IMES DISCUSSION PAPER SERIES

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

Naohiko Baba

Discussion Paper No. 2000-E-5

IMES

INSTITUTE FOR MONETARY AND ECONOMIC STUDIES

BANK OF JAPAN

C.P.O BOX 203 TOKYO

100-8630 JAPAN

IMES Discussion Paper Series 2000-E-5
February 2000

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

Naohiko Baba*

Abstract

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 1980-1997. Several methodologies are used to test the P-CAPM, which include the 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

JEL Classification: E22; E44; G12

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

I would like to express my sincere gratitude to Professors Richard Lyons and James Pierce for their encouragement and helpful comments. I also benefited a lot from discussion with Professors Bradford DeLong, Roger Craine, Maurice Obstfeld, Keiichi Hori, and James Wilcox. My special thanks go to Sachiko Nakada (Kuroda), Masaki Nakahigashi, and Yoichi Kita for providing me with the data. Of course, any remaining errors are entirely mine.

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 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 the economic activity underlying it. The number of studies concerning 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 empirical framework.

For example, Chan, Laconishok and Hamao (1991) have explored the relationship between U.S. capital market fundamentals and stock market returns in a cross-sectional context. Also, Campbell and Hamao (1992) have 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 and he concluded 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 first 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 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 much more than consumption, as suggested by Mehra and Prescott (1985).

Nevertheless, the P-CAPM shares many features with the C-CAPM. For example, 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 both models coincide in a particular case.

More specifically, the return on investment is the marginal rate at which a firm can transfer resources through time by increasing investment in the 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 inferred 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 are based on the *q* theory of investment originally proposed by Tobin (1969). Although its theoretical basis is robust, measures of the *q* index are often empirically inappropriate for testing whether or not stock prices reflect their fundamental values. Concretely speaking, in computing Tobin's *q*, one is obliged to use either (i) firm

---

[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).

value evaluated in the stock market divided by the market value of existing capita stock (average q) or (ii) the present value of a stream of firm profits with some interest rate as its discount rate (marginal q).

However, it is difficult to measure (i) the market value of equity net of cross-holdings[3] and/or the capital stock in computing average q, and (ii) the discount rate in computing marginal q. Hence the accuracy of measuring Tobin's q mainly depends on the choice made between those methodologies. Further, *ex post* stock prices, which are usually used to construct average q, have a lot of noisy components, which, by definition, do not reflect fundamental firm activity associated with both investment and production. In this regard, the use of the P-CAPM enables one to avoid such problems because it concentrates on the *ex ante* relationship between asset returns and investment, although from the perspective of the theoretical basis, the two models are closely related to each other.

Motivated by the above discussion, this paper tries to examine the relationship between asset returns and physical investment 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].

[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 Kashap (1990) also point out this kind of problems, 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 out 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 U.S., Japan, the UK, Germany, and Canada. The result shows that the P-CAPM performs better than the C-CAPM.

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 do 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 applies GMM to the Euler 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 on 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 returns on physical investment.

Thus, this paper can be thought to be an application of the methodologies used by Cochrane (1991,1996) to deal with Japanese industry-level asset return data, but the following modifications have been made: (i) 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. (ii) 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 on the adjustment cost function, not on the production function, I use the specification such that the marginal productivity of capital is also time-varying. (iii)

[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, thus the stock returns.
[7] In other words, he ignored the Euler equation for the risk-free interest rate itself. Let me discuss this point later. Also he estimated the quarterly industry GDP under the assumption that the output of each

Relating to this point, Cochrane (1991,1996) also gives an arbitrary value to a parameter of the adjustment cost function and tests whether or not 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. (iv) 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. Section II outlines a basic theoretical framework of the P-CAPM, referring to the link with the *q* theory of investment. Then I will discuss the testable implications of the P-CAPM. Section 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. Section IV describes the empirical results, which turned out to be favorable to the P-CAPM. Section V concludes the paper.

II. Theoretical Framework

A. Basic Model[8]

(i) 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 physical investment and asset returns.

---

industry has the same pattern of quarterly variation as has total output. This treatment might cause another bias.

[8] Description of the basic model follows Hori (1997).

Now, consider the following production economy similar to those of Lucas and Prescott (1981), Abel and Blanchard (1986), and Cochrane (1996)[9]. There are *N* securities in frictionless markets. By frictionless markets, I mean that agents are able to buy and sell any securities at a given price without paying any transaction costs[10].

Different securities correspond to different technologies. There are numerous investors in the stock market 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.

Under this setting, the technology[11] can be described as

$$Q_t = F(K_t, L_t)v_t - C(I_t, K_t) - w_t L_t, \tag{1}$$

and $$K_{t+1} = (1-\delta)(K_t + I_t), \tag{2}$$

where Q_t is the cash flow, $F(K_t, L_t)$ the production function, $C(I_t, K_t)$ the adjustment cost function, K_t the capital stock, w_t the wage rate, L_t the labor input, v_t the exogenous shock, and δ the constant depreciation rate. The production function is concave and increasing in its arguments. The adjustment costs indicate deadweight costs incurred by installing and transforming investment goods into capital stock.

The firm pays out a dividend D_{t+j} that is equal to the net cash flow such that

$$D_{t+j} = Q_{t+j} - I_{t+j}. \tag{3}$$

Given the technology (1) and the capital accumulation rule (2), the firm chooses I_{t+j} and L_{t+j} in order to maximize its present discounted value. Thus, the maximization problem for the firm can be written as

---

[9] These works are descended from Breeden (1979).

[10] Later I refer to the implications derived from frictionless asset markets.

[11] One alternative specification is that adjustment costs are included in the capital accumulation rule instead of the production function 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), Baksi, Chen, and Naka (1995), and Arroyo (1996).

$$V_t = \underset{\{I_{t+j}, L_{t+j}\}}{Max} E_t\left[\sum_{j=0}^{\infty} M_{t,t+j} D_{t+j}\right], \tag{4}$$

s.t. (1), (2), (3), and $K_t = \overline{K}$,

where E_t denotes the expectation operator conditional on the information set available at the beginning of period *t*, and $M_{t,t+j}$ is a stochastic discount factor (pricing kernel) or an intertemporal marginal rate of substitution from period *t* to *t+j*[12], which is assumed to be common to every investor. In a complete market, $M_{t,t+j}$ is equivalent to the contingent claims price divided by the probability, hence the present value (4) is equal to the firm's period *t* contingent claims value.

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

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

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

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. Now equation (6) can be rewritten as

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

Thus the one-period investment return $R^I_{t,t+1}$ [13] can be defined as

$$R^I_{t,t+1} \equiv (1-\delta)\frac{1 + C_I(t+1) + F_k(t+1)v_{t+1} - C_K(t+1)}{1 + C_I(t)}. \tag{9}$$

---

[12] In general, $M_{t,t+j}$ is defined as $M_{t,t+j} = \rho U'(C_{t+j})/U'(C_t)$, 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 $M_{t,t+j} = M_{t,t+1} \times M_{t+1,t+j}$.

[13] 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 on *p* lags of investment, then a *p*-period investment strategy must be considered.

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

$$E_t\left[M_{t,t+1}R^I_{t,t+1}\right]=1 . \tag{10}$$

The pricing condition (10) says 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.

(ii) Specification of the Production Function and the Adjustment Cost Function

To estimate the parameters in definition (9) within the framework of the Euler equation (10), one needs to specify a concrete form of the investment return R^I_{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 income going to capital in total income.

Next, I will specify the adjustment cost function as[14][15]:

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

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 defined as (9) can be rewritten as

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

[14] This form is used in Cochrane (1996) and Hori (1997).
[15] 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).

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[16].

(iii) Relation with Tobin's q

Here, the so-called envelope condition is given by

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

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

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

Equation (15) states that when adjustment costs are zero, that is, when $\beta \to 0$, marginal q is 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 literature, marginal q is increasing in the investment-to-capital ratio (I/K) and β. A positive technology shock, $v_t > 0$, 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

[16] In the case in which the alternative specification of the capital accumulation rule is used as in Cochrane (1991) and Baksi, Chen, and Naka (1995), other things 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 (13) and empirically, almost the same results are obtained.

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

Therefore, other things 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 series of 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

$$E_t\left[M_{t,t+1}R_{t,t+1}\right] = 1\text{ [17]}, \tag{17}$$

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

C. Testable Form of the P-CAPM

According to Ross (1978), Hansen and Richard (1987), and Hansen and Jagannathan (1991), if there are no arbitrage opportunities, then a stochastic discount

[17] 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,

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:

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

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)[18]. For reference, let me sketch what this type of the model looks like. Consider the following simplified version of the one-sector stochastic growth model:

$$\underset{C_{t+j}}{Max} \quad E\left[\sum_{j=0}^{\infty} \rho^j \ln\left(C_{t+j}\right)\right], \tag{19}$$

subject to $C_{t+j} + I_{t+j} = Y_{t+j} = \gamma_{t+j} I^{\alpha}_{t+j-1}$ and $\ln\gamma_{t+j} = \chi \ln\gamma_{t+j-1} + \varepsilon_{t+j}$, where Y_{t+j} denotes the income and ε_{t+j} denotes white noise.

Then, the investment return can be computed as $R^I_{t,t+1} = \alpha\gamma_{t+1} I_t^{\alpha-1} = \alpha Y_{t+1}/I_t$. The solution to the model gives $C_t = (1-\alpha\beta)Y_t$ and $I_t = \alpha\beta Y_t$. Substituting this solution into the investment return yields

$$R^I_{t,t+1} = \frac{1}{\rho}\frac{C_{t+1}}{C_t} = \frac{1}{M_{t,t+1}}. \tag{20}$$

Thus, one can obtain the condition (18).

$1 = \sum_{s=1}^{S} p_s R_s = \sum_{s=1}^{S} \pi_s M^s_{t,t+1} R_s = E[M_{t,t+1} R_{t,t+1}]$, where p_s is state price, π_s is the probability of state s occurring. For more details, see Cambell, Lo, and MacKinlay (1997).

[18] 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 $M_{t,t+1} = b_0 + b_R R^I_{t,t+1} + \ldots$. 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 $M_{t,t+1} = \left(1/R^I_{t,t+1}\right) \approx 2 - R^I_{t,t+1}$, the restriction in this paper implies that $b_0 = 2$ and $b_R = -1$ in terms of his formulation.

Now let me clearly restate the system of equations to be estimated. I estimate the following system[19]:

$$E_t\left[M_{t,t+1}R^b_{t,t+1}\right]=1 \quad \text{for the bond return} \tag{21}$$

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

Of course, the system such that $E_t\left[M_{t,t+1}R^b_{t,t+1}\right]=1$ and $E_t\left[M_{t,t+1}\left(R^i_{t,t+1}-R^b_{t,t+1}\right)\right]=0$ 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 $E_t\left[M_{t,t+1}\left(R^i_{t,t+1}-R^b_{t,t+1}\right)\right]=0$, as done by Hori (1997), is problematic because this treatment allows the right-hand side of each Euler equation to differ from 1. That is, even if it is equal to some constant other than 1, if and only if it is the same constant across all the Euler equations, is the relationship $E_t\left[M_{t,t+1}\left(R^i_{t,t+1}-R^b_{t,t+1}\right)\right]=0$ satisfied.

III. Empirical Methodologies

A. GMM Tests of the Euler Equations

As emphasized by Cochrane (1996), Generalized Method of Moments (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[20].

---

[19] He and Modest (1996) and Luttmer (1996) independently show that, for example, in the case in which there are short-sale constraints for some assets, it follows that $E\left[M_{t,t+1}R^i_{t,t+1}\right]=1$ for $i \subseteq A^c$ and $E\left[M_{t,t+1}R^i_{t,t+1}\right]\leq 1$ 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.

[20] For example, Hamilton (1994) explains this point as follows*: people's behavior is often influenced by their expectations about 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 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 $E(\mathbf{e}_{t+1} \mid \mathbf{Z}_t) = 0$ 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 NxR-dimensional vector $\mathbf{g}_t$ such that $\mathbf{g}_t = \mathbf{e}_t \otimes \mathbf{Z}_t$, where $\otimes$ denotes the Kronecker product. By the law of iterated expectation, it follows that

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

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

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

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.

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*-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 plain words, the *J*-statistic tests whether or not 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 statistics indicates a high probability that the model is misspecified[21].

Now let me proceed to the application of GMM to the P-CAPM. 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 to be 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)

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

discusses how to select optimal instrumental variables, but his methodology is difficult to implement in practice[22].

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 Z1, includes a constant and one-lagged values of the investment-capital ratio, the output-capital stock ratio, and the weighted average of industrial stock returns in excess of the government bond rate. The second one, denoted Z2, includes a constant and two-lagged values of the same variables. In theory, components of Z1 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, Z1 might not be available to investors at that time. So in this paper, Z2 is also used.

B. Hansen and Jagannathan's Volatility Bound Test[23]

(i) 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 [24]onto the space spanned by a vector of asset returns $\mathbf{R}$ and the constant as

$$M = \tilde{\mathbf{R}}'\theta_0 + \mu \,, \tag{26}$$

where $\tilde{\mathbf{R}}' = (1 \quad \mathbf{R}')$ 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

[22] 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) strongly suggest that one should be quite parsimonious in the selection of the conditioning information set.
[23] Craig (1994) provides an excellent survey on this topic. In what follows, basically, I follow his explanation.

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

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

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

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

where Σ_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

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

Here let me form the estimate:

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

which allows the formation of an estimated bound such that

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

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

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

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

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

Clearly, the population value of ς must be nonnegative.

---

[24] In this section, both M and M_t indicate $M_{t,t+1}$.

Figure 1 plots both (i) the second-moment volatility bounds[25] computed by the actual data of the Japanese asset returns, and (ii) sample pairs of $(\overline{M} \quad \hat{M}_m)$ implied by the P-CAPM for given values of β . Evidently, any sample pair of $(\overline{M} \quad \hat{M}_m)$ cannot satisfy the volatility bound, but the larger the parameter β becomes, the smaller the distance is. In this situation, statistical inference should play a role.

(ii) 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 β . According to Cecchetti, Lam, and Mark (1994), two sources of uncertainty emanate when one compares between the mean-standard deviation (or equivalently, second-moment centered around zero) pairs from 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 statistical inference originally proposed by Cochrane and Hansen (1992)[26]. The sample distance measure $\hat{\varsigma}$

[25] In Figure 1, two versions of the second-moment volatility bound are plotted. One is from a portfolio consisting of 2 asset returns (the returns on the bond and the weighted average of 12 stock returns), and the other is from a portfolio consisting of 13 asset returns (returns on the bond and 12 industry stock returns).

[26] In this paper, I choose to use this version of the volatility bound test rather than the one based on the variance (29) due to the computational facility of standard errors associated with the vertical distance parameter estimated via the GMM framework. For the statistical inference based on the inequality (29), see, for example, Ceccheti, Lam, and Mark (1994).

can be obtained using the GMM estimation. They showed that an exactly identified GMM framework that exploits the *k+2* moment conditions:

$$E\left[\begin{pmatrix} M_t \\ \mathbf{l} \end{pmatrix} - \widetilde{\mathbf{R}}_t\widetilde{\mathbf{R}}_t'\Theta\right] = \mathbf{0}\,, \tag{35}$$

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

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

$$\overline{\mathbf{g}}_t(\alpha) = \begin{pmatrix} \dfrac{1}{T}\sum\limits_{t=1}^{T}\left[\begin{pmatrix} M_t \\ \mathbf{l} \end{pmatrix} - \widetilde{\mathbf{R}}_t\widetilde{\mathbf{R}}_t'\Theta\right] \\ \dfrac{1}{T}\left[M_t^2 - (M_t \quad \mathbf{l}')\Theta - \varsigma\right] \end{pmatrix}. \tag{37}$$

Since the estimator is exactly identified, the sample moments can be set exactly to 0 by the estimates:

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

and $$\varsigma = \frac{1}{T}\sum_{t=1}^{T}M_t^2 - \frac{1}{T}\sum_{t=1}^{T}(M_t \quad \mathbf{l}')\hat{\Theta} = \hat{M}_M - \widetilde{M}'\hat{\Theta}\,. \tag{39}$$

The asymptotic covariance matrix of the vector $\sqrt{T}(\hat{a} - a_0)$ is given by

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

where $\mathbf{S}_0 = \sum\limits_{i=-\infty}^{\infty}E[f(x_t, \alpha_0)f(x_t, \alpha_0)']$ and $\mathbf{D}_0 = E[\partial f(x_t, \alpha_0)/\partial\alpha]$. These quantities are estimated by $\mathbf{Var}(\hat{a}) = [\mathbf{D}_T'\mathbf{S}_T^{-1}\mathbf{D}_T]^{-1}$, where

$$\begin{aligned} \mathbf{S}_T = {} & \frac{1}{T}\sum_{t=1}^{T}f(x_t, \hat{a})f(x_t, \hat{a})' + \sum_{i=1}^{n}\left[1 - \frac{i}{n+1}\right] \\ & \times\left[\frac{1}{T}\sum_{t=1+i}^{T}f(x_t, \hat{a})f(x_{t-i}, \hat{a})' + \frac{1}{T}\sum_{t=1}^{T-i}f(x_t, \hat{a})f(x_{t+i}, \hat{a})'\right], \end{aligned} \tag{41}$$

and $$\mathbf{D}_T = \frac{1}{T}\sum_{t=1}^{T}\frac{\partial f(x_t, \hat{a})}{\partial a}\,. \tag{42}$$

This method is due to Newey and West (1987). *n*=4 is used throughout the paper.

Finally, the statistic Z [27] is given by

$$Z = \sqrt{T}\,\frac{\hat{\varsigma}}{\left[\mathbf{V\hat{a}r}(\hat{a})_{k+2,k+2}\right]^{\frac{1}{2}}}, \tag{43}$$

where $\mathbf{Var}(\hat{a})_{k+2,k+2}$ 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

Next econometric methodology exploits the informal diagnostic 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 s to the asset-pricing Euler equations:

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

and $$E_t\left[M_{t,t+1}(R^i_{t,t+1} + \eta^i)\right] = 1 \text{ for the } i\text{-th stock return } (i = 1,2,...n) \tag{45}$$

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 exactly to 0. The asymptotic covariance of the parameters η s 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

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

[27] Cochrane and Hansen (1982) 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.

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

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

If φ^i s are found to be significantly negative given the value of β, then it means that the representative agent can gain at the margin by borrowing at the government bond rate and 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

---

[28] Bakshi and Naka (1997) use this method to compare the pricing performance of several types of C-

using stock returns. Motivated by these arguments, I check whether or not 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 1Q of 1980 and 1Q of 1997 due to the availability of the data. This period covers noteworthy episodes of "bubble economy" from the mid-1980's to the early 1990s and the "post-bubble" economic sluggishness afterwards.

Concerning the industries, let me concentrate on the following 12 manufacturing industries: Textiles, Pulp, Paper and Paper Products, Chemicals, Petroleum and Coal Products, Non-Metallic 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 (i) 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 (ii) there are no quarterly data of the operating ratio and production for such industries as Food in manufacturing and the other 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.

B. Data Description

(i) Investment, Capital Stock, and Depreciation Rate

The data of investment and capital stock are taken from *Gross Capital Stock of Private Enterprises* issued by the Economic Planning Agency (EPA). They cover all

---

CAPM specifications.

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 % 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 second-hand goods. Taking into account of these points, I use an *ad hoc* constant quarterly depreciation rate of 0.7 %[30] instead of the estimated 1.07 %.

(ii) 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[32] reported by Ministry of International Trade and Industry (MITI). This is not a value, but an index

[29] This data is 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 5th 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%) divided by 1.54 is equal to about 0.7%.
[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.

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 is issued by the MITI and is available from the Nikkei NEEDS tape.

(iii) Industry Stock and Government Bond Returns

In this paper, I use the NIKKO Stock Performance Index (NIKKO SPI) issued by Nikko Securities Inc. 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-share-holding-adjusted index and an unadjusted index. The cross-holding 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-share-holding adjusted series. In terms of the coverage, it reflects all the stock returns of the firms that are listed in Tokyo, Osaka, and Nagoya Stock Exchanges as well as on the over-the-counter (OTC) market.

For the bond return, I use the rate of return on the 10-year Japanese government bond. It is taken from the Economic Statistics, Monthly published by the Bank of Japan[34].

---

[32] This is value-added data in real terms. I got it 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.
[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.

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

C. Coping with Seasonality, Trading-day Effects, and Trends

(i) 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 Education Ministry'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 X11 and X12 despite the fact that it is sometimes an important component, particularly in the case of stock returns[38].

(ii) Linear Trend

One of the maintained assumptions of GMM is that all the observable variables be 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.

---

[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.

[39] It turns out that the investment-capital ratios and the government bond rate, in particular, have deterministic trends that are statistically significant.

D. Properties of the Data

(i) Summary Statistics

Table 2A 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 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 6th and 7th columns in Table 2A report excess skewness and kurtosis. The estimation result shows that excess skewness for quarterly Japanese asset returns tends to be negative, and excess 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]. By contrast, the 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.

In addition, to investigate the autocorrelation pattern of the data set, Table 2A 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.

[40] For a detailed analysis of the U.S. asset returns, see Campbell, Lo, and MacKinlay (1997).

(ii) Correlation Matrix

Table 2B 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. Also 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 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 3A and 3B report 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 3A shows the result when all asset returns including the bond return and every stock return are used in estimation, and Table 3B reports the result in the case in which 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.

Now, let me look at Table 3A 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% significance level in any specification. Estimated values of β differ from 8.838 in the case of the system (1-2) to 15.349 in the case of the system (2-1), but all the estimated β s are significant at the 5% 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 Z2 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 or not.

Figure 1 depicts the relative relationship between (i) the second-moment volatility bound, which is computed from raw Japanese asset returns and (ii) the pair of (a) the mean of the candidate stochastic discount factor $\overline{M}$ and (b) its second-moment centered around zero M_m, which is implied by the Japanese investment data when the value of β is given from 0 to 50. This figure shows that for all the positive values of β[41], any pairs of $\overline{M}$ and M_m are below the second-moment volatility bounds. But, apparently, as the value of β is getting larger and larger, the vertical distance to the second-moment bounds is getting smaller and smaller. In such a situation, as discussed before, the statistical inference of this vertical distance plays an important role in judging whether the distance is statistically zero or not, once one takes account of the sampling and measurement errors in the relevant variables.

The last two columns of Table 3A 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 the portfolio A consisting of the bond and the weighted average of 12 industrial 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 the portfolio B consisting of the bond and 12 individual stock returns is used. The one-sided *t*-test shows that in any case, the null hypothesis that the vertical distance is zero cannot be rejected at the 5% significance level. Thus, one can conclude that the values of β estimated by GMM consistent with Hansen and Jagannathan's volatility bound test.

Next, let me move on to Table 3B, 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])[42] when Z1 is used as an information set and from 7.226 (system [7-2]) to 9.607 (system [4-2])[43] when Z2 is used. This similarity of the values of the estimated β across the subset of asset returns, particularly in the case in which Z2 is used as the information set, can be inferred from the high correlation between the 12 stock returns. Similarly to the results of Table 3A, the *P*-values associated with the J_T statistics of the overidentifying restrictions test suggest that the model cannot be rejected at the 5% 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 $\overline{M}$ and M_m is zero cannot be rejected at the 5% 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 Z1 as the information set are used[44], mispricing coefficients

---

[41] Actually, I changed the value of β from zero to 10000, but in any case, this result still holds.

[42] The system (14-1) includes the returns on the bond and the portfolio of precision instrument industry, while the system (9-1) includes the returns on the bond and the portfolio of nonferrous metals and products industry.

[43] The system (7-2) includes the returns on the bond and the portfolio of pulp, paper and paper products industry, while the system (4-2) includes the returns on the bond and the portfolio of nonferrous metals and products industry.

[44] This corresponds to the systems (1-1) and (2-1).

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 Z2 as the information set are used[45], however, the mispricing coefficient of the bond return is found to be different from zero at the 5% significance level, while those of stock returns are still not found to be different from zero. The latter result implies that the stochastic discount factor derived from the investment return tends to over-discount the payoff from the bond.

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. Figures 2A and 2B illustrate this relationship. According to these figures, the *t*-value 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% significance level around the point of β=12.00. Hence when the estimated value of β is larger than 12.00 (this corresponds to the result of the systems [1-1] and [2-1]), the mispricing coefficients are not found to be significantly different from zero. Particularly, in the case of the system (2-1), which includes the bond and 12 individual industrial returns and Z1 is used as the information set, at any values of β in the 95% confidence interval, the *t*-statistic of the mispricing coefficient on the bond return is always below the line of the 5% significance level.

[45] This corresponds to the systems (1-2) and (2-2).

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

Table 5A and 5B summarize findings of both the single and the multiple regressions of the output and investment[46] growth rate on the current and two lags of either the stock return, the investment return, or marginal q.

For the output growth rate, the lagged values of the investment return and marginal q have significant predictive power. For example, the investment return explains 25.7% and marginal q explains 34.5% of the variation of the future production growth, while the stock return explains only 7.8%[47].

Also as for the investment growth, there is a very similar tendency. The investment return and the marginal q are superior as forecasters of the investment growth to the stock return[48]. Lastly, Figure 3A shows that production and investment have a very similar pattern of the movement, while Figure 3B 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 noises.

VI. Concluding Remarks

This article have attempted to provide an empirical investigation of the validity of the production-based capital asset-pricing model in Japanese asset markets during the period 1980-1997.

In this paper, several methods have been used to test the implications of the P-CAPM as rigorously as possible. Those methods include the GMM test of the Euler equation, the statistical inference of Hansen and Jagannathan's volatility bound test,

[46] Here, output and investment refer to the total of 12 industries.
[47] But, the F-value suggests that two lags of the stock return are jointly significant forecasters of future production growth.

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 supports 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 shortsales 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.

[48] 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.

References

Abel, A. B., and O. J. Blanchard, "The Present Value of Profits and Cyclical Movements in Investment," *Econometrica*, Vol. 54, 1986, pp. 249-273.

Arroyo, C. R., "Testing a Production-Based Asset Pricing Model," *Economic Inquiry*, Vol. 34, 1996, pp. 357-377.

Bakshi, G. S., Z. Chen, and A. Naka, "Production-Based Asset Pricing in Japan," *Pacific-Basin Financial Journal* Vol. 3, 1995, pp. 217-240.

Bakshi, G. S., and A. Naka, "An Empirical Investigation of Asset Pricing Models Using Japanese Stock Market Data," *Journal of International Money and Finance*, Vol. 16, 1997, pp. 81-112.

Breeden, D. T., "An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities," *Journal of Financial Economics*, Vol. 7, 1979, pp. 265-296.

Brock, W., "Asset Prices in a Production Economy," in J. McCall, eds., *The Economics of Information and Uncertainty*, 1982, University of Chicago Press, Chicago, IL.

Campbell, J. Y., and Y. Hamao, "Predictable Stock Returns in the United States and Japan: A Study of Long-Term Capital Market Integration," *Journal of Finance*, Vol. 47, 1992, pp. 43-69.

Campbell, J. Y., A. W. Lo, and A. C. MacKinlay, *The Econometrics of Financial Markets*, 1997, Princeton University Press, Princeton, NJ.

Cecchetti, S. G., P-S Lam, and N. C. Mark, "Testing Volatility Restrictions on Intertemporal Marginal Rates of Substitution Implied by Euler Equations and Asset Returns," *Journal of Finance*, Vol. 49, 1994, pp. 123-152.

Chan, L., J. Lakonishok, and Y. Hamao, "Fundamentals and Stock Returns in Japan," *Journal of Finance*, 1991, Vol. 46, pp. 137-167.

Chen, N. F., "Financial Investment Opportunities and the Macroeconomy," *Journal of Finance*, Vol. 46, 1991, pp. 529-554.

Chen, N. F., R. Roll, and S. A. Ross, "Economic Forces and the Stock Market," *Journal of Business*, Vol. 59, 1986, pp. 383-403.

Cochrane, J. H., "Production-Based Asset Pricing and the Link between Stock Returns and Economic Fluctuations," *Journal of Finance*, Vol. 46, 1991, pp. 209-237.

Cochrane, J. H., "A Cross-Sectional Test of an Investment-Based Asset Pricing Model," *Journal of Political Economy*, Vol. 104, 1996, pp. 572-621.

Cochrane, J. H., and L. P. Hansen, "Asset pricing Explorations for Macroeconomics," *NBER Macroeconomics Annual*, 1992, pp. 115-165.

Cox, J., J. Ingersoll, and S. Ross, “An Intertemporal General Equilibrium Model of Asset Prices,” *Econometrica*, Vol. 53, 1985, pp. 363-384.

Craig, B., “Hansen-Jagannathan Bounds as Classical Tests of Asset-Pricing Models,” *Journal of Business & Economic Statistics*, Vol. 12, 1994, pp. 57-79.

Fama, E. F., and M. Gibbons, “Inflation, Real Returns, and Capital Investment,” *Journal of Monetary Economics*, Vol. 13, 1982, pp. 327-348.

Fama, E. F., and M. Gibbons, “A Comparison of Inflation Forecasts,” *Journal of Monetary Economics*, Vol. 13, 1984, pp. 327-348.

Ferson, W., and G. Constantinides, “Habit Persistence and Durability in Aggregate Consumption: Empirical Tests,” *Journal of Financial Economics*, Vol. 29, 1991, pp. 199-240.

Ferson, W., and S. Foerster, “Finite Sample Properties of the Generalized Method of Moments Tests of Conditional Asset pricing Models,’ *Journal of Financial Economics*, Vol. 36, 1994, pp. 29-55.

French, K., “Stock Returns and the Weekend Effect,” *Journal of Financial Economics*, Vol. 8, 1980, pp. 55-69.

Gibbons, M., and P. Hess, “Day of the Week Effects and Asset Returns,” *Journal of Business*, Vol. 54, 1981, pp. 579-596.

Hamilton, J. D., *Time Series Analysis*, Princeton University Press, 1994, Princeton, NJ.

Hamori, S., “Test of C-CAPM for Japan: 1980-1988,” *Economics Letters*, Vol. 38, 1992, pp. 67-72.

Hamori, S., “The Non-Expected Utility Model and Asset Returns: Some Evidence from Japan,” *Japanese Journal of Financial Economics*, Vol. 1, 1994, pp. 89-99.

Hansen, L. P., “Large Sample Properties of Generalized Method of Moments Estimators,” *Econometrica*, Vol. 50, 1982, pp. 1029-1054.

Hansen, L. P., “A Method of Calculating Bounds on the Asymptotic Covariance Matrices of Generalized Method of Moments Estimators,” *Journal of Econometrics*, Vol. 30, 1985, pp. 203-238.

Hansen, L. P., and R. Jagannathan, “Implications of Security Market Data for Models of Dynamic Economies,” *Journal of Political Economy*, Vol. 99, 1991, pp. 225-262.

Hansen, L. P., and S. F. Richard, “The Role of Conditioning Information in Deducing Testable Restrictions implied by Dynamic Asset Pricing Models,” *Econometrica*, Vol. 55, 1987, pp. 587-613.

Hayashi, F., “Tobin’s Marginal Q and Average Q: A Neoclassical Interpretation,” *Econometrica*, Vol. 50, 1982, pp. 213-224.

He, H., and D. M. Modest, “Market Frictions and Consumption-Based Asset Pricing,” *Journal of Political Economy*, Vol. 103, 1995, pp. 94-117.

Hori, K., "Japanese Stock Return and Investment: A Test of Production-Based Asset Pricing Model," *Japan and the World Economy*, Vol. 9, 1997, pp. 37-56.

Hori, K., "*Nihon no Shisan Shijo ni okeru Shohi-Shisan-Kakaku-Kettei Moderu no Saikensho* (A Reexamination of the Consumption-based Capital Asset Pricing Model in the Japanese Asset Markets)," in Japanese, *Osaka Econ*, *Paper*, Vol. 45, 1996, pp. 76-90.

Hoshi, T., and A. K. Kashyap, "Evidence on *q* and Investment for Japanese Firms," *Journal of the Japanese and International Economies*, Vol. 4, 1990, pp. 371-400.

Kasa, K., "Consumption-Based versus Production-Based Models of International Equity Markets," *Journal of International Money and Finance*, Vol. 16, 1997, pp. 653-680.

Kitagawa, G., and W. Gersch, "A Smoothness Priors-State Space Modeling of time Series with Trend and Seasonality," *Journal of the American Statistical Association*, Vol. 79, 1984, pp. 378-389.

Kiyotaki, N., and K.D. West, "Business Fixed Investment and the Recent Business Cycle in Japan, *NBER Macroeconomics Annual*, 1996, pp. 277-323.

Kocherlakota, N. R., "On Tests of Representative Consumer Asset Pricing Models," *Journal of Monetary Economics*, Vol. 26, 1990, pp. 285-304.

Lucas, R., "Asset Prices in an Exchange Economy," *Econometrica*, Vol. 46, 1978, pp. 1429-1445.

Lucas, R., and E. Prescott, "Investment under Uncertainty," in R. E. Lucas, and T.J. Sargent, eds, *Rational Expectations and Econometric Practice*, Vol. 1, 1981, University of Minnesota Press, Minneapolis, MN.

Luttmer, E. G., "Asset Pricing in Economies with Frictions," *Econometrica*, Vol. 64, 1996, pp. 1439-1467.

Ljung, G. M., and G. P. Box, "On a Measure of Lack of Fit in Time Series Model,' *Biometrika*, Vol. 66, 1979, pp. 297-303.

Mehra, R., and E. C. Prescott, "The Equity Premium: A Puzzle," *Journal of Monetary Economics*, Vol. 15, 1985, pp. 145-161.

Newey, W. K., "Generalized Method of Moments Specification Testing," *Journal of Econometrics*, Vol. 29, 1985, pp. 229-256.

Newey, W. K., and K. D. West, "A Simple, Positive Semi-Definite, Heteroskedaticicity And Autocorrelation Consistent Covariance Matrix," *Econometrica,* Vol. 55, 1987, pp. 703-708.

Obstfeld, M., and K. Rogoff, *Foundations of International Macroeconomics*, The MIT Press, 1996, Cambridge, MA.

Ross, S. A., "A Simple Approach to the Valuation of Risky Streams," *Journal of Business*, Vol. 51, 1978, pp. 453-475.

Singleton, K. J., "Specification and Estimation of Intertemporal Asset Pricing Model," in G. M. Friedman and F. H. Hahn, eds., *Handbook of Monetary Economics*, Vol. 1, 1990, pp. 583-626, North-Holland, Amsterdam.

Tauchen, G., "Statistical Properties of Generalized Method-of Moments Estimators of Structural Parameters Obtained from Financial Market Data," *Journal of Business and Economic Statistics,* Vol. 4, 1986, pp. 397-416.

Tobin, J., "A General Equilibrium Approach to Monetary Theory," *Journal of Money, Credit, and Banking,* Vol. 1, 1969, pp. 15-29.

Table 1: Industry Portfolio

Portfolio	Industry	Capitalization Weight (%) 1980/1Q	1997/1Q
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	Non-Metallic 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

Notes: 1. The real stock returns 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, Nagoya Stock Exchanges, and on the over-the-counter (OTC) market. It is adjusted for cross-share-holdings by *Keiretsu* firm group.

2. TOTAL is the average of quarterly real returns of 12 industry real returns (E1-E12), which is weighted by each capitalization value. All the returns are adjusted for seasonality and trading-day effects by the web-based program "DECOMP," whose main idea was originally developed by Kitagawa and Gersch (1984).

Table 2: Properties of the Data Set (1980/1Q- 1997/1Q)

A. Summary Statistics

	Mean	S. D	Min	Max	Skewness	Kurtosis	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. RHO(L) is the partial-autocorrelation coefficient and Q(L) is Ljung and Box's (1978) Q-statistic at lag length of L. The Q(L) static is distributed χ^2 (L) under the null hypothesis of no serial correlation. The *p*-values are reported in brackets.

B. 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”.

.

Table 3: The GMM Estimation Results of the Euler Equations and the Corresponding Volatility Bound Tests (1980/3Q-1997/1Q)

$E_t\left[M_{t,t+1}R^b_{t,t+1}\right]=1$ for the bond return.

and $E_t\left[M_{t,t+1}R^i_{t,t+1}\right]=1$. for the i-th stock return (i = 1,2,.....n),

where $M_{t,t+1}$ is the stochastic discount factor characterized by the investment return, $R^b_{t,t+1}$ is the real return on the government bond, and $R^i_{t,t+1}$ is the i-th real stock return.

A. Estimation Results Based on All Assets Returns

System	Info Set	β	J_T	DF	Implied Value of		Volatility Bound Test (δ)	
					Em	Mm	Portfolio A	Portfolio B
(1-1) BOND and TOTAL	Z1	13.400	9.879	7	0.986	0.971	-0.331	-0.448
		(1.983)	[0.196]				(-0.443)	(-1.007)
		[0.047]					[0.173]	[0.142]
(1-2) BOND and TOTAL	Z2	8.838	10.165	7	0.985	0.970	-0.479	-0.620
		(2.064)	[0.179]				(-1.445)	(-1.527)
		[0.039]					[0.074]	[0.063]
(2-1) BOND and E1-E12	Z1	15.349	14.126	51	0.986	0.972	-0.282	-0.391
		(14.234)	[0.999]				(-0.805)	(-0.943)
		[0.000]					[0.210]	[0.173]
(2-2) BOND and E1-E12	Z2	11.257	14.103	51	0.985	0.971	-0.394	-0.521
		(21.219)	[0.999]				(-1.140)	(-1.253)
		[0.000]					[0.127]	[0.105]

Notes: 1. Estimation of the Euler equations is based on Hansen's (1982) generalized method of moments (GMM). The information set Z1 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 Z2 contains the same variables as in Z1, but lagged twice. The t-values are reported in parentheses, which are calculated based on standard errors corrected by the Newey and West's (1987) method (a lag length of 4 is used). The corresponding p-values are reported in brackets. The J_T static 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. Em is the sample mean of the stochastic discount factor implied by the estimated value of β , and Mm 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 Mm 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.

B. Estimation Results Based on the Bond Return and each Industry Stock Return

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

Continued

System	Info set	β	J_T	DF	Implied Value of		Volatility Bound Test (δ)	
					Em	Mm	Portfolio A	Portfolio B
(11-1)BOND and E9	Z1	13.803	7.938	7	0.986	0.972	-0.321	-0.435
		(2.281)	[0.338]				(-0.912)	(-1.043)
		[0.023]					[0.181]	[0.149]
(11-2)BOND and E9	Z2	9.381	8.754	7	0.985	0.970	-0.458	-0.597
		(2.165)	[0.271]				(-1.367)	(-1.458)
		[0.030]					[0.086]	[0.072]
(12-1)BOND and E10	Z1	13.527	10.485	7	0.986	0.971	-0.328	-0.444
		(1.996)	[0.163]				(-0.933)	(-1.062)
		[0.046]					[0.175]	[0.144]
(12-2)BOND and E10	Z2	9.474	10.427	7	0.985	0.970	-0.455	-0.593
		(2.106)	[0.166]				(-1.354)	(-1.447)
		[0.035]					[0.088]	[0.074]
(13-1)BOND and E11	Z1	14.184	8.553	7	0.986	0.972	-0.311	-0.424
		(1.907)	[0.286]				(-0.884)	(-1.016)
		[0.057]					[0.188]	[0.155]
(13-2)BOND and E11	Z2	8.300	9.893	7	0.985	0.970	-0.500	-0.645
		(2.022)	[0.195]				(-1.530)	(-1.601)
		[0.043]					[0.063]	[0.055]
(14-1)BOND and E12	Z1	10.099	9.477	7	0.985	0.970	-0.433	-0.566
		(2.127)	[0.220]				(-1.273)	(-1.374)
		[0.033]					[0.102]	[0.085]
(14-2)BOND and E12	Z2	9.442	9.227	7	0.985	0.970	-0.456	-0.594
		(2.293)	[0.237]				(-1.359)	(-1.451)
		[0.022]					[0.087]	[0.073]

Notes: 1. Estimation of the Euler equations is based on Hansen's (1982) generalized method of moments (GMM). The information set Z1 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 Z2 contains the same variables as in Z1, but lagged twice. The *t*-values are reported in parentheses, which are calculated based on standard errors corrected by the Newey and West's (1987) method (a lag length of 4 is used). The corresponding *p*-values are reported in brackets. The J_T static 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. Em is the sample mean of the stochastic discount factor implied by the estimated value of β , and Mm 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 Mm 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 4: Estimation of Mispricing Coefficients (1980/3Q-1997/1Q)

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

and $$E_t\left[M_{t,t+1}(R^i_{t,t+1}-R^b_{t,t+1}+\varphi^i)\right]=0 \qquad \text{for the } i\text{-th stock return } (i = 1,2,.....n),$$

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

Pricing Error Coefficient	BOND and TOTAL		BOND and E1-E12	
	(1-1) BETA=13.400	(1-2) BETA=8.838	(2-1) BETA=15.349	(2-2) BETA=10.419
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]
φ_{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}			-0.0129 (-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) generalized 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 the Newey and West's (1987) method (a lag length of 4 is used here). The corresponding *p*-values are reported in brackets.

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

A. Production Growth
(i) OLS Single Regression

$$Production\ Growth_t = Constant + \gamma_{t-j} Return_{t-j} \quad \text{for } j = 0, 1, 2.$$

	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]

(ii) OLS Multiple Regression

$$Production\ Growth_t = Constant + \gamma_{t-1} Return_{t-1} + \gamma_{t-2} Return_{t-2}$$

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

B. Investment Growth
(i) OLS Single Regression

$$Investment\ Growth_t = Constant + \gamma_{t-j} Return_{t-j} \quad \text{for } j = 0, 1, 2.$$

	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]

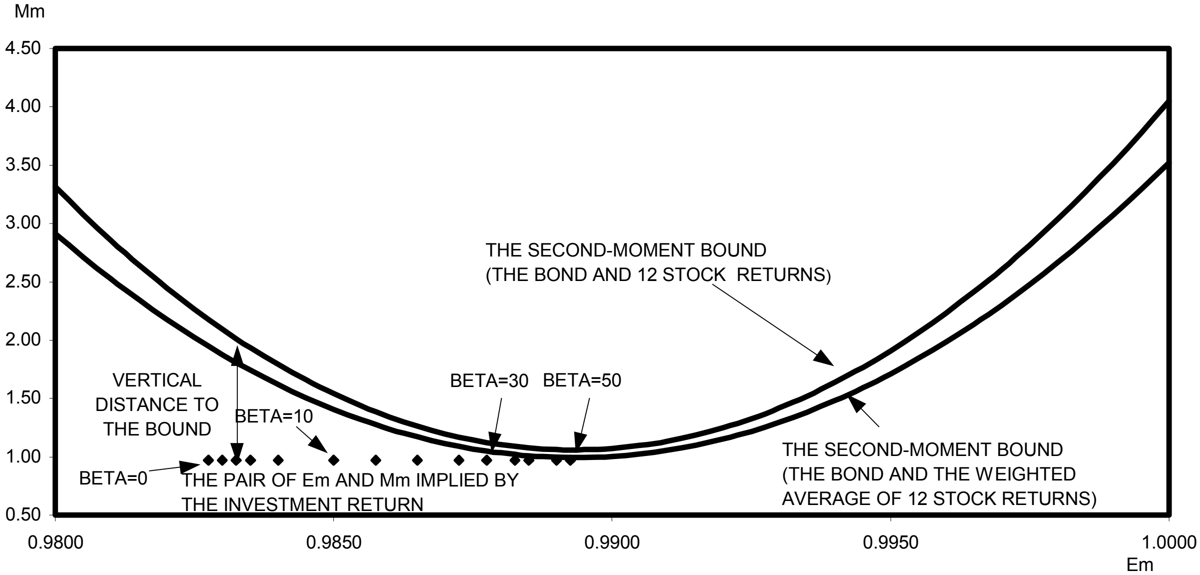
(ii) OLS Multiple Regression

$$Investment\ Growth_t = Constant + \gamma_{t-1} Return_{t-1} + \gamma_{t-2} Return_{t-2}$$

	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. Production 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 the marginal q, see equation (15).
3. The t-values are reported in parentheses and the corresponding p-values are reported in brackets.

Figure 1: The Second-Moment Volatility Bound and the Pair of Em and Mm Implied by the Japanese Investment Data



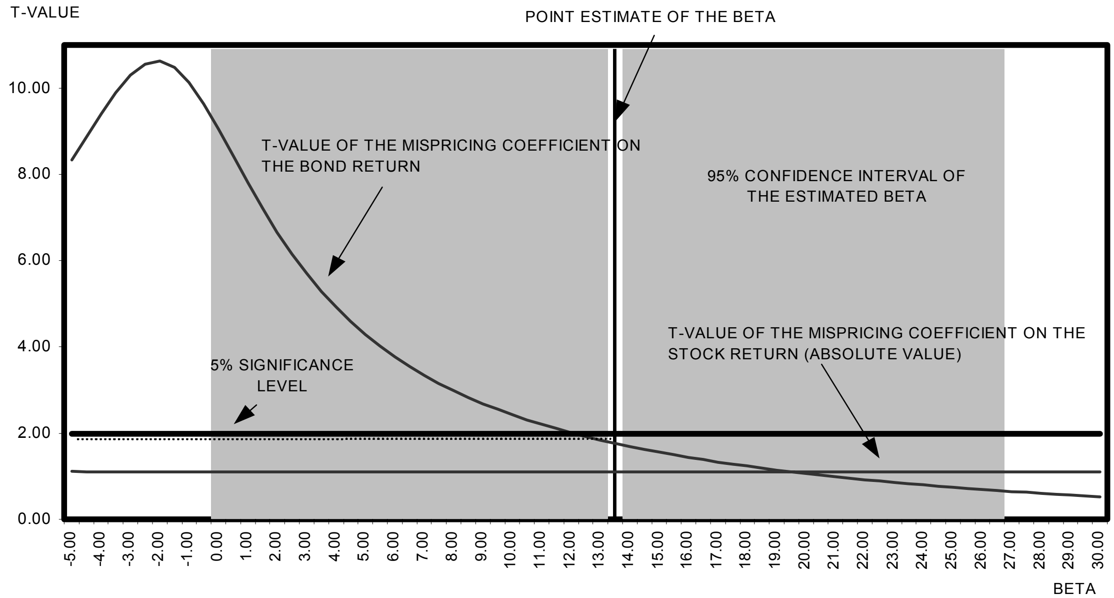
Notes: 1. Two versions of the second-moment volatility bound are computed. One is derived from the bond return and 12 individual industry stock returns and the other is from the bond return and the weighted average of these industry stock returns.

2. ♦ indicates the implied pair of the mean (Em) and the second-moment centered around zero (Mm) of the candidate stochastic discount factor calculated given each value of β.

Figure 4-2: The Relationship between the Values of β and the Mispricing Coefficients

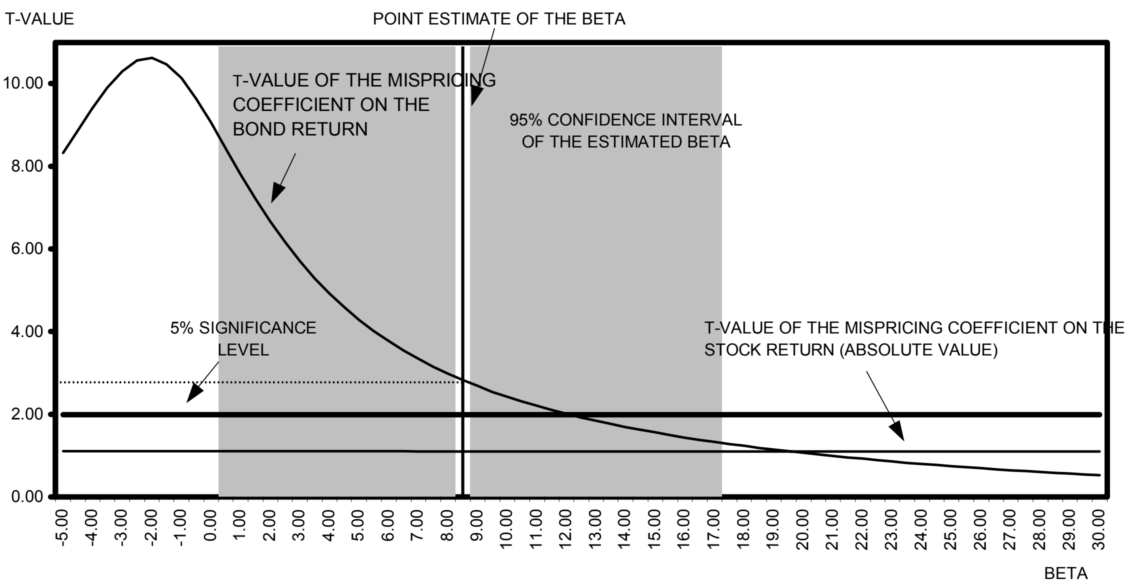
A. The System of the Bond and the Weighted Average of Stock Returns

(i) Using Z1 as the Information Set (System [1-1])



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

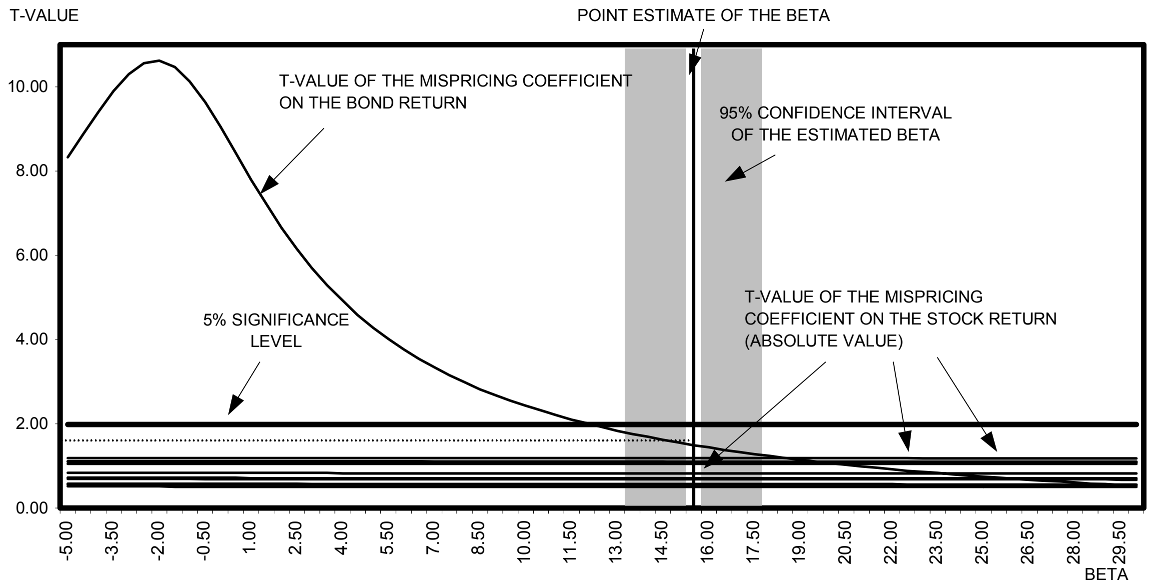
B. Using Z2 as the Information Set (System [1-2])



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

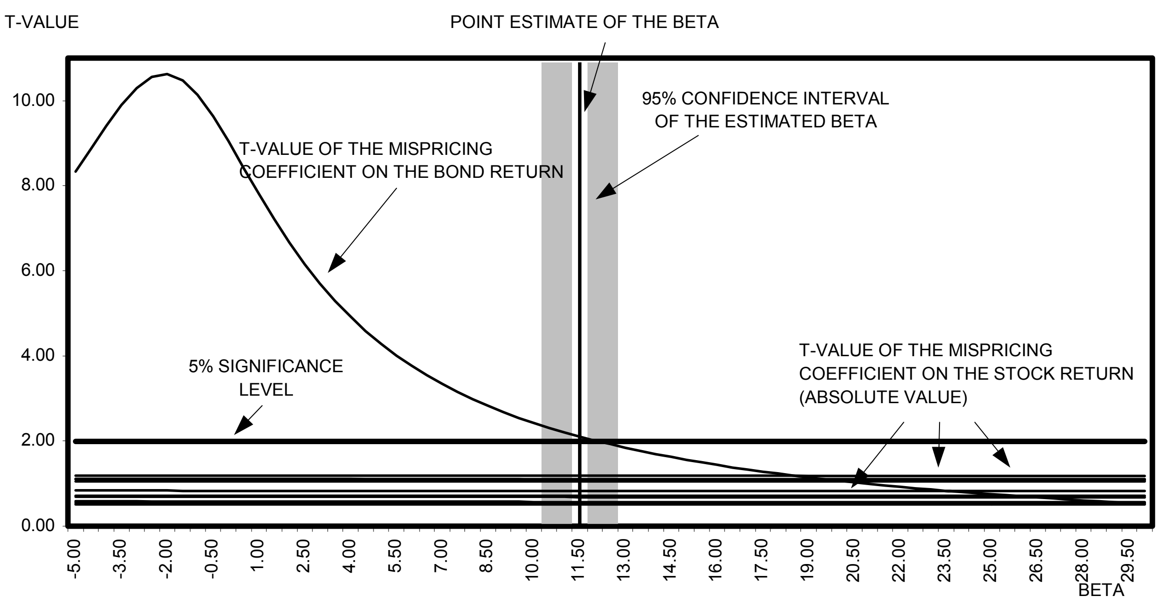
B. The System of the Bond and 12 Industry Stock Returns

(i) Using Z1 as the Information Set (System [2-1])



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

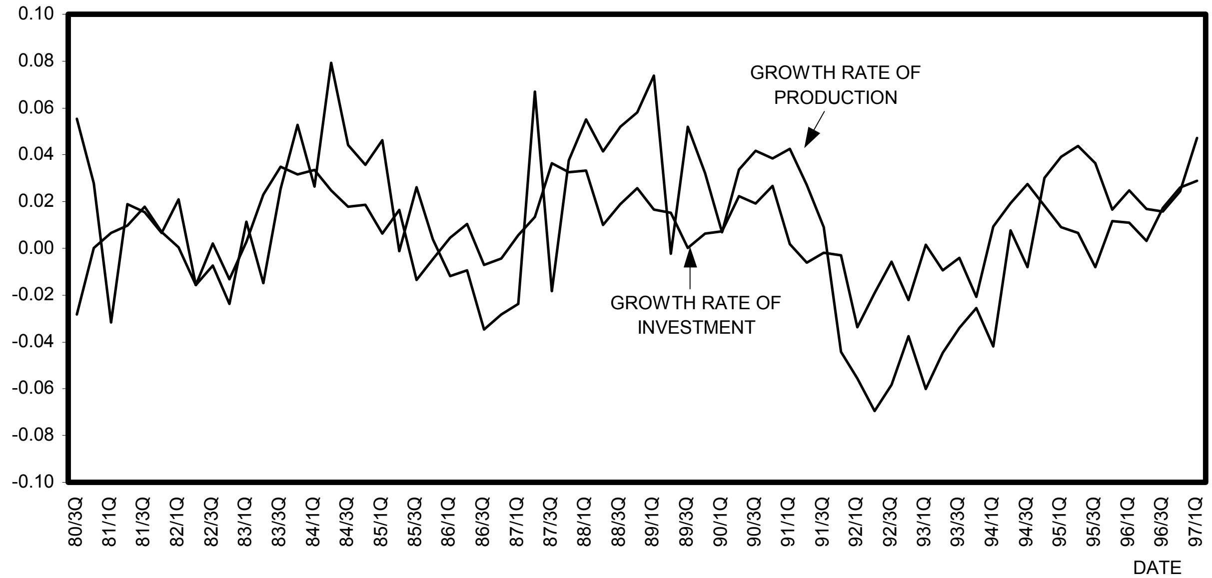
(ii) Using Z2 as the Information Set (System [2-2])



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

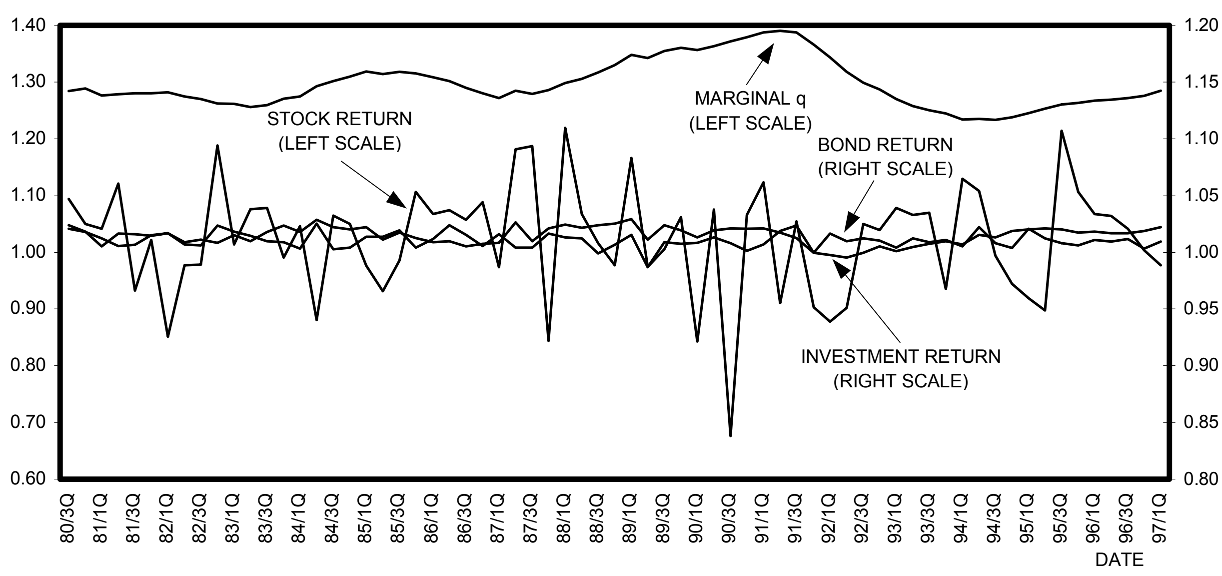
Figure 3: Production-Related Variables and the Investment Return

A. 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".

B. 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".