \ldots n$),

where $M_{t,t+1}$ is the stochastic discount factor characterized by the investment return, $R_{t,t+1}^b$ is the real return on the government bond, and $R_{t,t+1}^i$ is the i-th industry's real stock return.

[1] Estimation Results Based on All Asset Returns

System	Information set	β	J_T	DF	Implied value of		Volatility bound test (ς)	
					$\bar{M}$	$\hat{M}_m$	Portfolio A	Portfolio B
(1-1) BOND and TOTAL	Z1	13.400 (1.983) [0.047]	9.879 [0.196]	7	0.986	0.971	−0.331 (−0.443) [0.173]	−0.448 (−1.007) [0.142]
(1-2) BOND and TOTAL	Z2	8.838 (2.064) [0.039]	10.165 [0.179]	7	0.985	0.970	−0.479 (−1.445) [0.074]	−0.620 (−1.527) [0.063]
(2-1) BOND and E1–E12	Z1	15.349 (14.234) [0.000]	14.126 [0.999]	51	0.986	0.972	−0.282 (−0.805) [0.210]	−0.391 (−0.943) [0.173]
(2-2) BOND and E1–E12	Z2	11.257 (21.219) [0.000]	14.103 [0.999]	51	0.985	0.971	−0.394 (−1.140) [0.127]	−0.521 (−1.253) [0.105]

Notes: 1. Estimation of the Euler equations is based on Hansen's (1982) generalized method of moments (GMM). The information set **Z**1 contains one-period-lagged each of the return on the weighted average of 12 industry returns in excess of the bond rate, *I/K*, and *Y/K*, as well as a constant, while **Z**2 contains the same variables as in **Z**1, but lagged twice. The *t*-values on β and the Z-values on ς are reported in parentheses, which are calculated based on standard errors corrected by White's (1980) and Newey and West's (1987) methods (a lag length of 4 is used). The corresponding *p*-values (in two-tail tests for β and in one-tail tests for ς) are reported in brackets. The *J_T*-statistic tests whether the overidentifying restrictions of the model are consistent with the data. It is distributed χ^2 with the degrees of freedom denoted DF.
2. $\bar{M}$ is the sample mean of the stochastic discount factor implied by the estimated value of β, and $\hat{M}_m$ is the sample second moment of the stochastic discount factor centered around zero. The volatility bound test is based on the vertical distance between the implied value of $\hat{M}_m$ and the raw second-moment volatility bound computed using two portfolios A and B. Portfolio A consists of the bond and the weighted average of 12 industry stock returns and Portfolio B consists of the bond and 12 individual industry stock returns.

[2] Estimation Results Based on the Bond Return and Each Industry Stock Return

System	Information set	β	J_T	DF	Implied value of		Volatility bound test (ς)	
					$\bar{M}$	$\hat{M}_m$	Portfolio A	Portfolio B
(3-1) BOND and E1	Z1	11.682 (1.959) [0.050]	10.097 [0.183]	7	0.985	0.971	−0.381 (−1.097) [0.136]	−0.506 (−1.213) [0.113]
(3-2) BOND and E1	Z2	7.859 (1.979) [0.048]	9.480 [0.220]	7	0.985	0.969	−0.517 (−1.605) [0.054]	−0.666 (−1.666) [0.048]
(4-1) BOND and E2	Z1	15.110 (2.058) [0.040]	9.667 [0.208]	7	0.986	0.972	−0.288 (−0.820) [0.206]	−0.397 (−0.957) [0.169]
(4-2) BOND and E2	Z2	9.607 (1.924) [0.054]	9.039 [0.250]	7	0.985	0.970	−0.450 (−1.336) [0.091]	−0.587 (−1.431) [0.076]
(5-1) BOND and E3	Z1	12.374 (1.915) [0.055]	8.965 [0.255]	7	0.985	0.971	−0.360 (−1.031) [0.151]	−0.481 (−1.153) [0.125]
(5-2) BOND and E3	Z2	8.586 (1.914) [0.056]	9.821 [0.199]	7	0.985	0.970	−0.488 (−1.484) [0.069]	−0.632 (−1.561) [0.059]
(6-1) BOND and E4	Z1	13.304 (2.272) [0.023]	7.017 [0.427]	7	0.986	0.972	−0.334 (−0.951) [0.171]	−0.451 (−1.079) [0.140]
(6-2) BOND and E4	Z2	8.514 (2.498) [0.012]	8.163 [0.318]	7	0.985	0.970	−0.491 (−1.495) [0.067]	−0.635 (−1.571) [0.058]
(7-1) BOND and E5	Z1	11.761 (1.913) [0.056]	9.348 [0.229]	7	0.985	0.971	−0.378 (−1.089) [0.138]	−0.503 (−1.206) [0.114]
(7-2) BOND and E5	Z2	7.226 (1.893) [0.058]	9.928 [0.193]	7	0.984	0.969	−0.545 (−1.722) [0.043]	−0.698 (−1.765) [0.039]
(8-1) BOND and E6	Z1	12.034 (2.120) [0.034]	9.053 [0.249]	7	0.985	0.971	−0.370 (−1.062) [0.144]	−0.493 (−1.182) [0.118]
(8-2) BOND and E7	Z2	9.571 (2.048) [0.041]	8.978 [0.254]	7	0.985	0.970	−0.451 (−1.341) [0.090]	−0.588 (−1.435) [0.076]
(9-1) BOND and E7	Z1	15.906 (1.907) [0.057]	10.116 [0.182]	7	0.986	0.972	−0.270 (−0.771) [0.220]	−0.376 (−0.911) [0.181]
(9-2) BOND and E7	Z2	9.536 (2.191) [0.028]	9.922 [0.193]	7	0.985	0.970	−0.453 (−1.346) [0.089]	−0.590 (−1.439) [0.075]
(10-1) BOND and E8	Z1	12.664 (2.090) [0.037]	6.626 [0.469]	7	0.985	0.971	−0.352 (−1.005) [0.157]	−0.472 (−1.129) [0.130]
(10-2) BOND and E8	Z2	8.062 (2.041) [0.041]	8.442 [0.295]	7	0.985	0.970	−0.509 (−1.570) [0.058]	−0.656 (−1.636) [0.051]
(11-1) BOND and E9	Z1	13.803 (2.281) [0.023]	7.938 [0.338]	7	0.986	0.972	−0.321 (−0.912) [0.181]	−0.435 (−1.043) [0.149]
(11-2) BOND and E9	Z2	9.381 (2.165) [0.030]	8.754 [0.271]	7	0.985	0.970	−0.458 (−1.367) [0.086]	−0.597 (−1.458) [0.072]

[Continued]

System	Information set	β	J_T	DF	Implied value of		Volatility bound test (ς)	
					$\bar{M}$	$\hat{M}_m$	Portfolio A	Portfolio B
(12-1) BOND and E10	**Z**1	13.527 (1.996) [0.046]	10.485 [0.163]	7	0.986	0.971	−0.328 (−0.933) [0.175]	−0.444 (−1.062) [0.144]
(12-2) BOND and E10	**Z**2	9.474 (2.106) [0.035]	10.427 [0.166]	7	0.985	0.970	−0.455 (−1.354) [0.088]	−0.593 (−1.447) [0.074]
(13-1) BOND and E11	**Z**1	14.184 (1.907) [0.057]	8.553 [0.286]	7	0.986	0.972	−0.311 (−0.884) [0.188]	−0.424 (−1.016) [0.155]
(13-2) BOND and E11	**Z**2	8.300 (2.022) [0.043]	9.893 [0.195]	7	0.985	0.970	−0.500 (−1.530) [0.063]	−0.645 (−1.601) [0.055]
(14-1) BOND and E12	**Z**1	10.099 (2.127) [0.033]	9.477 [0.220]	7	0.985	0.970	−0.433 (−1.273) [0.102]	−0.566 (−1.374) [0.085]
(14-2) BOND and E12	**Z**2	9.442 (2.293) [0.022]	9.227 [0.237]	7	0.985	0.970	−0.456 (−1.359) [0.087]	−0.594 (−1.451) [0.073]

Notes: 1. Estimation of the Euler equations is based on Hansen's (1982) generalized method of moments (GMM). The information set **Z**1 contains one-period-lagged each of the return on the weighted average of 12 industry returns in excess of the bond rate, I/K, and Y/K, as well as a constant, while **Z**2 contains the same variables as in **Z**1, but lagged twice. The *t*-values on β and the Z-values on ς are reported in parentheses, which are calculated based on standard errors corrected by White's (1980) and Newey and West's (1987) methods (a lag length of 4 is used). The corresponding *p*-values (in two-tail tests for β and in one-tail tests for ς) are reported in brackets. The J_T-statistic tests whether the overidentifying restrictions of the model are consistent with the data. It is distributed χ^2 with the degrees of freedom denoted DF.
2. $\bar{M}$ is the sample mean of the stochastic discount factor implied by the estimated value of β, and $\hat{M}_m$ is the sample second moment of the stochastic discount factor centered around zero. The volatility bound test is based on the vertical distance between the implied value of $\hat{M}_m$ and the raw second-moment volatility bound computed using two portfolios A and B. Portfolio A consists of the bond and the weighted average of 12 industry stock returns and Portfolio B consists of the bond and 12 individual industry stock returns.

Table 3 [1] shows the result when all asset returns including the bond return and every stock return are used in estimation, and Table 3 [2] reports the result when the bond return and the individual industry stock returns are used in estimation. The GMM test results here seem to provide a more convincing piece of evidence for the P-CAPM than in previous studies such as Hori (1997). The significantly positive value of the estimated β implies that the stochastic discount factor is time-varying, since β determines the variation in the investment return to a large extent.

Now, let me look at Table 3 [1] in detail. The *p*-values associated with the J_T-statistics of the overidentifying restrictions test suggest that the model cannot be rejected at the 5 percent significance level in any specification. Estimated values of β differ from 8.838 in the case of system (1-2) to 15.349 in the case of system (2-1), but all the estimated β are significant at the 5 percent level. There is a tendency to have a larger value of β when 13 (bond plus 12 stock returns) asset returns are included and/or **Z**1 is used as the information set. Now that all the estimation results are satisfactory in terms of the GMM test, let me proceed to the next stage: that is, the determination of whether the degree of variation in the stochastic discount factor is enough to satisfy the volatility bound test.

The last two columns of Table 3 [1] report the results of the vertical distance of the volatility bound test and its statistical inference. The vertical distance varies from −0.282 (system [2-1]) to −0.479 (system [1-2]) when portfolio A consisting of the

bond and the weighted average of 12 industry stock returns is used to construct the unconditional second-moment bound, and from –0.391 (system [2-1]) to –0.620 (system [1-2]) when portfolio B consisting of the bond and 12 individual stock returns is used. The one-sided test shows that, in any case, the null hypothesis that the vertical distance is zero cannot be rejected at the 5 percent significance level. Thus, one can conclude that the values of β estimated by GMM are consistent with Hansen and Jagannathan's volatility bound test.

Next, let me move on to Table 3 [2], which is meant to compare the estimated coefficient of β across the subset of returns. The estimated β ranges from 10.099 (system [14-1]) to 15.906 (system [9-1])[41] when $\mathbf{Z}$1 is used as the information set and from 7.226 (system [7-2]) to 9.607 (system [4-2])[42] when $\mathbf{Z}$2 is used. This similarity of the values of the estimated β across the subset of asset returns, particularly in the case in which $\mathbf{Z}$2 is used as the information set, can be inferred from the high correlation between the 12 stock returns. Similarly to the results of Table 3 [1], the p-values associated with the J_T-statistics of the overidentifying restrictions test suggest that the model cannot be rejected at the 5 percent significance level in any case. Also, except for a few cases, the null hypothesis that the vertical distance between the second-moment bound and the implied pair of $\bar{M}$ and M_m is zero cannot be rejected at the 5 percent significance level.

B. Estimation of Mispricing Coefficients

Table 4 reports the mispricing coefficients estimated using the unconditional version of GMM since the system is exactly identified. According to the result, when the values of β estimated using $\mathbf{Z}$1 as the information set are used,[43] mispricing coefficients of all asset returns are not found to be significantly different from zero, which implies that both risk-free rate and equity premium puzzles do not occur.

When the values of β estimated using $\mathbf{Z}$2 as the information set are used,[44] however, the mispricing coefficient of the bond return is found to differ from zero at the 5 percent significance level, while those of stock returns are still not found to differ from zero. This result implies that the stochastic discount factor derived from the investment return tends to over-discount the payoff from the bond.

....

41. System (14-1) includes the returns on the bond and the portfolio of the precision instruments industry, while system (9-1) includes the returns on the bond and the portfolio of the nonferrous metals and products industry.
42. System (7-2) includes the returns on the bond and the portfolio of the nonmetallic mineral industry, while system (4-2) includes the returns on the bond and the portfolio of the pulp, paper, and paper products industry.
43. This corresponds to systems (1-1) and (2-1).
44. This corresponds to systems (1-2) and (2-2).

Table 4 Estimation of Mispricing Coefficients (1980/III–1997/I)

$$E_t[M_{t,t+1}(R_{t,t+1}^b + \eta^b)] = 1 \qquad \text{for the bond return,}$$

and $\quad E_t[M_{t,t+1}(R_{t,t+1}^i - R_{t,t+1}^b + \varphi^i)] = 0$ for the *i*-th stock return $(i = 1, 2, \ldots n)$,

where $\varphi^i = \eta^i - \eta^b$.

Mispricing coefficient	BOND and TOTAL		BOND and E1–E12	
	(1-1) β = 13.400	(1-2) β = 8.838	(2-1) β = 15.349	(2-2) β = 11.257
η^{BOND}	0.398E-02 (1.779) [0.075]	0.480E-02 (2.728) [0.006]	0.367E-02 (1.515) [0.130]	0.435E-02 (2.152) [0.031]
η^{TOTAL}	−0.013 (−1.102) [0.270]	−0.013 (−1.103) [0.270]		
φ^{E1}			−0.895E-02 (−0.824) [0.410]	−0.896E-02 (−0.826) [0.409]
φ^{E2}			−0.744E-02 (−0.510) [0.610]	−0.744E-02 (−0.510) [0.610]
φ^{E3}			−0.011 (−1.050) [0.294]	−0.011 (−1.050) [0.294]
φ^{E4}			−0.361E-03 (−0.027) [0.978]	−0.349E-03 (−0.026) [0.979]
φ^{E5}			−0.855E-02 (−0.712) [0.477]	−0.856E-02 (−0.712) [0.476]
φ^{E6}			−0.012 (−0.554) [0.580]	−0.012 (−0.554) [0.580]
φ^{E7}			−0.013 (−1.095) [0.274]	−0.0129 (−1.096) [0.273]
φ^{E8}			−0.967E-02 (−0.681) [0.496]	−0.970E-02 (−0.683) [0.495]
φ^{E9}			−0.748E-02 (−0.566) [0.571]	−0.751E-02 (−0.569) [0.569]
φ^{E10}			−0.016 (−1.184) [0.236]	−0.016 (−1.185) [0.236]
φ^{E11}			−0.015 (−1.092) [0.275]	−0.015 (−1.093) [0.275]
φ^{E12}			−0.015 (−1.104) [0.269]	−0.015 (−1.106) [0.269]

Note: Estimation of the Euler equation is based on unconditional version of Hansen's (1982) gener-
alized method of moments (GMM). The system is exactly identified so that unconditional
sample moments are used to estimate pricing error coefficients. The *t*-values are reported
in parentheses, which are calculated using the standard errors corrected by White's (1980) and
Newey and West's (1987) methods (a lag length of 4 is used here). The corresponding *p*-values
are reported in brackets.

To further investigate the implications of these puzzles, I examined the change in the absolute value of the t-statistic of each mispricing coefficient induced by the change in the value of β. Figure 2 [1] and [2] illustrates this relationship. According to these figures, the t-statistic of the mispricing coefficient on the bond return declines monotonically in tandem with the value of β over the positive range of β and crosses the line of the 5 percent significance level around the point of $\beta = 12.00$. Hence, when the estimated value of β is larger than 12.00 (this corresponds to the result of systems [1-1] and [2-1]), the mispricing coefficients are not found to differ significantly from zero. Particularly, in the case of system (2-1), in which the bond and 12 individual industry returns are included and $\mathbf{Z}1$ is used as the information set, at any values of β in the 95 percent confidence interval, the t-statistic of the mispricing coefficient on the bond return is always below the line of the 5 percent significance level.

Figure 2 The Relationship between the Values of β and the Mispricing Coefficients

[1] The System of the Bond and the Weighted Average of Stock Returns

[a] Using **Z**1 as the information set (system [1-1])

Note: Mispricing coefficients are defined as in equations (46) and (47). They are estimated by GMM using White's (1980) and Newey and West's (1987) methods of correcting standard errors (a lag length of 4 is used). The system is exactly identified so that sample moments are used to get these coefficients.

[b] Using **Z**2 as the information set (system [1-2])

Note: Mispricing coefficients are defined as in equations (46) and (47). They are estimated by GMM using White's (1980) and Newey and West's (1987) methods of correcting standard errors (a lag length of 4 is used). The system is exactly identified so that sample moments are used to get these coefficients.

[2] The System of the Bond and 12 Industry Stock Returns

[a] Using **Z**1 as the information set (system [2-1])

t-value

10.00

8.00

6.00

t-value of the mispricing coefficient on the bond return

Point estimate of β

95 percent confidence interval of β

t-values of the mispricing coefficients on the stock returns (absolute value)

4.00

5 percent significance level

2.00

0.00

−5.00 −3.50 −2.00 −0.50 1.00 2.50 4.00 5.50 7.00 8.50 10.00 11.50 13.00 14.50 16.00 17.50 19.00 20.50 22.00 23.50 25.00 26.50 28.00 29.50

β

Note: Mispricing coefficients are defined as in equations (46) and (47). They are estimated by GMM using White's (1980) and Newey and West's (1987) methods of correcting standard errors (a lag length of 4 is used). The system is exactly identified so that sample moments are used to get these coefficients.

[b] Using **Z**2 as the information set (system [2-2])

t-value

10.00

8.00

6.00

t-value of the mispricing coefficient on the bond return

Point estimate of β

95 percent confidence interval of β

t-values of the mispricing coefficients on the stock returns (absolute value)

4.00

5 percent significance level

2.00

0.00

−5.00 −3.50 −2.00 −0.50 1.00 2.50 4.00 5.50 7.00 8.50 10.00 11.50 13.00 14.50 16.00 17.50 19.00 20.50 22.00 23.50 25.00 26.50 28.00 29.50

β

Note: Mispricing coefficients are defined as in equations (46) and (47). They are estimated by GMM using White's (1980) and Newey and West's (1987) methods of correcting standard errors (a lag length of 4 is used). The system is exactly identified so that sample moments are used to get these coefficients.

C. Testing the Ability of Stock and Investment Returns to Forecast Future Economic Activity

Table 5 [1] and [2] summarizes findings of both the single and the multiple regressions of the production and investment[45] growth rate on the current and two lags of either the stock return, the investment return, or marginal q.

Table 5 Return Forecasts of Production and Investment Growth Based on the GMM Estimation Result of System (2-2) (β = 11.257)

[1] Production Growth
[a] OLS single regression

Production growth$_t$ = constant + γ_{t-j} return$_{t-j}$ for j = 0, 1, 2.

	Stock return	Investment return	Marginal q
γ_t	0.012	1.200	−0.032
	(0.633)	(5.865)	(−0.689)
	[0.529]	[0.000]	[0.493]
γ_{t-1}	0.024	1.072	−0.084
	(1.267)	(4.930)	(−1.835)
	[0.216]	[0.000]	[0.071]
γ_{t-2}	0.042	0.605	−0.130
	(2.220)	(2.498)	(−2.958)
	[0.030]	[0.015]	[0.004]

[b] OLS multiple regression

Production growth$_t$ = constant + γ_{t-1} return$_{t-1}$ + γ_{t-2} return$_{t-2}$

	Stock return	Investment return	Marginal q
γ_{t-1}	0.029	1.142	0.791
	(1.545)	(4.046)	(4.875)
	[0.127]	[0.000]	[0.000]
γ_{t-2}	0.045	−0.110	−0.900
	(2.387)	(−0.393)	(−5.542)
	[0.020]	[0.696]	[0.000]
Adj. R^2	0.078	0.257	0.345
F-value	3.711	12.067	17.838
	[0.030]	[0.000]	[0.000]

Notes: 1. Production refers to the total output of 12 industries. It is adjusted for seasonality and trading-day effects by the web-based program "Decomp."
2. For derivation of marginal q, see equation (15).
3. The t-values are reported in parentheses and the corresponding p-values are reported in brackets.

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45. Here, output and investment refer to the total of 12 industries.

[2] Investment Growth
[a] OLS single regression

Investment growth$_t$ = constant + γ_{t-j} return$_{t-j}$ for j = 0, 1, 2.

	Stock return	Investment return	Marginal q
γ_t	−0.357E-02	4.617	0.188
	(−0.079)	(51.470)	(1.780)
	[0.937]	[0.000]	[0.080]
γ_{t-1}	−0.012	3.021	−0.010
	(−0.266)	(6.664)	(−0.091)
	[0.791]	[0.000]	[0.928]
γ_{t-2}	0.031	2.897	−0.138
	(0.694)	(6.306)	(−1.291)
	[0.490]	[0.000]	[0.202]

[b] OLS multiple regression

Investment growth$_t$ = constant + γ_{t-1} return$_{t-1}$ + γ_{t-2} return$_{t-2}$

	Stock return	Investment return	Marginal q
γ_{t-1}	−0.901E-02	1.955	2.314
	(−0.197)	(3.563)	(6.428)
	[0.844]	[0.001]	[0.000]
γ_{t-2}	0.030	1.674	−2.391
	(0.666)	(3.077)	(−6.636)
	[0.508]	[0.003]	[0.000]
Adj. R^2	−0.024	0.475	0.397
F-value	0.257	29.920	22.026
	[0.774]	[0.000]	[0.000]

Notes: 1. Investment refers to the total of 12 industries. It is adjusted for seasonality and trading-day effects by the web-based program "Decomp."
2. For derivation of marginal q, see equation (15).
3. The t-values are reported in parentheses and the corresponding p-values are reported in brackets.
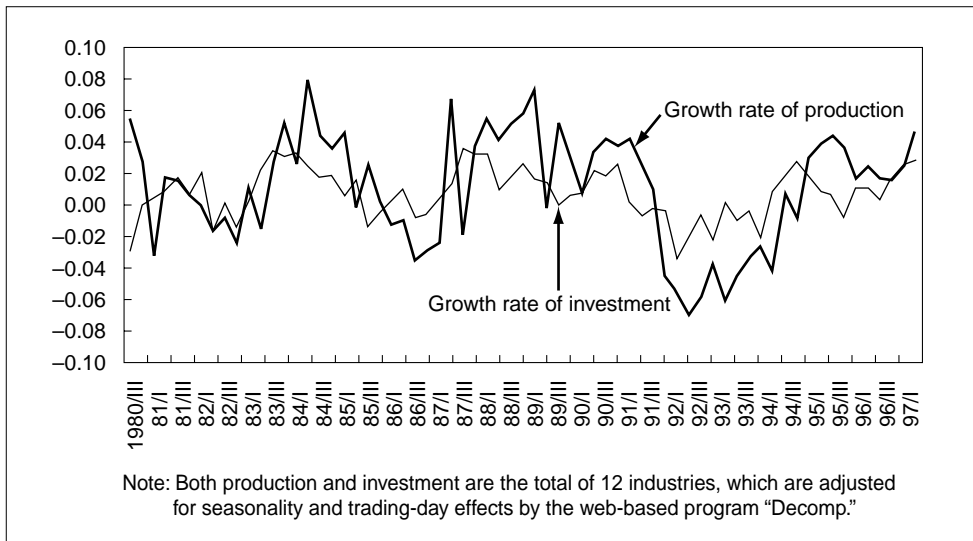
For the production growth rate, the lagged values of the investment return and marginal q have significant predictive power. For example, the investment return explains 25.7 percent and marginal q explains 34.5 percent of the variation of the future production growth, while the stock return explains only 7.8 percent.[46]

46. But, the F-value suggests that two lags of the stock return are jointly significant forecasters of future production growth.
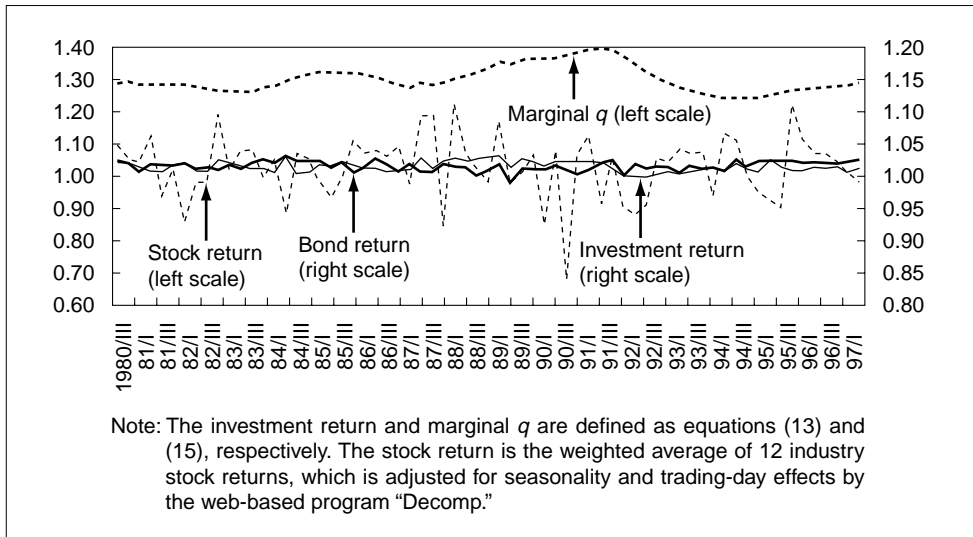
Also as for the investment growth, there is a very similar tendency. The investment return and marginal q are superior as forecasters of the investment growth to the stock return.[47] Lastly, Figure 3 [1] shows that production and investment have a very similar pattern of the movement, while Figure 3 [2] shows that the stock return is much more volatile than the investment return and marginal q, which implies that the stock return consists of a lot of noise.

Figure 3 Production-Related Variables and Various Returns

[1] Production and Investment Growth

Note: Both production and investment are the total of 12 industries, which are adjusted for seasonality and trading-day effects by the web-based program "Decomp."

[2] Gross Asset Returns, Investment Return, and Marginal q

Note: The investment return and marginal q are defined as equations (13) and (15), respectively. The stock return is the weighted average of 12 industry stock returns, which is adjusted for seasonality and trading-day effects by the web-based program "Decomp."

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47. In this case, the *F*-value suggests that two-period-lags of the stock return are not jointly significant forecasters of the future investment growth.

VI. Concluding Remarks

This article has attempted to provide an empirical investigation into the validity of the P-CAPM in Japanese asset markets during the period 1980-97.

In this paper, several methods were used to test the implications of the P-CAPM as rigorously as possible. Those methods included the GMM test of the Euler equation, the statistical inference of Hansen and Jagannathan's volatility bound test, estimation of the mispricing coefficients, and the test of the ability of stock and investment returns to forecast future economic activity. Taken all together, the results basically support the P-CAPM, which means that although *ex post* stock returns are very noisy, at least in the expectations of investors, they follow fundamental movements of investment and production.

For example, the GMM test of the Euler equation strongly favors the P-CAPM in terms of the estimated parameter of the adjustment cost function and the overidentification test. Also, the corresponding statistical inference of the volatility bound test cannot reject the null hypothesis of zero-vertical distance. On the other hand, estimation of the mispricing coefficients suggests that the risk-free rate puzzle is more formidable than the equity premium puzzle during this period. Lastly, the test result of the ability of stock and investment returns to forecast future economic activity indicates that the stock return is not a good forecaster of future economic activity, while the investment return and the implied value of marginal q are found to be superior forecasters.

It should be noted here, however, that throughout the paper I assume that the asset markets are frictionless, which implies that there are no constraints such as short sales of bonds and/or equities. In this regard, He and Modest (1995) and Luttmer (1996) show that these constraints can significantly change some aspects of the test results, including the shape of Hansen and Jagannathan's volatility bound. I believe that this line of research provides a promising direction for future research.

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