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Exploring the Role of Money in Asset Pricing in Japan: Does Monetary Consideration Significantly Improve the Empirical Performance of C-CAPM?

Naohiko Baba*

Abstract

This paper attempts to explore the role of money in asset pricing in Japan within a stochastic intertemporal framework. It compares the empirical performance of competing models including (i) the standard consumption-based CAPM (C-CAPM), (ii) the habit formation model, (iii) the money-in-the-utility model, and (iv) the cash-in-advance model. Empirical results based on the quarterly data of the period 1980-1998 show that in terms of the estimation of underlying parameters by Hansen's (1982) Generalized Method of Moments (GMM), the habit formation and the cash-in-advance models are significantly rejected in most cases, although no significant difference can be found in terms of the volatility bound test among models. The specification test between the standard C-CAPM and the money-in-the-utility model generally favors the latter model, implying that the proper stochastic discount factor should be characterized by money as well as by consumption data. Additionally, this paper empirically investigates possible market frictions in financial asset markets.

Key Words: Asset Pricing; CAPM; Money-in-the-Utility; Cash-in-Advance; Habit Formation; Volatility Bound; Market Frictions

JEL Classification: G12; E41; E21

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I. Introduction

As emphasized by Giovannini and Labadie (1991) and others, empirical regularities involving nominal interest rates, asset prices, and inflation should be determined by money. The role of aggregate money, however, is underemphasized, particularly in terms of empirical asset-pricing literature, although the relationship between asset prices and real macroeconomic variables such as aggregate consumption has been extensively investigated.

In fact, it is often argued that one possible reason for the rejection of the Consumption-based Capital Asset-Pricing Model (C-CAPM) is the absence of monetary consideration[1]. To be more specific, the C-CAPM puts monetary issues aside on the implicit assumption that transactions on the real side of the economy can be carried out frictionlessly without the aid of money. In this paper, I will deal with more realistic models in which money serves as a medium of exchange that reduces transaction costs. In this regard, I can state that the purpose of this paper is to examine the empirical performance of the so-called Money-based Capital Asset Pricing Model (M-CAPM) using the Japanese data set.

Also, it is often emphasized that the consumption data from whatever source exhibits non-negligible biases due to the fact that they are basically constructed from a sample survey. In this regard, money data have an advantage over consumption data, since the former can be fairly accurately grasped from the balance sheets of banks.

Theoretically speaking, however, because of the difficulty with regard to capturing the roles played by money, there is no universally accepted framework for understanding the microfoundations of money demand, that is, how to incorporate money in the representative agent's utility function. Debates over the appropriate model of money sometimes reflect an almost religious zeal. Hence, I prefer to take an eclectic stance between the competing specifications.

Empirically, Singleton (1985) and Poterba and Rotemberg (1987) investigated asset-pricing models that include both consumption and money balances. Also, recently, Holman (1998) examined the empirical relevance of the money-in-the-utility model by Hansen's (1982) Generalized Methods of Moments (GMM). And Chan, Foresi, and Lang (1996) provided an in-depth analysis of the M-CAPM via the tests such as Hansen and Jagannathan's (1991) volatility bound test as well as the parameter estimation by GMM. Unfortunately,

[1] Hamori (1992, 1994) was the first to apply the C-CAPM to the Japanese stock market and consumption data, concluding that it performed well over the period from the 1970s to the 1980s in terms of Hansen's (1982) Generalized Method of Moments (GMM)-based overidentifying restrictions test. Hori (1996) rejected the C-CAPM in terms of Hansen and Jagannathan's (1991) volatility bound test despite the fact that Hamori (1992, 1994) and Hori (1996) used very similar data sets. Since both types of the test frequently reject the C-CAPM in the case of the U.S. data, the coexistence of these paradoxical empirical results has been regarded as a characteristic of Japanese asset markets. Also, the

however, this preceding research examines only the U.S. data and, to my knowledge, there exists no research regarding the interaction between the representative agent's intertemporal monetary decisions about his or her resource allocation and various Japanese financial asset returns[2].

To formally test the empirical relevance of the role of money in asset pricing in Japan, this paper attempts to investigate the role of aggregate money by comparing the empirical performance of (i) the class of the C-CAPM including (a) the standard C-CAPM and (b) the habit formation model and (ii) the class of the M-CAPM derived from two types of monetary model, (a) the money-in-the-utility model and (b) the cash-in-advance model. In addition, this paper tries to empirically analyze the impact of frictions in asset markets such as the short-sale constraint, the borrowing constraint, and transaction costs by estimating the so-called mispricing coefficients, which are theoretically derived from the existence of these market frictions.

The rest of the paper is organized as follows. Section II presents the theoretical frameworks to be investigated empirically in this paper. Section III reviews empirical methodologies, including the estimation of underlying parameters by GMM, the specification test used to distinguish between competing models, Hansen and Jagannathan's (1991) volatility bound test, Hansen and Jagannathan's (1997) specification error test, and the mispricing test. Section IV describes the data. Section V reports the empirical results and their implications. Section VI concludes the paper.

II. Theoretical Frameworks

A. Assuming Frictionless Asset Market[3]

(i) Consumption-Based Capital Asset-Pricing Model (C-CAPM)

a. Standard Model

Let me begin with a standard C-CAPM. Assume that there exist N assets whose returns are stochastic. A representative agent chooses a stream of consumption[4] and quantity of each

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production-based CAPM (P-CAPM) ignores the existence of money. See Baba (2000) for the application of the P-CAPM to the Japanese data.

[2] Indeed, there exist very few empirical studies of money demand function itself using the recent Japanese data. In this regard, Fujiki and Mulligan (1996) provide the sole comprehensive study. They used Japanese prefecture data to estimate the parameters of the money demand function within a framework of household production technology.

[3] See Table 1 for overview of the basic structural formulation of utility maximization problems and Table 2 for empirical specifications of derived stochastic discount factors.

[4] As in the studies of many other researchers, by consumption I mean consumption expenditures of non-durables and services. The reason for the exclusion of durables and semi-durables is that they are typically consumed over many periods rather than just one. In fact, the consumption of these types of goods can be analyzed under the umbrella of intertemporally additive preferences just by imputing their rental costs. This paper, however, does not step into this area.

asset in order to maximize his or her expected discounted utility from consumption from today to the infinite future. The maximization problem for this representative agent can be written as

$$\underset{C_t}{\text{Max}} \quad U_t = E_t\left[\sum_{s=t}^{\infty} \beta^{s-t} u(C_s)\right] \qquad\qquad 0 < \beta < 1 \tag{1}$$

$$\text{s.t.} \qquad \sum_{i=1}^{N} q_t^i Q_{t+1}^i = \sum_{i=1}^{N} \left(q_t^i + d_t^i\right) Q_t^i + Y_t - C_t - T_t\,^{5}, \tag{2}$$

where E_t is the expectation operator that is conditional on the information set available at the start of period *t*, β the subjective discount factor, C_t real consumption in period *t*, q_t^i the period *t* price of asset *i*, d_t^i the dividend (return) of asset *i*, Q_t^i the quantity of asset *i* given at the start of period *t*, Y_t the labor income (output), and T_t the lump sum tax.

Maximizing problem (1) subject to budget constraint (2) yields the following set of Euler equations:

$$E_t\left[m_{t,t+1}^C R_{t,t+1}^i - 1\right] \equiv E_t\left[\beta \frac{u'(C_{t+1})}{u'(C_t)} R_{t,t+1}^i - 1\right] = 0, \qquad \text{for asset } i \ (i=1,2,...N), \tag{3}$$

where I made use of the definition of the gross return $R_{t,t+1}^i = \left(q_{t+1}^i + d_{t+1}^i\right)/q_t^i$ and $m_{t,t+1}^C$ denotes the intertemporal marginal rate of substitution between period *t*+1 and *t*. Now, the Euler equation for asset *i* (3) implies that

$$q_t^i = E_t\left[\sum_{s=t+1}^{\infty} \beta^{s-t} \frac{u'(C_{s+1})}{u'(C_s)} d_{s+1}^i\right]. \tag{4}$$

Here, notice that any asset price can be thought of as the value of the future stream of dividends discounted by $m_{t,t+1}^C$. Thus, $m_{t,t+1}^C$ is also called the stochastic discount factor or the pricing kernel.

Suppose that the period utility function takes the form:

$$u(C_t) = \frac{C_t^{1-\rho}}{1-\rho} \qquad\qquad 0 \le \rho\,^{6}, \tag{5}$$

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[5] Note that Q_t^i is predetermined at the start of period *t*.

where $\rho \equiv -Cu''(C)/u'(C)$ denotes the Arrow-Pratt coefficient of relative risk aversion[7] and unlike the certainty-equivalent permanent income hypothesis, this specification yields convex marginal utility, implying that there is a precautionary motive for saving[8].

Thus, one can rewrite the Euler equation for asset *i* as follows:

$$E_t\left[m_{t,t+1}^C R_{t,t+1}^i - 1\right] \equiv E_t\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\rho} R_{t,t+1}^i - 1\right] = 0\,. \tag{6}$$

b. The Habit Formation Model

One promising variation of the standard C-CAPM is to allow for nonseparability in utility over time. Among others, Constantinides (1990) and Sundaresan (1989) have emphasized the importance of habit formation, which is defined as a positive effect of today's consumption on tomorrow's marginal utility of consumption.

Now, let me write the period utility function as $u(C_t, X_t)$, where X_t denotes the time-varying habit or subsistence level. Abel (1990, 1999) has argued that $u(C_t, X_t)$ should be a power function of the ratio C_t/X_t, and I follow this specification in this paper[9].

Generally speaking, there are two forms regarding the effect of an agent's own decisions on future levels of habit. One is called the internal-habit formation model, as proposed by Constantinides (1990), for example, in which habit depends upon the agent's own consumption and the agent takes account of this when choosing his or her consumption. The other is called the external-habit formation model, as suggested by Abel (1990, 1999)[10] and Campbell and Cochrane (1999), in which habit depends upon aggregate consumption that is unaffected by any individual agent's own decisions.

Here, suppose that an agent's utility can be written as

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[6] This type of utility function is called the constant relative risk aversion (CRRA) class of function. In the case where $\rho \to 1$, this class of utility function reduces to $u(C_t) = log(C_t)$. Note that, as fully documented by Obstfeld and Rogoff (1996), one really has to write the period utility function as $u(C_t) = \left(C_t^{1-\rho} - 1\right)/(1-\rho)$ to converge it to logarithmic as $\rho \to 1$.

[7] $1/\rho$ means the intertemporal substitution elasticity. A consumer is said to be risk neutral when $u''(C) = 0$, implying that $\rho = 0$.

[8] See Romer (1996) for details.

[9] Instead, Campbell and Cochrane (1999) and Constantinides (1990) have proposed a power function of the difference $C_t - X_t$.

[10] Abel (1990, 1999) calls it *catching up with Jones*.

$$u(C_t) = \frac{(C_t / X_t)^{1-\rho}}{1-\rho}, \tag{7}$$

where X can be specified as an internal or an external habit. Using one lag of consumption for simplicity, one can get the internal-habit formation as

$$X_t = \overline{C}_{t-1}^{k} \qquad 0 < k < 1, \tag{8}$$

where $\overline{C}_{t-1}$ denotes the aggregate past consumption level and the parameter k governs the degree of time-nonseparability. Since there is a representative agent, in equilibrium aggregate consumption equals the agent's own consumption, that is,

$$X_t = C_{t-1}^{k}, \tag{9}$$

With this specification in mind, the Euler condition for asset i can be written as

$$E_t\left[m_{t,t+1}^{H} R_{t,t+1}^{i} - 1\right] \equiv E_t\left[\beta \left(\frac{C_t}{C_{t-1}}\right)^{k(\rho-1)} \left(\frac{C_{t+1}}{C_t}\right)^{-\rho} R_{t,t+1}^{i} - 1\right] = 0. \tag{10}$$

(ii) The Role of Money in Asset-Pricing Models

a. A Brief Review of the Theoretical Treatment of Money

Before proceeding to the theoretical foundation of the M-CAPM, let me clarify the scope of the monetary models which are used in empirical studies in this paper. In this context, I believe that a brief review of theoretical treatments of money in the literature is of some help[11].

The first type of model I refer to is an overlapping generations model, which was originally developed by Samuelson (1958)[12]. One of the main distinguishing features of this class of model is that it can generate an endogenous demand for money entirely out of its store-of-value role, and thus there is no room for any *ad hoc* transactions technology. A defect of this class of model, on the other hand, is that the period of decision making, which amounts

[11] On this topic, Kocherlakota (1998), Wallace (1998), and Obstfeld and Rogoff (1996) provide excellent surveys.

[12] See Freeman (1996) for the application of this class of model..

to half a lifetime, seems quite incompatible with the frequency with which agents actually make decisions about money holdings[13].

In fact, the so-called turnpike model proposed by Townsend (1980) can avoid this problem. Recapping the essence of the model in words of Kocherlakota (1998), in a turnpike model, the transfers in any stationary monetary equilibrium are an equilibrium path of transfers in a gift-giving game. Put more plainly, money serves as an imperfect mnemonic device. As suggested by Hurwicz (1980), however, one must be careful about attributing the defects of particular trading arrangements to money. In this context, the failure to allocate resources efficiently is not due to some weakness in money itself, but rather to a defect in the procedure that individuals use to exchange goods for money.

Here, it should be noted that neither the overlapping generations model nor the turnpike model successfully captures one of the most traditional reasons agents hold money, that is, to get over an absence of a double coincidence of wants[14]. In their seminal paper, Kiyotaki and Wright (1991) developed a model that emphasizes the microfoundations of market trading structures, showing that money can arise as a social convention that improves on the barter equilibrium.

Lastly, McCallum and Goodfriend (1987) derive the demand for money solely from the medium-of-exchange role of money by assuming that to acquire consumption goods agents must expend time and energy in shopping. The amount of time and energy so spent depends positively upon the volume of consumption, but for any given volume, this amount is reduced by additional money holdings. This effect occurs because these money holdings facilitate transactions[15]. Also, money can be held due to the precautionary motive of wishing to prepare for unexpected expenditures in the future, which is usually included in the transactions demand for money.

As I remarked earlier, at least up to today, one can find no universally accepted approach to modeling the microfoundations of money. Also, since the most important motivation of this paper lies in the empirical assessment of the role of money in an asset-pricing context, I prefer to use functional forms that are manageable in empirical analysis and at the same time can encompass a representative motive for holding money, that is, the transactions and precautionary money demands.

[13] Another noteworthy drawback suggested by Wallace (1998) is that the store-of-value role generates a demand for money if and only if agents have no other remunerative alternative such as capital, bonds, or foreign lending

[14] In this regard, Wallace (1997) provides a concise survey.

[15] As will be mentioned a little later, McCallum and Goodfriend's (1987) shopping time model can be included in the category of the money-in-the-utility model.

b. Basic Assumptions regarding the Scope of Money

First, unless otherwise stated, money indicates currency in this paper. By currency I mean currency in circulation and/or deposit money, both of which are used in everyday transactions. Hence, the theoretical discussion can abstract from the banking system and from any devices such as checks and credit cards. By focusing upon a narrow interpretation of money, I believe that the models become simpler and their implications more transparent.

Second, I assume that currency does not bear interest. The reason for this treatment is that since my purpose is to explore the role of money in asset pricing, interest-bearing money should be categorized as assets rather than money.

c. Directly Including Money in the Utility Function

Now assume that the representative agent holds money because real balances are an argument of the utility function. Forming the basis for this approach is the implicit assumption that the agent gains utility from both consumption and leisure. That is, holding real balances allows the agent to save time in conducting his or her transactions. Although there are arguments regarding the microeconomic foundation of this approach, it is considered to implicitly capture the essence of money's role as a medium of exchange[16].

In general form, the agent's maximization problem can be written as

$$\underset{C_t,\, M_t}{\text{Max}} \quad U_t = E_t\left[\sum_{s=t}^{\infty} \beta^{s-t} u\left(C_s, \frac{M_s}{P_s}\right)\right] \tag{11}$$

s.t. $$\sum_{i=1}^{N} q_t^i Q_{t+1}^i + \frac{M_t}{P_t} = \sum_{i=1}^{N} \left(q_t^i + d_t^i\right) Q_t^i + \frac{M_{t-1}}{P_t} + Y_t - C_t - T_t, \tag{12}$$

where it is assumed that $u_C > 0$, $u_{M/P} > 0$ and that $u(C, M/P)$ is strictly concave.

Now the first-order conditions for $s=t+1$ can be derived as

$$E_t\left[u_C\left(C_t, \frac{M_t}{P_t}\right)\right] = E_t\left[\beta u_C\left(C_{t+1}, \frac{M_{t+1}}{P_{t+1}}\right) R_{t,t+1}^i\right] \quad \text{for asset } i \ (i=1,2,\ldots N), \tag{13}$$

[16] Feenstra (1986) demonstrated a functional equivalence between including money directly in the utility function and entering it into the liquidity costs that appear in the budget constraint. The liquidity costs can be derived from the transactions and precautionary motives for holding money. Hence, the money-in-the-utility model can capture wider roles of money than the mere cash-in-advance model, which focuses upon only the role of mitigating transaction costs, as suggested by Stockman (1989).

and $$E_t\left[\frac{1}{P_t}u_C\left(C_t,\frac{M_t}{P_t}\right)\right]=E_t\left[\frac{1}{P_t}u_{M/P}\left(C_t,\frac{M_t}{P_t}\right)\right]+E_t\left[\frac{1}{P_{t+1}}\beta u_C\left(C_{t+1},\frac{M_{t+1}}{P_{t+1}}\right)\right]$$

for money balances. (14)

As suggested by Obstfeld and Rogoff (1996), from an individual's perspective, money can be thought of as a nontraded durable good, and the two Euler conditions (13) and (14) highlight this analogy. Condition (13) can be regarded as the standard first-order condition in the presence of a nontraded good that enters additively into period utility. On the other hand, on the left-hand side of condition (14), $1/P_t$ denotes the quantity of current consumption that the agent must forgo to raise money by another currency unit, and $u_C(C_t, M_t/P_t)$ is the marginal utility of that consumption. The first term on the right-hand side is the marginal utility that the agent gets from having another unit of currency with which to conduct transactions. Breaking down the second term on the right-hand side, $1/P_{t+1}$ is the quantity of consumption the agent will be able to buy in period t+1 with the extra currency unit, and $\beta u_C(C_{t+1}, M_{t+1}/P_{t+1})$ is the marginal utility of period t+1 consumption, which is discounted to period t.

Now these conditions can be rewritten as

$$E_t\left[m^{MU}_{t,t+1}R^i_{t,t+1}-1\right]\equiv E_t\left[\beta\frac{u_C(C_{t+1},M_{t+1}/P_{t+1})}{u_C(C_t,M_t/P_t)}R^i_{t,t+1}-1\right]=0\,, \tag{15}$$

and $$E_t\left[m^{MU}_{t,t+1}\left(\frac{P_t}{P_{t+1}}\right)\right]\equiv E_t\left[\beta\left(\frac{P_t}{P_{t+1}}\right)\frac{u_C(C_{t+1},M_{t+1}/P_{t+1})}{u_C(C_t,M_t/P_t)}\right]=1-\frac{u_{M/P}(C_t,M_t/P_t)}{u_C(C_t,M_t/P_t)}\,. \tag{16}$$

Suppose that the period utility takes the functional form[17]:

$$u\left(C_t,\frac{M_t}{P_t}\right)=\frac{\left[C_t^{\gamma}\left(M_t/P_t\right)^{1-\gamma}\right]^{1-\rho}}{1-\rho}\qquad 0<\gamma<1 \text{ and } 0<\rho\,, \tag{17}$$

where equation (17) assumes a constant substitution elasticity γ between consumption and real balances.

Now Euler equations (15) and (16) can be rewritten as[18]

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[17] As will be explained later, the use of this functional form suggests that the standard C-CAPM is a special case of the money-in-the-utility model so that one can test the relevance of money in the agent's utility function by the size and significance of the parameter γ after imposing the same value on other parameters β and ρ estimated by the standard C-CAPM.

$$E_t\left[m^{MU}_{t,t+1}R^i_{t,t+1}-1\right]=E_t\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{\gamma(1-\rho)-1}\left(\frac{M_{t+1}}{M_t}\frac{P_t}{P_{t+1}}\right)^{(1-\gamma)(1-\rho)}R^i_{t,t+1}-1\right]=0\,, \tag{18}$$

and

$$\begin{aligned}&E_t\left[m^{MU}_{t,t+1}R^i_{t,t+1}\left(\frac{P_t}{P_{t+1}}\right)+\frac{u_{M/P}(C_t,M_t/P_t)}{u_C(C_t,M_t/P_t)}-1\right]\\&=E_t\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{\gamma(1-\rho)-1}\left(\frac{M_{t+1}}{M_t}\frac{P_t}{P_{t+1}}\right)^{(1-\gamma)(1-\rho)}\left(\frac{P_t}{P_{t+1}}\right)+\left(\frac{1-\gamma}{\gamma}\right)\left(\frac{P_tC_t}{M_t}\right)-1\right]=0\end{aligned}\,. \tag{19}$$

d. The Cash-in-Advance Model

Another popular way to model the relationship between asset returns and money is to assume a cash-in-advance constraint, a method which was introduced by Clower (1967). Although there are several variations, the central assumption is the same: money must be used to purchase goods, or at least some specified subset of goods. The cash-in-advance model is in essence a very extreme transactions-technology model in which money does not simply economize on transactions, but is also essential for carrying out any transactions. One appeal of cash-in-advance models is that they can deliver extremely tractable money demand functions while preserving the central advantages of an approach based on microfoundations.

In the most ordinary variant of the cash-in-advance model[19], the representative agent must acquire cash by the end of period t-1[20] that is sufficient to cover all consumption expenditures he or she plans to make in period t.

Formally, the agent's maximization problem can be written as

[18] Note that if one assumes that there is only one financial asset except for money, that is, a bond that bears a certain real net interest rate $r_{t,t+1}$, then, in the case s=t+1, conditions (13) and (14) can be jointly expressed as

$$\frac{u_{M/P}(C_t,M_t/P_t)}{u_C(C_t,M_t/P_t)}=1-\frac{1}{1+r_{t,t+1}}\frac{P_t}{P_{t+1}}=\frac{i_{t,t+1}}{1+i_{t,t+1}}\,,$$

under the assumption that the following Fisher parity holds: $1+i_{t,t+1}=(1+r_{t,t+1})P_{t+1}/P_t$.
One can think of this equation, which relates the marginal rate of substitution between real balances and consumption to the nominal interest rate, as the money demand function in a stationary equilibrium. Then, specification (17) yields the following money demand function:

$$\frac{M_t}{P_t}=\left(\frac{1-\gamma}{\gamma}\right)\left(1+\frac{1}{i_{t,t+1}}\right)C_t\,,$$

where the preceding equation has the same general form as the Keynes-Hicks LM curve, except that consumption rather than income captures the transaction demand for money.

[19] In fact there are ample studies of the cash-in-advance model. See, for example, Bohn (1991), Hodrick, Kocherlakota, and Lucas (1991), and Lucas and Stokey (1987).

[20] In other words, he or she must have necessary cash at the start of period t.

$$\max_{C_t} \quad U_t = E_t\left[\sum_{s=t}^{\infty} \beta^{s-t} u(C_s)\right] \tag{20}$$

$$\text{s.t.} \quad \sum_{i=1}^{N} q_t^i Q_{t+1}^i + \frac{M_t}{P_t} = \sum_{i=1}^{N} \left(q_t^i + d_t^i\right) Q_t^i + \frac{M_{t-1}}{P_t} + Y_t - C_t - T_t, \tag{21}$$

and $$M_{t-1} \geq P_t C_t, \tag{22}$$

where equation (21) is the same period budget constraint as in the money-in-the-utility model and inequality (22) is the additional cash-in-advance constraint[21]. Here, note that if the nominal interest rate is positive, the cash-in-advance constraint always binds: the agent never holds money in excess of the current period's consumption when he or she could instead earn a higher return by lending the cash out. If attention is restricted to equilibria with a positive nominal interest rate, then

$$M_{t-1} = P_t C_t \tag{23}$$

always holds, and one can use this equality to eliminate M_t and M_{t-1} from equation (21), leaving the simplified budget constraint:

$$\sum_{i=1}^{N} q_t^i Q_{t+1}^i = \sum_{i=1}^{N} \left(q_t^i + d_t^i\right) Q_t^i + Y_t - \frac{P_{t+1}}{P_t} C_{t+1} - T_t, \tag{24}$$

where the second term on the right-hand side of this equation is derived by the substitution $M_{t+1}/P_t = \left(P_{t+1}/P_t\right) C_{t+1}$ .The intertemporal Euler equation for asset *t* is then derived by

$$E_t\left[\frac{P_t}{P_{t+1}} u'\left(C_{t+1}\right) q_t^i\right] = E_t\left[\beta \frac{P_{t+1}}{P_{t+2}} u'\left(C_{t+2}\right)\left(q_{t+1}^i + d_{t+1}^i\right)\right]. \tag{25}$$

To understand the difference between equation (25) and the usual consumption Euler equation (3), note that consumption involves an additional cost here, since the agent must wait one full period between the period in which he or she converts assets or output into cash and the period in which he or she actually consumes[22].

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[21] This is the original form of the cash-in-advance constraint introduced by Clower (1967). Helpman (1981) and Lucas (1982), however, reformulate the cash-in-advance constraint as $M_t \geq P_t C_t$ so that people acquire the cash they need for the current period by first visiting asset markets at the beginning of the period, after current period shocks have been observed.

[22] In a stationary equilibrium with constant money growth, nominal returns and the implied consumption tax are constant, so equation (25) boils down to the usual consumption Euler equation.

Using the definition of gross return as in the case of the standard C-CAPM, the preceding equation can be rewritten as

$$E_t\left[m_{t,t+1}^{CA} R_{t,t+1}^i - 1\right] \equiv E_t\left[\beta \frac{P_{t+1}}{P_{t+2}} \frac{P_{t+1}}{P_t} \frac{u'(C_{t+2})}{u'(C_{t+1})} R_{t,t+1}^i - 1\right] = 0 . \tag{26}$$

In this case, let me use the same CRRA class of utility function (5) as in the standard C-CAPM in order to facilitate comparison of their performance.

Thus, the Euler equation for the cash-in advance model can be rewritten as

$$E_t\left[m_{t,t+1}^{CA} R_{t,t+1}^i - 1\right] = E_t\left[\beta\left(\frac{M_{t+1}}{M_t} \frac{P_{t+1}}{P_{t+2}}\right)^{-\rho} \frac{P_{t+1}}{P_t} \frac{P_{t+1}}{P_{t+2}} R_{t,t+1}^i - 1\right] = 0 . \tag{27}$$

B. Allowing for Friction in Asset Markets

The above-mentioned theoretical implications are derived from the assumption that there are no market frictions. As is well recognized, however, in practice, there are quite a few frictions in financial assets markets. Does the existence of those frictions alter the testable theoretical implications and if it does, how? In what follows, based on He and Modest (1995)[23], I pick up three types of market friction and see how each one of them alters the discussion above.

(i) Short-Sale Constraints

If there exist short-sale constraints, the agent solves his or her maximization problem subject to an additional constraint such that the holdings of some assets cannot be negative. Now let A denote the subset of assets that cannot be sold short and A^c its complement set. The equilibrium Euler conditions are now replaced by

$$E_t\left[m_{t,t+1} R_{t,t+1}^i\right] = 1 \qquad \text{for } i \in A^c , \tag{28}$$

and $$E_t\left[m_{t,t+1} R_{t,t+1}^i\right] \leq 1 \qquad \text{for } i \in A . \tag{29}$$

Hence, returns on assets with no short-sale constraints ($i \in A^c$) satisfy the same equality Euler equation as before. The inequality restriction for the complement set may be strict. It is due to

[23] On this topic, see also Luttmer (1996).

the fact that in equilibrium there is a possibility that the agent may hold a zero amount of those assets, which corresponds to the corner solution.

(ii) Borrowing Constraints

In the case of borrowing constraints, the agent is not allowed to consume more than his or her current wealth or, equivalently, his or her financial wealth must always be nonnegative. This conjecture yields the following conditions:

$$E_t\left[m_{t,t+1}\left(R^i_{t,t+1} - R^j_{t,t+1}\right)\right] = 0 \qquad \text{for } \forall\, i,\, j, \tag{30}$$

and $$E_t\left[m_{t,t+1} R^i_{t,t+1}\right] \le 1 \qquad \text{for } \forall\, i. \tag{31}$$

The strict inequality in (31) may hold also in the case where the consumption plan at the optimum may be the corner solution[24].

(iii) Transaction Costs

The conditions above can be obtained when there are no transaction costs like taxes. In practice, however, transaction costs probably affect equilibrium asset returns. Here, let B denote the subset of assets that needs transaction costs and B^c the complement set. It turns out that when there are transaction costs in purchasing assets,

$$E_t\left[m_{t,t+1} R^i_{t,t+1}\right] = 1 \qquad \text{for } i \in B^c, \tag{32}$$

and $$E_t\left[m_{t,t+1} R^i_{t,t+1}\right] \le \frac{1+\pi^i}{1-\pi^i} \qquad \text{for } i \in B, \tag{33}$$

where transaction costs are assumed to be paid for in proportion to the amount traded and π^i denotes the proportional costs for purchasing asset $i \in B$.

Similarly, when there are transaction costs in selling assets,

$$E_t\left[m_{t,t+1} R^i_{t,t+1}\right] = 1 \qquad \text{for } i \in C^c, \tag{34}$$

and $$\frac{1-\lambda^i}{1+\lambda^i} \le E_t\left[m_{t,t+1} R^i_{t,t+1}\right] \qquad \text{for } i \in C, \tag{35}$$

[24] Solvency constraints are closely related to borrowing constraints except for the fact that solvency constraints put restrictions on wealth in the next period rather than on current consumption. For a further discussion of this distinction, see Cochrane and Hansen (1992).

where λ^i denotes the proportional costs for selling asset $i \in C$. It should be noted that all these inequalities derived above may be strict and they also hold in unconditional form[25].

III. Empirical Methodologies

This section reviews the empirical strategy used in this paper. Table 3 provides an overview of the procedures. First, assuming frictionless financial markets, I conduct tests based solely on each model, which includes the GMM estimation of the underlying parameters, the *J*-test for overidentifying restrictions, Hansen and Jagannathan's (1991) volatility bound test, and Hansen and Jagannathan's (1997) specification error test. These tests are meant to verify the relevancy of each independent model without any constraints.

Second, as explained in Section II, the standard C-CAPM can be viewed as a special case of other models such as the habit formation and the money-in-the-utility models. Hence, at least regarding these models, one can perform specification tests between the standard C-CAPM and each of these models by imposing the estimated standard C-CAPM parameters on each model.

Unfortunately, one cannot conduct this kind of specification tests between the cash-in-advance model and other competing models as well as between the habit formation model and the money-in-the-utility model. It turns out, however, that in most cases, the cash-in-advance model is rejected due to the violation of the required range of the parameters, and at the same time, the habit formation model is found to be rejected for the same reason. Thus, putting them together, the model favored by the specification test between the standard C-CAPM and the money-in-the-utility model can be thought of as the most acceptable for a given data set[26].

Third and lastly, in order to detect friction in asset markets, I perform the mispricing tests by imposing the stochastic discount factor derived by each model on the individual Euler equation for each asset return.

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[25] For the formal proof of equilibrium conditions in the presence of transaction costs, see He and Modest (1995).

[26] Of course, one cannot rule out the possibility that the rejection of both the habit formation model against the standard C-CAPM and the standard C-CAPM against the money-in-the-utility model might yield the rejection of the money-in-the-utility model against the habit formation model. In this regard, the analysis in this paper might not be completely robust. To present the test method that overcomes this point is one of my future tasks.

A. The GMM-based Test of Euler Equations

(i) Estimation of Underlying Free Parameters

The Generalized Method of Moments (GMM) proposed by Hansen (1982) is known to be especially convenient when it comes to testing the dynamic properties of a stochastic discount factor model.

Basically, all one has to do is scale the period t+1 returns by any variables that are included in the information set as of period t. Now let me define an K-dimensional error vector $\mathbf{e}_{t+1}$ such that $E(\mathbf{e}_{t+1} \mid \mathbf{Z}_t) = 0$ from the Euler conditions, where $\mathbf{Z}_t$ is the R-dimensional vector of instrumental variables[27]. Next, define the KxR-dimensional vector $\mathbf{g}_t$ such that $\mathbf{g}_t = \mathbf{e}_{t+1} \otimes \mathbf{Z}_t$, where $\otimes$ denotes the Kronecker product. By the law of iterated expectation, it follows that

$$E(\mathbf{g}_t) = E[E_t(\mathbf{g}_t)] = E[E_t(\mathbf{e}_{t+1} \otimes \mathbf{Z}_t)] = E[E_t(\mathbf{e}_{t+1}) \otimes \mathbf{Z}_t] = 0 . \tag{36}$$

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

$$\overline{\mathbf{g}}_T = \frac{1}{T} \sum_{t=1}^{T} \mathbf{g}_t . \tag{37}$$

Under this setting, the GMM estimates $\hat{\theta}$ are obtained by

$$\hat{\theta} = \arg\min_{\theta} \overline{\mathbf{g}}_T \,' \mathbf{W}_T \; \overline{\mathbf{g}}_T , \tag{38}$$

where $\mathbf{W}_T$ denotes the weight matrix[28]. Hansen (1982) showed that if one chooses a consistent estimate of the covariance matrix of the sample pricing errors $\overline{\mathbf{g}}_T$ as $\mathbf{W}_T$, the GMM estimator is optimal in the sense that this variance matrix is as small as possible.

(ii) Hansen's *J*-test for Overidentifying Restrictions

Hansen (1982) has also shown that the minimized value of the quadratic form $\overline{\mathbf{g}}_T \,' \mathbf{W}_T \; \overline{\mathbf{g}}_T$ times the number of observation T, called the J-statistic, is χ^2 distributed under the null

[27] The choice of instrumental variables will be discussed in Section IV.
[28] Throughout the paper, the TSP (Time Series Processor: version 4.4) algorithm for GMM is used for estimation.

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[29].

B. Other Diagnostic Tests on the Derived Stochastic Discount Factors

(i) Hansen and Jagannathan's (1991) Volatility Bound Test[30]

a. The Basic Framework

In their seminal paper, Hansen and Jagannathan (1991) proposed a set of restrictions in terms of a volatility bound derived from the Euler conditions for equilibrium asset pricing. If the candidate stochastic discount factor does not generate enough volatility, then it will lie outside Hansen and Jagannathan's volatility bound, which leads to the judgement that the asset-pricing model is inconsistent with the asset market data.

Hansen and Jagannathan's volatility bound can be expressed as

$$Var(m) \geq (\mathbf{1} - E[m]E[\mathbf{R}])' \boldsymbol{\Sigma}_R^{-1} (\mathbf{1} - E[m]E[\mathbf{R}]), \tag{39}$$

where m is the stochastic discount factor in general, $\mathbf{R}$ is the vector of asset returns, and $\boldsymbol{\Sigma}_R$ 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. Now, imposing the Euler conditions into the projection condition yields[31]

$$E[m^2] \geq (E[m] \quad \mathbf{1}')\mathbf{M}_R^{-1}\begin{pmatrix} E[m] \\ \mathbf{1} \end{pmatrix}, \tag{40}$$

where $\mathbf{M}_R \equiv E\left[\tilde{\mathbf{R}}\tilde{\mathbf{R}}'\right]$ and $\tilde{\mathbf{R}}' \equiv (1 \quad \mathbf{R}')$. Now let me form the estimate:

$$\hat{\mathbf{M}}_R = \frac{1}{T}\sum_{t=1}^{T} \tilde{\mathbf{R}}_t \tilde{\mathbf{R}}_t', \tag{41}$$

which allows the formation of an estimated bound such that

[29] In plain words, the *J*-statistic tests whether the estimated error of an investor's forecast is uncorrelated with any instrumental variable in the information set available at the time of the forecast. A high value of this statistic indicates a high probability that the model is misspecified.

[30] Craig (1994) provides an excellent survey on this topic. In what follows, I follow his explanation.

[31] To be precise, basic Euler conditions for financial assets are imposed on the projection condition.

$$\left(E[m] \quad \mathbf{1}'\right)\hat{\mathbf{M}}_R^{-1}\begin{pmatrix} E[m] \\ \mathbf{1} \end{pmatrix}. \tag{42}$$

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

$$\overline{m} = \frac{1}{T}\sum_{t=1}^{T} m_t \,, \tag{43}$$

and
$$\hat{m}_m = \frac{1}{T}\sum_{t=1}^{T} m_t^2 \,. \tag{44}$$

Next, define the vertical distance to the second-moment volatility bound as

$$\varsigma = \hat{m}_m - \left(\overline{m} \quad \mathbf{1}'\right)\hat{\mathbf{M}}_R^{-1}\begin{pmatrix} \overline{m} \\ \mathbf{1} \end{pmatrix}. \tag{45}$$

Clearly, the population value of ς must be nonnegative to satisfy the volatility bound.

b. Statistical Inference from the Volatility Bound Test

In what follows, let me review the method of statistical inference from the volatility bound test by Cochrane and Hansen (1992)[32]. First, the sample distance measure $\hat{\varsigma}$ can be obtained using the GMM estimation. Cochrane and Hansen showed that an exactly identified GMM framework that exploits the *K+2* moment conditions:

$$E\left[\begin{pmatrix} m_t \\ \mathbf{1} \end{pmatrix} - \tilde{\mathbf{R}}_t \tilde{\mathbf{R}}_t' \mathbf{\Theta}\right] = \mathbf{0}\,, \tag{46}$$

and
$$E\left[m_t^2 - \left(m_t \quad \mathbf{1}'\right)\mathbf{\Theta} - \varsigma\right] = 0\,, \tag{47}$$

can be used to obtain the estimate $\hat{\varsigma}$. These moment restrictions can be written in generic form as $E[f(\mathbf{x}_t, \mathbf{a})] = \mathbf{0}$, where $\mathbf{x}_t$ represents the data and $\mathbf{a}$ is the combined vector to be estimated, that is, $\mathbf{a} = \left(\hat{\mathbf{\Theta}}' \quad \hat{\varsigma}\right)'$.

[32] Cecchetti, Lam, and Mark (1994) also propose a similar statistical test based on the volatility bound.

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

$\mathbf{Var}\left(\hat{\mathbf{a}}\right)=\left[\mathbf{D}_0'\mathbf{S}_0^{-1}\mathbf{D}_0\right]^{-1}$, where $\mathbf{S}_0=\sum_{i=-\infty}^{\infty}E\left[f(\mathbf{x}_t,\mathbf{a}_0)f(\mathbf{x}_t,\mathbf{a}_0)'\right]$ and $\mathbf{D}_0=E\left[\partial f\left(\mathbf{x}_t,\mathbf{a}_0\right)/\partial\mathbf{a}\right]$. These quantities are estimated by $\mathbf{Var}\left(\hat{\mathbf{a}}\right)=\left[\mathbf{D}_T'\mathbf{S}_T^{-1}\mathbf{D}_T\right]^{-1}$ via Newey and West's (1987) method, where

$$\begin{aligned}\mathbf{S}_T&=\frac{1}{T}\sum_{t=1}^{T}f\left(\mathbf{x}_t,\hat{\mathbf{a}}\right)f\left(\mathbf{x}_t,\hat{\mathbf{a}}\right)'+\sum_{i=1}^{n}\left[1-\frac{i}{n+1}\right]\\&\times\left[\frac{1}{T}\sum_{t=1+i}^{T}f\left(\mathbf{x}_t,\hat{\mathbf{a}}\right)f\left(\mathbf{x}_t,\hat{\mathbf{a}}\right)'+\frac{1}{T}\sum_{t=1}^{T-i}f\left(\mathbf{x}_t,\hat{\mathbf{a}}\right)f\left(\mathbf{x}_t,\hat{\mathbf{a}}\right)'\right],\end{aligned} \tag{48}$$

and $$\mathbf{D}_T=\frac{1}{T}\sum_{t=1}^{T}\frac{\partial f\left(\mathbf{x}_t,\hat{\mathbf{a}}\right)}{\partial\mathbf{a}}. \tag{49}$$

Finally, the statistic Z_1 is given by

$$Z_1=\sqrt{T}\,\frac{\hat{\varsigma}}{\left[\mathbf{V\hat{a}r}(\hat{\mathbf{a}})_{k+2,k+2}\right]^{\frac{1}{2}}}, \tag{50}$$

where $\mathbf{Var}(\hat{\mathbf{a}})_{k+2,k+2}$ corresponds to the variance of $\hat{\varsigma}$. Under the null hypothesis of $\varsigma=0$, the statistic Z_1 satisfies the property of $Z_1\xrightarrow{d}N(0,\quad 1)$, given the GMM estimators. Hence, one can use the usual one-sided *t*-test to test the null hypothesis of $H_0:\varsigma=0$ against $H_1:\varsigma<0$.

(ii) Hansen and Jagannathan's (1997) Specification Error Test

The specification error statistic proposed by Hansen and Jagannathan (1997) computes the maximum pricing error associated with a stochastic discount factor and measures the least squares distance between a candidate stochastic discount factor denoted $\hat{m}$ and the set of admissible stochastic discount factors denoted by m^*. Conceptually, a square of the specification error Δ can be obtained as a solution to the following minimization problem:[33]

$$\Delta=\underset{m^*\in M^*}{\text{Min}}\;E\left[\left(\hat{m}-m^*\right)^2\right]. \tag{51}$$

According to Hansen and Jagannathan (1997), the specification error criterion can be written as

$$\Delta = (\mathbf{1} - E[m\mathbf{R}])' \mathbf{M}_R^{-1} (\mathbf{1} - E[m\mathbf{R}]). \tag{52}$$

All the variables in the criterion (52) were defined earlier. The distance criterion for any admissible stochastic discount factor that correctly prices the set of payoffs under investigation is identical to zero. Thus, among the set of candidate stochastic discount factors, the one with the smallest distance measure is judged to be the best.

As in the volatility bound test, this specification error criterion Δ and its standard deviation can be calculated under the framework of the exactly identified GMM as follows:

$$E\left[(\mathbf{1} - m_t \mathbf{R}_t) - \mathbf{R}_t \mathbf{R}_t' \boldsymbol{\Psi}\right] = \mathbf{0}, \tag{53}$$

and $$E\left[(\mathbf{1} - m_t \mathbf{R}_t)' \boldsymbol{\Psi} - \Delta\right] = 0. \tag{54}$$

In this case, the corresponding sample moments are given by

$$g_T(\boldsymbol{\omega}) = \begin{pmatrix} \frac{1}{T} \sum_{t=1}^{T} \left[(\mathbf{1} - m_t \mathbf{R}_t) - \mathbf{R}_t \mathbf{R}_t' \boldsymbol{\Psi}\right] \\ \frac{1}{T} \sum_{t=1}^{T} \left[(\mathbf{1} - m_t \mathbf{R}_t)' \boldsymbol{\Psi} - \Delta\right] \end{pmatrix}, \tag{55}$$

where $\boldsymbol{\omega} = (\boldsymbol{\Psi}', \Delta)$ is the coefficient vector to be estimated. Since the estimator is exactly identified, the sample moments can be set exactly to zero by the estimates:

$$\hat{\boldsymbol{\Psi}} = \left[\frac{1}{T} \sum_{t=1}^{T} \mathbf{R}_t \mathbf{R}_t'\right]^{-1} \frac{1}{T} \sum_{t=1}^{T} (\mathbf{1} - m_t \mathbf{R}_t), \tag{56}$$

and $$\hat{\Delta} = (\mathbf{1} - m_t \mathbf{R}_t)' \boldsymbol{\Psi}. \tag{57}$$

The asymptotic covariance matrix of $\hat{\boldsymbol{\omega}} = (\hat{\boldsymbol{\Psi}}', \hat{\Delta})$ can be estimated as in the volatility bound test. The statistic Z_2 is simply given by

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[33] Hansen, Heaton, and Luttmer (1995) demonstrated that for the special case where $\hat{m}$ =0, the

$$Z_2 = \sqrt{T}\frac{\hat{\Delta}}{\left[\hat{\mathbf{Var}}(\hat{\mathbf{a}})_{k+1,k+1}\right]^{\frac{1}{2}}}. \tag{58}$$

Under the null hypothesis of $\Delta = 0$, the static Z_2 satisfies the property of $Z_2 \xrightarrow{d} N(0, \quad 1)$, given the GMM estimators. Hence, one can use the usual one-sided *t*-test to test the null hypothesis of $H_0 : \Delta = 0$ against $H_1 : \Delta < 0$.

C. Specification Tests between Competing Models[34]

(i) Standard C-CAPM vs. Habit Formation Model

As mentioned in Section II, the standard C-CAPM can be regarded as one special case of the habit formation model. To be specific, as the degree of time-nonseparability $k \to 0$ in equation (10), the habit formation model converges to the standard C-CAPM. Hence, given the required bound $0 < k < 1$, one can test the above hypothesis using a one-sided *t*-test

Now, this hypothesis can be written as

$$H_0 : \ k = 0, \tag{59}$$

and $$H_1 : k > 0. \tag{60}$$

Failure to reject the null hypothesis indicates that superiority of the standard C-CAPM over the habit formation model cannot be rejected[35].

(ii) Standard C-CAPM vs. Money-in-the-Utility Model

Also, the standard C-CAPM is also thought to be a special case of the money-in-the-utility model. Comparison between equations (6) and (18) clearly shows that as the parameter of intertemporal elasticity substitution $\gamma \to 1$, the money-in-the-utility model converges to the standard C-CAPM. Thus, similarly to the preceding case, given the required bound $0 < \gamma < 1$, one can test the hypothesis using a one-sided *t*-test.

More specifically, this hypothesis test can be written as

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minimization problem (52) boils down to the volatility bound (39).

[34] Each hypothesis test here is performed based on a comparison between competing models using the same treatment of the data in terms of the adjustment of seasonality and trading-day effects.

[35] I also conduct a hypothesis test that includes $H_0 : \ k = 1$ and $H_1 : \ k < 1$ to confirm whether concavity of the habit formation function is satisfied or not.

$$H_0 : \gamma = 1, \tag{61}$$

and $$H_1 : \gamma < 1. \tag{62}$$

Failure to reject the null hypothesis indicates that superiority of the standard C-CAPM over the money-in-the-utility model cannot be rejected. Otherwise, if the additional condition that γ is significantly larger than zero is satisfied, then the money-in-the-utility model can be regarded as a better specification given the data set[36].

D. Estimation of Mispricing Coefficients to Gauge the Degree of Market Frictions

The last econometric methodology exploits the informal diagnostic suggested by Ferson and Constantinides (1991), which I believe is useful to test the hypothesis of frictionless market. The trust of estimation method is straightforward: just add a new parameter η^i to each unconditional version of each Euler condition such that

$$E\left[m_{t,t+1}(R^i_{t,t+1} + \eta^i)\right] = 1 \qquad \text{for asset } i \ (i = 1,2,\ldots N), \tag{63}$$

where each η^i can be interpreted as a mispricing coefficient or a pricing error similar to Jensen's alpha[37]. Using the same set of assets as before, the restrictions imposed by equation (63) can be tested also via GMM given the value of underlying parameters obtained by the GMM estimation. Since the system is exactly identified, the sample moments can be set exactly to zero. Its asymptotic covariance is also given by Newey and West's (1987) method, as in the preceding section.

The discussion about market frictions in Section II implies that a significant value of the parameter η^i implies the existence of market friction. Unfortunately, however, if the parameter η^i is significantly smaller than zero, which implies that $E\left[m_{t,t+1}R^i_{t,t+1}\right] < 1$, one cannot tell which constraint is binding, short-sale constraint, borrowing constraints, or transaction costs in selling the assets. One hope, however, is that if it is significantly larger than zero, it implies $E\left[m_{t,t+1}R^i_{t,t+1}\right] > 1$, which corresponds to the case of that

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[36] To be more precise, the hypothesis test involving $H_0 : \gamma = 0$ and $H_1 : \gamma > 0$ investigates appropriateness of the money-in-the-utility model against a special form of the cash-in-advance model that uses current money stock instead of lagged money stock as a cash-in-advance constraint.

[37] Note that the specification of the mispricing test (63) is slightly different from the theoretically-implied form: $E\left[m_{t,t+1}R^i_{t,t+1} + \theta^i\right] = 1$, where $H_0 : \theta^i = 0$ should be tested. The specification (63) is still robust, however, because the tests on θ^i and η^i are indeed identical since $\theta^i = \eta^i \overline{m}_{t,t+1}$.

$\frac{1+\lambda^i}{1-\lambda^i} \le E_t\left[m_{t,t+1}R^i_{t,t+1}\right] \le \frac{1+\pi^i}{1-\pi^i}$ (a combination of conditions (33) and (35) holds) and ρ^i (transaction costs for purchasing asset *i*) is significantly large enough relative to the value of λ^i (transaction costs for selling asset *i*).

IV. The Data

(i) Description of the Data[38]

A. Consumption, Money Stock, Price Data

As for consumption data, throughout the paper, I use the index of real consumption expenditures of non-durables plus services[39], which is reported in the *Annual Report on National Accounts* issued by the Economic Planning Agency (EPA).

As for money stock data, I use the following set of money stock data: (i) cash in circulation (CA), (ii) cash currency plus deposit money owned by individuals (CAD)[40], (iii) M1 (CAD plus deposit money owned by corporations), or (iv) M2 (M1 plus quasi-money [time deposits etc]). The money stock data is available in the *Financial and Economic Statistics, Monthly* issued by the Bank of Japan.

Regarding the price data, I use the price deflator for total consumption expenditures, which is reported in *Annual Report on National Accounts* issued by EPA.

B. Asset Return Data

The asset returns I used in this paper are computed from the NIKKO Japan Mix Index, which is issued by Nikko Securities Inc. Ltd. It includes four indexes of weighted averages of four asset classes: (i) short-term instruments (SB), (ii) long-term bonds (LB), (iii) stocks (SR), and (iv) convertible bonds (CB). Each class of assets includes only returns of high marketability (liquidity).

C. Information Set

In order to estimate the stochastic model by GMM, one needs to specify the instrumental variables that are assumed to be included in the information set. As pointed out by many

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38 Table 4 provides a definition of all economic variables used in this paper.
39 In fact, the literature suggests that researchers should use this category of consumption expenditure because durable goods such as refrigerators and automobiles are typically consumed over many periods rather just one. See, for example, Hall (1978), Flavin (1981), and He and Modest (1995).
40 The use of this data is due to the fact that consumption expenditures are the data on the side of households, not corporations.

researchers, no asset-pricing model can alone provide any guidance as to which variables should be included.

In light of the spirit of the information set, one should choose variables that have some forecasting power concerning future aggregate economic activity. In this regard, first, as suggested by Estrella and Mishkin (1996) and Estrella and Hardouvelis (1990), the term structure that is defined as the spread between the ten-year Treasury note and the three-month Treasury bill in the U.S. case is known to be a valuable forecasting tool. They argue that a rise in the short rate applied by the monetary authority tends to flatten the yield curve as well as slow real growth in the near future. Also, expectations of future inflation and real interest rates contained in the yield curve spread seem to play an important role in the prediction of future economic activity. In Japan, there is no direct correspondence to the three-month Treasury bill, thus I use the overnight call rate instead to compute the term structure variable as the difference from the return on the 10-year government bond.

Second, as Friedman and Kuttner (1993) and Stock and Watson (1989) note in the U.S. case, the spread of returns between commercial paper and the Treasury bill, typically termed the default risk premium, is thought to have some forecasting power[41]. Motivated by these arguments, I use as the Japanese counterpart the spread between corporate bond and the long-term government bond.

Third, I use the rate of change in the real effective exchange rate of the yen as one of the information variables. This is due to the well-established fact that the Japanese economy has been deeply influenced by the change in exchange rates and in particular many manufacturing companies have suffered from unexpected losses and/or gains from unexpected changes in exchange rates[42].

Fourth, the recent literature[43] on macroeconomics suggests the importance of the credit channel. According to this view, the direct effects of monetary policy on interest rates are amplified by endogenous changes in the external finance premium, which is typically defined as the difference in costs between funds raised externally by issuing equity or debt and funds generated internally by retaining earnings. A change in monetary policy that raises or lowers open-market interest rates tends to change the external finance premium. Since in the Japanese case there has been a heavy dependence upon debt finance, I use the diffusion

[41] One common interpretation is that the spread simply reflects the default risk premium and that this forward-looking property is what makes it a good predictor. On the other hand, Kashyap, Stein, and Wilcox (1993) suggest instead that the spread is a proxy for the stance of monetary policy: tight monetary policy leads to an increase in corporate bond issuance, which exerts upward pressure on bond rates. If tight money eventually has an output effect, this effect will have been forecast by the movement in the spread.

[42] For an empirical analysis on currency exposure of Japanese manufacturers, see Baba and Fukao (2000), for example.

[43] Bernanke and Gertler (1995) provide an excellent survey on this issue.

index of the lending attitude of financial institutions of all industries, issued by the Bank of Japan as a proxy for the effects that occur via the credit channel.

In sum, I use the following set of instrumental variables, which includes one- and two-period lagged variables of the default risk premium (DR), term structure (TS), the rate of change of the real effective exchange rate of the yen (REX), and the diffusion index of the lending attitude of financial institutions (DI).

D. Coping with Seasonality and Trading-Day Effects

In this paper, I use both original time series and seasonal-adjusted series for consumption and money stock. The program I adopt for seasonal adjustment is DECOMP, which was originally developed by Kitagawa and Gersch (1984) and later refined by Kitagawa (1995)[44]. By this method, one can decompose any time-series into not only trend, seasonal and autoregressive components, but also into components such as trading-day effects[45], which cannot be estimated by other popular methods such as X11[46].

(ii) Properties of the Data

a. Summary Statistics

Table 5A reports summary statistics of the data, which are adjusted for seasonality and trading-day effects. Note that consumption and effective exchange rate data are in real terms, although other data including money stock and asset returns are in nominal terms. As easily expected, the stock return exhibits the highest volatility, while the short-term bond rate has the lowest volatility among asset returns. Also, money stock data are more volatile and at the same time less serially correlated than consumption data.

b. Correlation Matrix

Table 5B reports coefficients of correlation between these variables. First, it should be noted that there is a relatively high correlation between asset returns and consumption or money stock data. Also note that in general, instrumental variables are highly correlated with asset

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[44] DECOMP can be accessed on the Education Ministry's Institute of Statistical Mathematics web site at http://ssnt.ism.ac.jp/inets/inets_html.

[45] As noted by He and Modest (1995), there appear to be calendar dependencies in such data as consumption and money stock based on the number of days in the month and the number of Mondays, Tuesdays, etc. in a month.

[46] Higo and Nakada (1998) provide an excellent survey on comparison among representative seasonality adjustment methodologies such as the Henderson moving average, the Band-Pass filter, and the DECOMP from an empirical point of view.

returns, consumption and money stock data, which might show the validity of the choice of the instrumental variables.

V. Empirical Results

First, take a look at Table 6, which reports the GMM estimation results of underlying parameters, Hansen's *J*-test of the overidentifying restrictions, the statistical inference of the volatility bound test, and the specification error test for both original and seasonally-adjusted series. As a whole, the empirical results show that (i) the models cannot be rejected in terms of Hansen's *J*-test and that (ii) neither the volatility bound test[47] nor the specification error test can reject each model significantly if one computes the confidence regions, which suggests that the only way to compare the performance of any two competing models is (i) to check whether parameter estimates fall within the range implied by each theoretical foundation and/or (ii) to see the results of the direct specification tests for competing models.

Keeping this in mind, let me turn to the estimation result of each parameter in more detail. As for the C-CAPM, the estimation result for the standard C-CAPM shows that both parameters β and ρ are significantly different from zero and are within the region required by the theory[48], while the estimated parameters of the habit formation model are not found to be consistent with its theoretical foundation[49].

On the other hand, as regards M-CAPM, a sharp contrast can be observed between the money-in-the-utility model and the cash-in-advance model in terms for which the data used is money stock data. To be concrete, while the money-in-the-utility model yields fairy reasonable parameter estimates except for the case where M2 is used, the cash-in-advance model can be adopted only when seasonally-adjusted M2 is used and in other cases it can be rejected due to negative estimates of the parameter ρ.

Another noteworthy point to make is the difference in the level of estimated parameters except for the subjective discount factor β between two data sets, (i) the original series and (ii) the seasonality and trading-day effects adjusted series. For example, if one looks at the result for the standard C-CAPM, the estimated value of the Arrow-Pratt coefficient of relative risk aversion ρ is about 0.18 when the original series is used, but it is about 0.72 when the adjusted series is used. The same tendency is observed in the case of the money-in-the-utility model.

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[47] Figure 1 demonstrates that no stochastic discount factor derived from any model can satisfy the second-moment volatility bound unless one considers the statistical confidence regions.
[48] Recall that the restrictions here are $0 < \beta < 1$ and $0 < \rho$.
[49] The restrictions here are $0 < \beta < 1$, $0 < k < 1$ and $0 < \rho$.

Also, the estimated values of the coefficient of the substitution elasticity γ included in the money-in-the-utility model using the original series is almost twice as large as that derived from the adjusted series. That implies that the use of the adjusted series puts much more relative weight on real balances in an agent's utility function than does the use of the original series.

Unfortunately, however, due to the limited prior attempts to estimate these underlying parameters from the Japanese data, it seems too hasty to judge the appropriateness of their estimated values. But, it is very plausible to think that the high degree of seasonality and trading-day effects inherent in consumption and money stock data distort the estimated values.

Next, hypothesis testing regarding the choice between the standard C-CAPM and money-in-the-utility model (Table 7) shows that when CA, CAD, and M1 are used, the parameter γ of the money-in-the-utility model is significantly less than one even after imposing the values of the parameters β and ρ implied by the standard C-CAPM, suggesting that money stock data should be incorporated in the stochastic discount factor and thus in the representative agent's utility function.

Moreover, the estimation result of the mispricing test (Table 8) states that across all the specifications, the mispricing parameters associated with LBR (the weighted-average return on long-term bonds) are found to be significantly different from zero, taking negative values. From the perspective of the theoretical implication of market frictions, it is highly plausible that the transaction costs in the Japanese long-term bond market are asymmetric between acquisition and sale[50].

To put it in more detail, possible market frictions matter only in the long-term bond market in the specific case of purchasing long-term bonds, although other markets such as the short-term bond market, the stock market, and the convertible bond market are found to be frictionless or symmetric in transaction costs in a statistical sense. This evidence might be explained by the existence of the security transaction tax and withholding taxes, although the former tax was abolished in April 1999. The withholding tax increases transaction costs by imposing opportunity costs on holders in the form of lost interest income on coupons.

[50] Also, particularly when original data are used, the mispricing coefficient on CB (weighted-average on convertible bonds) takes negative values at the significance level of 10%.

VI. Concluding Remarks

This paper has explored the role of money in asset pricing in Japan within a stochastic intertemporal framework. Specifically, it has compared the performance of alternative models, including the standard C-CAPM, the habit formation model, the money-in-the-utility model, and the cash-in-advance model.

Empirical results based on the quarterly data of the period 1980-1998 show that, in terms of underlying parameter estimation by GMM, the habit formation and the cash-in-advance models are significantly rejected in most cases, although no significant difference can be found in the result of the statistical inference of the volatility bound test among all competing models. The specification test between the standard C-CAPM and the money-in-the-utility model generally favors the latter model significantly, so that it is possible to conclude by stating that the proper stochastic discount factor should be characterized by money as well as consumption data. This result suggests that it is plausible that the representative agent takes the role of money into consideration in making intertemporal decisions about his or her wealth.

Also, this paper has shown that, particularly in the long-term bond market, market friction matters. This point is closely related to the field of market microstructure. For the time being, the accumulation of empirical research in this field is far from enough. Hence, I sincerely hope that this direction of research will enrich the implications in the asset-pricing literature particularly from an empirical point of view.

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Table 1: Basic Structural Formulation of Utility Maximization Problems

Theoretical Foundation	Maximization Problem	Constraints: Budget Constraint	Constraints: Additional Constraint
(i) Standard C-CAPM	$\underset{C_t}{\text{Max}} \quad U_t = E_t\left[\sum_{s=t}^{\infty} \beta^{s-t} u(C_s)\right]$	$\sum_{i=1}^{N} q_t^i Q_{t+1}^i = \sum_{i=1}^{N} (q_t^i + d_t^i) Q_t^i + Y_t - C_t - T_t$	______________
(ii) Habit Formation	$\underset{C_t}{\text{Max}} \quad U_t = E_t\left[\sum_{s=t}^{\infty} \beta^{s-t} u(C_s, X_s)\right]$	$\sum_{i=1}^{N} q_t^i Q_{t+1}^i = \sum_{i=1}^{N} (q_t^i + d_t^i) Q_t^i + Y_t - C_t - T_t$	______________
(i) Money-in-the-Utility	$\underset{C_t, M_t}{\text{Max}} \quad U_t = E_t\left[\sum_{s=t}^{\infty} \beta^{s-t} u\left(C_s, \frac{M_s}{P_s}\right)\right]$	$\sum_{i=1}^{N} q_t^i Q_{t+1}^i + \frac{M_t}{P_t} = \sum_{i=1}^{N} (q_t^i + d_t^i) Q_t^i + \frac{M_{t-1}}{P_t} + Y_t - C_t - T_t$	______________
(ii) Cash-in-Advance	$\underset{C_t}{\text{Max}} \quad U_t = E_t\left[\sum_{s=t}^{\infty} \beta^{s-t} u(C_s)\right]$	$\sum_{i=1}^{N} q_t^i Q_{t+1}^i + \frac{M_t}{P_t} = \sum_{i=1}^{N} (q_t^i + d_t^i) Q_t^i + \frac{M_{t-1}}{P_t} + Y_t - C_t - T_t$	$M_{t-1} \geq P_t C_t$

Notations: E_t : Conditional expectation operator, β : Subjective discount factor, C_s : Consumption expenditures,
q_t^i : Price of asset *i*, d_t^i : Dividend (return) of asset *i*, Q_t^i : Quantity of asset *i*, Y_t : Labor income (output),
T_t : Lump sum tax, X_s : Habit formation, M_s / P_s : Real balances

Table 2: Empirical Specifications of Stochastic Discount Factors

Theoretical Foundation	Stochastic Discount Factor $m_{t,t+1}$		Period Utility Function
	General Form	Empirical Specification	
(1) Consumption-Based Capital Asset-Pricing Model (C-CAPM)			
(i) Standard C-CAPM	$\beta \frac{u'(C_{t+1})}{u'(C_t)}$	$\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\rho}$	$u(C_t)=\frac{C_t^{1-\rho}}{1-\rho}$
(ii) Habit Formation	$\beta \frac{u_C(C_{t+1}, X_{t+1})}{u_C(C_t, X_t)}$	$\beta\left(\frac{C_t}{C_{t-1}}\right)^{k(\rho-1)}\left(\frac{C_{t+1}}{C_t}\right)^{-\rho}$	$u(C_t, X_t)=u(C_t, C_{t-1})=\frac{(C_t/C_{t-1}^k)^{1-\rho}}{1-\rho}$
(2) Money-Based Capital Asset-Pricing Model (M-CAPM)			
(i) Money-in-the-Utility	$\beta \frac{u_C(C_{t+1}, M_{t+1}/P_{t+1})}{u_C(C_t, M_t/P_t)}$	$\beta\left(\frac{C_{t+1}}{C_t}\right)^{\gamma(1-\rho)-1}\left(\frac{M_{t+1}}{M_t}\frac{P_t}{P_{t+1}}\right)^{(1-\gamma)(1-\rho)}$	$u\left(C_t, \frac{M_t}{P_t}\right)=\frac{\left[C_t^{\gamma}(M_t/P_t)^{1-\gamma}\right]^{1-\rho}}{1-\rho}$
(ii) Cash-in-Advance	$\beta \frac{P_{t+1}}{P_{t+2}}\frac{P_{t+1}}{P_t}\frac{u'(C_{t+2})}{u'(C_{t+1})}$	$\beta\left(\frac{M_{t+1}}{M_t}\frac{P_{t+1}}{P_{t+2}}\right)^{-\rho}\frac{P_{t+1}}{P_t}\frac{P_{t+1}}{P_{t+2}}$	$u(C_t)=u\left(\frac{M_{t-1}}{P_t}\right)=\frac{(M_{t-1}/P_t)^{1-\rho}}{1-\rho}$

Notations: β : Subjective discount factor, C_s : Consumption expenditures, ρ : Arrow-Pratt coefficient of relative risk aversion

X_s : Habit formation, k : The degree of time-nonseparability M_s/P_s : Real balances

Table 3: Overview of Empirical Procedures

	Tests Based Solely on Each Model	Inter-model Specification Tests
Assuming Frictionless Asset Markets	**A. GMM-based Tests** **(i) Underlying Parameter Estimation** **(ii) *J*-test** **B. Other Diagnostic Tests** **(i) Volatility Bound Test** **(ii) Specification Error Test**	**C. Specification Tests between Competing Models** **(i) C-CAPM vs. Habit Formation** **(i) C-CAPM vs. Money-in-the-Utility** *Notes*: 1. Tests are performed by imposing the C-CAPM parameters on each alternative model. 2. Competing models under comparison use the same type of seasonal treatment for the data.
Allowing Frictions in Asset Markets	**D. Mispricing Tests** *Note*: Tests are performed by imposing the derived stochastic discount factor on individual Euler equation for each asset return.	

Table 4: Definition of Economic Variables

Symbol	Definition	Source
Consumption, Money Stock, and Price Data		
NSC	Real consumption expenditures for non-durable goods and services	Annual Report on National Accounts, Economic Planning Agency
CA	Nominal cash in circulation	Financial and Economic Statistics, Monthly, Bank of Japan
CAD	Nominal cash in circulation plus deposit money (demand deposits etc) owned by individuals	Financial and Economic Statistics, Monthly, Bank of Japan
M1	CAD plus nominal deposit money owned by corporations	Financial and Economic Statistics, Monthly, Bank of Japan
M2	M1 plus quasi-money (time deposits etc)	Financial and Economic Statistics, Monthly, Bank of Japan
P	Price deflator for total consumption expenditures	Annual Report on National Accounts, Economic Planning Agency
Asset Return Data		
SB	The real quarterly weighted-average gross return on the asset class of short-tem instruments with maturities of three months or less, which includes call, bill, Gensaki, CD, CP, government short-tem securities, but excludes securities held by the Bank of Japan and the Japanese government.	NIKKO Japan Mix Index, Nikko Securities Inc, Ltd.
LB	The real quarterly weighted-average gross return on the asset class of long-term bonds that includes government bonds, government guarantee bonds, corporate bonds, bank debentures and yen-denominated foreign bonds, whose term to maturity is in excess of one year and outstanding amount is in excess of 1 billion yen.	NIKKO Japan Mix Index, Nikko Securities Inc, Ltd.
SR	The real quarterly weighted-average gross return on the asset class of stocks that includes all the stocks listed on the first section of the Tokyo Stock Exchange. Individual rates of returns are adjusted for the dividends and right and cross-share-holding.	NIKKO Japan Mix Index, Nikko Securities Inc, Ltd.
CB	The real quarterly weighted-average gross return on convertible bonds (CB) that includes the CB listed on the Tokyo Stock Exchange except for issues with outstanding amount of less than 2 billion yen	NIKKO Japan Mix Index, Nikko Securities Inc, Ltd.
Instrumental Variables		
TS	Term structure defined as the difference between the 10-year government bond return and the risk-free return (call rate)	Financial and Economic Statistics, Monthly, Bank of Japan
DR	Default risk premium defined as the difference between returns on the corporate bond and the 10-year government bond	Financial and Economic Statistics, Monthly, Bank of Japan
REX	Real effective exchange rate of the yen. Figures are index of weighted average of yen's real exchange rates versus 24 major currencies that are calculated based on exchange rates and price indexes of the respective countries.	Available at the Bank of Japan 's home page at http://www.boj.or.jp
DI	Diffusion index of the lending attitude of financial institutions for all industries (forecast value)	Available at the Bank of Japan 's home page at http://www.boj.or.jp

Table 5: Properties of the Data Set (1980/3Q- 1998/3Q)

A. Summary Statistics of the Seasonally-Adjusted Data

	Mean	S. D	Min	Max	Ex-Skew	Ex-Kurt	Q(1)	Q(4)
Consumption, Money Stock, and Price Data								
NSC	1.0051	0.0075	0.6069	1.1905	-0.7805	1.7528	1.92 [0.17]	2.52 [0.64]
CA	1.0151	0.0119	0.6256	1.2008	0.3338	-0.5084	11.1 [0.00]	23.5 [0.00]
CAD	1.0177	0.0137	0.6628	1.4658	0.1131	-0.2325	34.9 [0.00]	57.0 [0.00]
M1	1.0140	0.0117	0.6840	1.2730	0.4346	0.9693	14.2 [0.00]	21.1 [0.00]
M2	1.0139	0.0097	0.7241	1.1920	0.2223	-0.6828	48.4 [0.00]	152 [0.00]
P	1.0037	0.0048	0.9954	1.0160	0.5637	-0.1319	6.17 [0.01]	24.0 [0.00]
Asset Return Data								
SB	1.0078	0.0060	0.9864	1.2194	-0.6085	1.2557	20.5 [0.00]	58.9 [0.00]
LB	1.0150	0.0240	0.9556	1.2072	-0.1889	0.1946	0.29 [0.59]	7.38 [0.12]
ST	1.0152	0.1085	0.7856	1.2465	-0.5527	0.8449	0.04 [0.83]	0.71 [0.95]
CB	1.0193	0.0688	0.6889	1.1782	-0.7455	3.7728	2.69 [0.10]	3.53 [0.47]
Instrumental Variables								
TS(-1)	0.0019	0.0035	0.6329	1.2979	-1.0951	2.0285	45.2 [0.00]	87.7 [0.00]
DR(-1)	0.0009	0.0009	0.6955	1.3289	0.2988	2.2084	26.8 [0.00]	77.9 [0.00]
REX(-1)	0.0019	0.0428	0.6735	1.3325	0.0942	1.0536	1.79 [0.18]	2.26 [0.69]
DI(-1)	10.4521	16.3044	-40.000	32.000	-0.8447	0.3910	54.3 [0.00]	142 [0.00]

Notes: 1. Consumption, money stock, and price data are adjusted for seasonality and trading-day effects by the web-based program DECOMP.
2. Ex-Skew indicates the excess skewness, and Ex-Kurt the excess kurtness.
3. 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

	NSC	CA	CAD	M1	M2	P	SB	LB	SR	CB	TS(-1)	DR(-1)	REX(-1)	DI(-1)
NSC	1.0000													
CA	0.2078	1.0000												
CAD	0.1909	0.8257	1.0000											
M1	0.2041	0.5245	0.7501	1.0000										
M2	0.2639	0.4271	0.1922	0.0268	1.0000									
P	-0.1757	-0.1456	-0.2869	-0.1984	0.2018	1.0000								
SB	0.3248	-0.1645	-0.3951	-0.2728	0.3028	-0.2671	1.0000							
LB	0.1561.	-0.0833	-0.1096	-0.0023	-0.2156	-0.3641	0.2986	1.0000						
SR	0.1477	0.2875	0.2199	0.1294	0.1570	-0.1705	0.2225	0.1617	1.0000					
CB	0.1397	0.1436	0.0937	0.0849	0.0238	-0.1463	0.1781	0.3383	0.7867	1.0000				
TS(-1)	-0.0426	0.2960	0.4728	0.2636	-0.1526	-0.3001	-0.5168	0.0213	0.0231	-0.0340	1.0000			
DR(-1)	-0.0724	0.1692	0.2592	0.1615	-0.1689	-0.3411	-0.1940	-0.0076	-0.0845	-0.1103	-0.0645	1.0000		
REX(-1)	-0.0033	0.0188	-0.1712	-0.0778	-0.0488	-0.1490	0.3412	0.1860	0.1728	0.2576	-0.2061	0.0367	1.0000	
DI(-1)	0.1774	0.5209	0.4910	0.1636	0.4849	-0.1616	-0.0175	-0.0811	0.2364	0.0901	0.4335	0.0899	-0.0559	1.0000

Note: Consumption, money stock, and price data are adjusted for seasonality and trading-day effects by the DECOMP.

Table 6: The GMM Estimation Results (1980/3Q-1998/3Q)

A. Consumption-Based CAPM

a. Standard C-CAPM: $E_t\left[m^C_{t,t+1}R^i_{t,t+1}-1\right]=E_t\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\rho}R^i_{t,t+1}-1\right]=0$ for i=SB, LB, SR, and CB

Parameters	β	ρ	$J(\chi^2)$	DF	Implied Value of $\overline{m}$	Implied Value of $\hat{m}_m$	Volatility Bound Test (ζ)	Specification Error Test (Δ)
Original Data	0.994	0.178	14.901	34	0.993	0.986	-0.109	0.105
	(2063.1)***	(8.595)***	[0.998]				(-1.182)	(1.144)
SA Data	0.996	0.721	14.761	34	0.992	0.984	-0.105	0.104
	(1710.3)***	(10.018)***	[0.998]				(-1.194)	(1.133)

b. Habit Formation Model: $E_t\left[m^H_{t,t+1}R^i_{t,t+1}-1\right]=E_t\left[\beta\left(\frac{C_t}{C_{t-1}}\right)^{k(\rho-1)}\left(\frac{C_{t+1}}{C_t}\right)^{-\rho}R^i_{t,t+1}-1\right]=0$ for i=SB, LB, SR, and CB

Parameters	β	ρ	k	$J(\chi^2)$	DF	Implied Value of $\overline{m}$	Implied Value of $\hat{m}_m$	Volatility Bound Test (ζ)	Specification Error Test (Δ)
Original Data	0.994	0.212	-0.039	14.907	33	1.096	0.986	-0.110	0.106
	(1500.5)***	(7.941)***	(-1.130)	[0.998]				(-1.233)	(1.146)
SA Data	1.001	2.178	0.428	14.679	33	1.089	0.985	-0.104	0.104
	(449.46)***	(3.318)***	(2.072)**	[0.998]				(-1.137)	(1.136)

Notes: 1. Estimation of the Euler equations is due to Hansen's (1982) GMM. The information set contains one- and two-period lagged each of DR, TS, REX, and DI. The *t*-values are reported in parentheses, which are calculated based on standard errors corrected by both Newey and West's (1987) and White's (1980) methods. (*: significant at the 10% level. **: significant at the 5% level. ***: significant at the 1% level.) The ***J***-statistic is distributed χ^2 with the degree of freedom denoted DF. Figures in brackets are *p*-values.

2. $\overline{m}$ is the sample mean of the stochastic discount factor, and $\hat{m}_m$ the sample second moment of the stochastic discount factor centered around zero.

3. SA denotes the use of the consumption data adjusted for seasonality and trading-day effects by the DECOMP.

B. Money-Based CAPM

a. Money-in-the-Utility Model: $E_t\left[m_{t,t+1}^{MU} R_{t,t+1}^i - 1\right] = E_t\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{\gamma(1-\rho)-1}\left(\frac{M_{t+1}}{M_t}\frac{P_t}{P_{t+1}}\right)^{(1-\gamma)(1-\rho)} R_{t,t+1}^i - 1\right] = 0$ for i=SB, LB, SR, and CB

Parameters	β	ρ	γ	$J(\chi^2)$	DF	Implied Value of $\overline{m}$	Implied Value of $\hat{m}_m$	Volatility Bound Test (ζ)	Specification Error Test (Δ)
(i) CA (Cash-in-Circulation)									
Original Data	0.995	0.183	0.930	14.882	33	0.993	0.986	-0.114	0.106
	(821.91)***	(3.802)***	(27.209)***	[0.997]				(-1.222)	(1.152)
SA Data	0.994	0.575	0.470	14.726	33	0.992	0.985	-0.104	0.104
	(1622.0)***	(7.598)***	(4.733)***	[0.997]				(-1.110)	(1.133)
(ii) CAD (Cash-in-Circulation and Deposit Money Owned by Individuals)									
Original Data	0.993	0.112	0.877	14.862	33	0.986	0.986	-0.110	0.106
	(688.31)***	(1.847)*	(21.001)***	[0.997]				(-1.233)	(1.146)
SA Data	0.992	0.430	0.539	14.780	33	0.992	0.985	-0.104	0.104
	(2154.2)***	(8.338)***	(8.338)***	[0.997]				(-1.137)	(1.136)
(iii) M1 (CAD+Deposit Money Owned by Corporations)									
Original Data	0.993	0.061	0.904	14.942	33	0.993	0.986	-0.110	0.106
	(991.53)***	(0.934)	(26.044)***	[0.997]				(-1.224)	(1.145)
SA Data	0.991	0.127	0.491	14.885	33	0.993	0.985	-0.106	0.104
	(1633.3)***	(1.297)	(7.755)***	[0.997]				(-1.148)	(1.135)
(iv) M2 (M1+Quasi-Money)									
Original Data	0.994	0.232	1.123	14.901	33	0.993	0.986	-0.107	0.105
	(1490.9)***	(6.908)***	(21.615)***	[0.997]				(-1.190)	(1.142)
SA Data	0.996	0.653	1.350	14.764	33	0.992	0.985	-0.104	0.104
	(1501.8)***	(9.828)***	(7.581)***	[0.997]				(-1.121)	(1.134)

Notes: 1. Estimation of the Euler equations is due to Hansen's (1982) GMM. The information set contains one- and two-period lagged each of DR, TS, REX, and DI. The t-values are reported in parentheses, which are calculated based on standard errors corrected by both Newey and West's (1987) and White's (1980) methods. (*: significant at the 10% level. **: significant at the 5% level. ***: significant at the 1% level.) The ***J***-statistic is distributed χ^2 with the degree of freedom denoted DF. Figures in brackets are p-values.

2. $\overline{m}$ is the sample mean of the stochastic discount factor, and $\hat{m}_m$ the sample second moment of the stochastic discount factor centered around zero.

3. SA denotes the use of the consumption, money stock, and price data adjusted for seasonality and trading-day effects by the DECOMP.

b. Cash-in-Advance Model: $E_t\left[m^{CA}_{t,t+1}R^i_{t,t+1}-1\right]=E_t\left[\beta\left(\frac{C_{t+2}}{C_{t+1}}\right)^{-\rho}\frac{P_{t+1}}{P_t}\frac{P_{t+1}}{P_{t+2}}R^i_{t,t+1}-1\right]=E_t\left[\beta\left(\frac{M_{t+1}}{M_t}\frac{P_{t+1}}{P_{t+2}}\right)^{-\rho}\frac{P_{t+1}}{P_t}\frac{P_{t+1}}{P_{t+2}}R^i_{t,t+1}-1\right]=0$

for i=SB, LB, SR, and CB

Parameters	β	ρ	$J(\chi^2)$	DF	Implied Value of $\overline{m}$	$\hat{m}_m$	Volatility Bound Test (ζ)	Specification Error Test (Δ)
(i) CA (Cash-in-Circulation)								
Original Data	0.991	-0.323	14.864	34	0.992	0.984	-0.108	0.104
	(1612.1)***	(-3.345)***	[0.998]				(-1.070)	(1.134)
SA Data	0.989	-0.287	14.895	34	0.992	0.984	-0.106	0.103
	(2527.6)***	(-9.112)***	[0.998]				(-1.058)	(1.131)
(ii) CAD (Cash-in-Circulation and Deposit Money Owned by Individuals)								
Original Data	0.990	-0.141	14.888	34	0.992	0.984	-0.108	0.104
	(1508.2)***	(-6.088)***	[0.998]				(-1.086)	(1.134)
SA Data	0.988	-0.280	15.073	34	0.992	0.984	-0.105	0.103
	(4273.0)***	(-27.339)***	[0.999]				(-1.091)	(1.131)
(iii) M1 (CAD+Deposit Money Owned by Corporations)								
Original Data	0.990	-0.159	15.003	34	0.992	0.984	-0.108	0.104
	(2117.8)***	(-9.561)***	[0.998]				(-1.092)	(1.130)
SA Data	0.987	-0.533	14.868	34	0.992	0.984	-0.104	0.103
	(2435.3)***	(-13.093)***	[0.998]				(-1.134)	(1.133)
(iv) M2 (M1+Quasi-Money)								
Original Data	0.991	-0.010	14.784	34	0.992	0.984	-0.112	0.103
	(2268.3)***	(-0.321)	[0.998]				(-1.060)	(1.128)
SA Data	0.994	0.220	14.914	34	0.992	0.984	-0.105	0.103
	(2211.8)***	(5.240)***	[0.999]				(-1.063)	(1.131)

Notes: 1. Estimation of the Euler equations is due to Hansen's (1982) GMM. The information set contains one- and two-period lagged each of DR, TS, REX, and DI. The t-values are reported in parentheses, which are calculated based on standard errors corrected by both Newey and West's (1987) and White's (1980) methods. (*: significant at the 10% level. **: significant at the 5% level. ***: significant at the 1% level.) The ***J***-statistic is distributed χ^2 with the degree of freedom denoted DF. Figures in brackets are p-values.

2. $\overline{m}$ is the sample mean of the stochastic discount factor, and $\hat{m}_m$ the sample second moment of the stochastic discount factor centered around zero.

3. SA denotes the use of the consumption, money stock, and price data adjusted for seasonality and trading-day effects by the DECOMP.

Table 7: Specification Tests between Competing Models

A. Standard C-CAPM vs. Habit Formation Model

Parameter	k		
	Two-Tail Test	One-Tail Test	
	H_0: $k = 0$ H_1: $k \neq 0$	H_0: $k = 0$ H_1: $k > 0$	H_0: $k = 1$ H_1: $k < 1$
Original Data		k = -0.023	
	(-1.173)	(——)	(-52.336)***
SA Data		k = 0.293	
	(1.693)*	(1.693)*	(-4.094)***

B. Standard C-CAPM vs. Money-in-the-Utility Model

Parameter	γ		
	Two-Tail Test	One-Tail Test	
	H_0: $\gamma = 0$ H_1: $\gamma \neq 0$	H_0: $\gamma = 0$ H_1: $\gamma > 0$	H_0: $\gamma = 1$ H_1: $\gamma < 1$
(i) CA (Cash-in-Circulation)			
Original Data		γ = 0.935	
	(40.469)***	(40.469)***	(-2.817)***
SA Data		γ = 0.486	
	(5.078)***	(5.078)***	(-5.363)***
(ii) CAD (Cash-in-Circulation and Deposit Money Owned by Individuals)			
Original Data		γ = 0.902	
	(30.594)***	(30.594)***	(-3.344)***
SA Data		γ = 0.486	
	(5.028)***	(5.029)***	(-6.299)***
(iii) M1 (CAD+Deposit Money Owned by Corporations)			
Original Data		γ = 0.950	
	(44.684)***	(44.684)***	(-2.357)***
SA Data		γ = 0.153	
	(1.036)	(1.036)	(-5.743)***
(iv) M2 (M1+Quasi-Money)			
Original Data		γ = 1.006	
	(58.195)***	(58.195)***	(——)
SA Data		γ = 1.172	
	(9.819)***	(9.819)***	(——)

Notes: 1. Each hypothesis testing is performed by imposing the values of β and ρ estimated by the corresponding standard C-CAPM.
2. Estimation of the Euler equations is due to Hansen's (1982) GMM. The information set is the same as in previous tests. The *t*-values are reported in parentheses, which are calculated based on standard errors corrected by both Newey and West's (1987) and White's (1980) methods. (*: significant at the 10% level. **: significant at the 5% level. ***: significant at the 1% level.)

Table 8: Mispricing Test

A. Consumption-Based CAPM
a. Standard C-CAPM

$$E\left[m^{C}_{t,t+1}\left(R^{i}_{t,t+1}+\eta^{i}\right)-1\right]\equiv E\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{-\rho}\left(R^{i}_{t,t+1}+\eta^{i}\right)-1\right]=0$$

for i=SB, LB, SR, and CB

Parameters	η^{SBR}	η^{LBR}	η^{SR}	η^{CB}
Original Data	-0.627E-03	-0.779E-02	-0.794E-02	-0.012
	(-0.501)	(-2.968)***	(-0.619)	(-1.646)
SA Data	0.138E-03	- 0.696E-02	-0.717E-02	-0.011
	(0.141)	(-2.697)***	(-0.565)	(-1.553)

b. Habit Formation Model

$$E\left[m^{H}_{t,t+1}\left(R^{i}_{t,t+1}+\eta^{i}\right)-1\right]\equiv E\left[\beta\left(\frac{C_t}{C_{t-1}}\right)^{k(\rho-1)}\left(\frac{C_{t+1}}{C_t}\right)^{-\rho}\left(R^{i}_{t,t+1}+\eta^{i}\right)-1\right]=0$$

for i=SB, LB, SR, and CB

Parameters	η^{SBR}	η^{LBR}	η^{SR}	η^{CB}
Original Data	-0.711E-03	-0.789E-02	-0.799E-02	-0.012
	(-0.542)	(-2.962)***	(-0.624)	(-1.656)
SA Data	-0.177E-03	-0.731E-02	-0.756E-02	-0.012
	(-0.157)	(-2.553)**	(-0.598)	(-1.551)

Notes: 1. Each hypothesis testing is performed by imposing the values of parameters except for η^{i} estimated by the corresponding specification.

2. Estimation of the Euler equations is due to Hansen's (1982) unconditional version of GMM. The *t*- values are reported in parentheses, which are calculated based on standard errors corrected by both Newey and West's (1987) and White's (1980) methods. (*: significant at the 10% level. **: significant at the 5% level. ***: significant at the 1% level.)

c. Money-in-the-Utility Model

$$E\left[m_{t,t+1}^{MU}\left(R_{t,t+1}^{i}+\eta^{i}\right)-1\right]\equiv E\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{\gamma(1-\rho)-1}\left(\frac{M_{t+1}}{M_t}\frac{P_t}{P_{t+1}}\right)^{(1-\gamma)(1-\rho)}\left(R_{t,t+1}^{i}+\eta^{i}\right)-1\right]=0$$

for i=SB, LB, SR, and CB

Parameters	η^{SBR}	η^{LBR}	η^{SR}	η^{CB}
(i) CA (Cash-in-Circulation)				
Original Data	-0.970E-03	- 0.816E-02	-0.826E-02	-0.012
	(-0.709)	(-2.987)***	(-0.643)	(-1.688)*
SA Data	-0.514E-03	-0.762E-02	-0.791E-02	-0.012
	(-0.729)	(-2.926)***	(-0.615)	(-1.630)
(ii) CAD (Cash-in-Circulation and Deposit Money Owned by Individuals)				
Original Data	-0.808E-03	- 0.801E-02	-0.809E-02	-0.012
	(-0.566)	(-2.881)***	(-0.628)	(-1.662)*
SA Data	-0.242E-03	-0.713E-02	-0.745E-02	-0.012
	(-0.033)	(-2.737)***	(-0.576)	(-1.558)
(iii) M1 (CAD+Deposit Money Owned by Corporations)				
Original Data	-0.107E-02	-0.824E-02	-0.837E-02	-0.013
	(-0.829)	(-3.084)***	(-0.650)	(-1.701)*
SA Data	-0.192E-02	-0.903E-02	-0.943E-02	-0.013
	(-1.824)*	(-3.273)***	(-0.717)	(-1.785)*
(iv) M2 (M1+Quasi-Money)				
Original Data	-0.179E-03	-0.732E-02	-0.752E-02	-0.012
	(-0.135)	(-2.809)***	(-0.588)	(-1.583)*
SA Data	0.459E-03	-0.664E-02	-0.682E-02	-0.011
	(0.357)	(-2.529)**	(-0.539)	(-1.506)

Notes: 1. Each hypothesis testing is performed by imposing the values of parameters except for η^{i} estimated by the corresponding specification.

2. Estimation of the Euler equations is due to Hansen's (1982) unconditional version of GMM. The *t*-values are reported in parentheses, which are calculated based on standard errors corrected by both Newey and West's (1987) and White's (1980) methods.(*: significant at the 10% level. **: significant at the 5% level. ***: significant at the 1% level.)

d. Cash-in-Advance Model

$$E\left[m_{t,t+1}^{CA}\left(R_{t,t+1}^{i}+\eta^{i}\right)-1\right]\equiv E\left[\beta\left(\frac{C_{t+2}}{C_{t+1}}\right)^{-\rho}\frac{P_{t+1}}{P_{t}}\frac{P_{t+1}}{P_{t+2}}\left(R_{t,t+1}^{i}+\eta^{i}\right)-1\right]$$

$$=E\left[\beta\left(\frac{M_{t+1}}{M_{t}}\frac{P_{t+1}}{P_{t+2}}\right)^{-\rho}\frac{P_{t+1}}{P_{t}}\frac{P_{t+1}}{P_{t+2}}\left(R_{t,t+1}^{i}+\eta^{i}\right)-1\right]=0$$

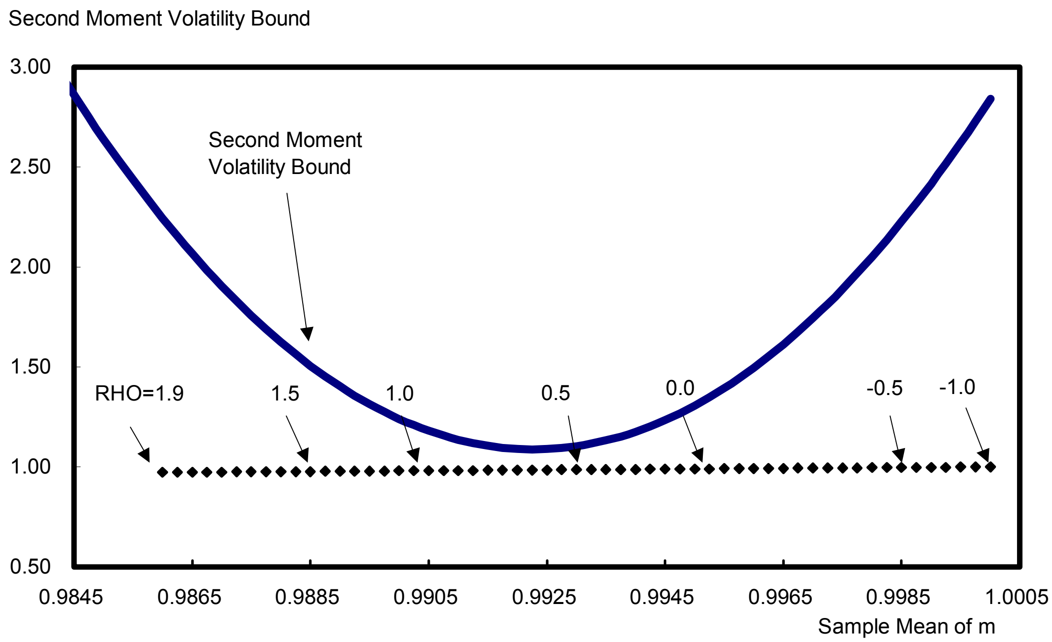
for i=SB, LB, SR, and CB

Parameters	η^{SBR}	η^{LBR}	η^{SR}	η^{CB}
(i) CA (Cash-in-Circulation)				
Original Data	0.946E-04	-0.699E-02	-0.722E-02	-0.011
	(0.087)	(-2.841)***	(-0.560)	(-1.541)*
SA Data	- 0.533E-03	-0.762E-02	-0.797E-02	-0.012
	(-0.540)	(-3.045)***	(-0.609)	(-1.611)*
(ii) CAD (Cash-in-Circulation and Deposit Money Owned by Individuals)				
Original Data	0.260E-03	-0.683E-02	-0.705E-02	-0.011
	(0.241)	(-2.749)***	(-0.545)	(-1.516)
SA Data	0.149E-03	-0.694E-02	-0.729E-02	-0.011
	(0.151)	(-2.772)***	(-0.557)	(-1.520)
(iii) M1 (CAD+Deposit Money Owned by Corporations)				
Original Data	0.270E-03	-0.682E-02	-0.706E-02	-0.011
	(0.245)	(-2.665)***	(-0.547)	(-1.514)
SA Data	-0.800E-04	-0.718E-02	-0.752E-02	-0.012
	(-0.069)	(-2.508)***	(-0.578)	(-1.551)
(iv) M2 (M1+Quasi-Money)				
Original Data	0.462E-03	-0.661E-02	-0.690E-02	-0.011
	(0.388)	(-2.663)***	(-0.534)	(-1.490)
SA Data	0.991E-04	-0.698E-02	-0.719E-02	-0.011
	(0.066)	(-2.826)***	(-0.560)	(-1.538)

Notes: 1. Each hypothesis testing is performed by imposing the values of parameters except for η^{i} estimated by the corresponding specification.

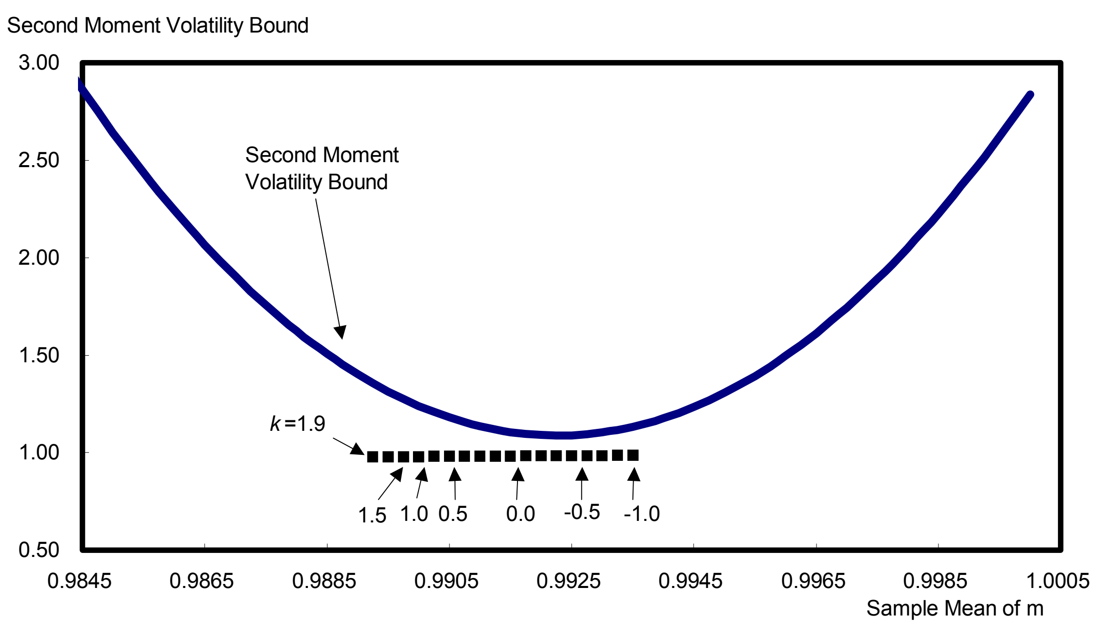
2. Estimation of the Euler equations is due to Hansen's (1982) unconditional version of GMM. The *t*-values are reported in parentheses, which are calculated based on standard errors corrected by both Newey and West's (1987) and White's (1980) methods. (*: significant at the 10% level. **: significant at the 5% level. ***: significant at the 1% level.)

Figure 1: Second-Moment Volatility Bound
A. Consumption-Based CAPM
(i) Standard C-CAPM



Note: • indicates the pair of the mean and the second-moment of the stochastic discount factor computed for various each value of ρ when β =0.9957, which corresponds to the estimated parameter in the case of the standard C-CAPM using the seasonal-adjusted data.

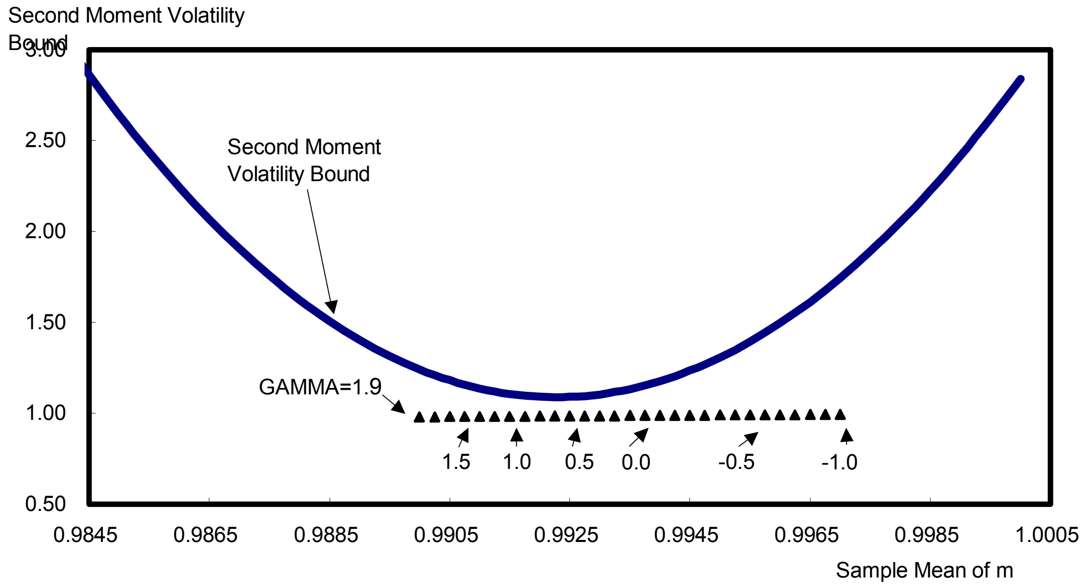
(ii) Habit Formation Model



Note: • indicates the pair of the mean and the second-moment of the stochastic discount factor computed for various each value of k when β =0.9957 and ρ =0.7214, which corresponds to the estimated parameters in the case of the standard C-CAPM using the seasonal-adjusted data.

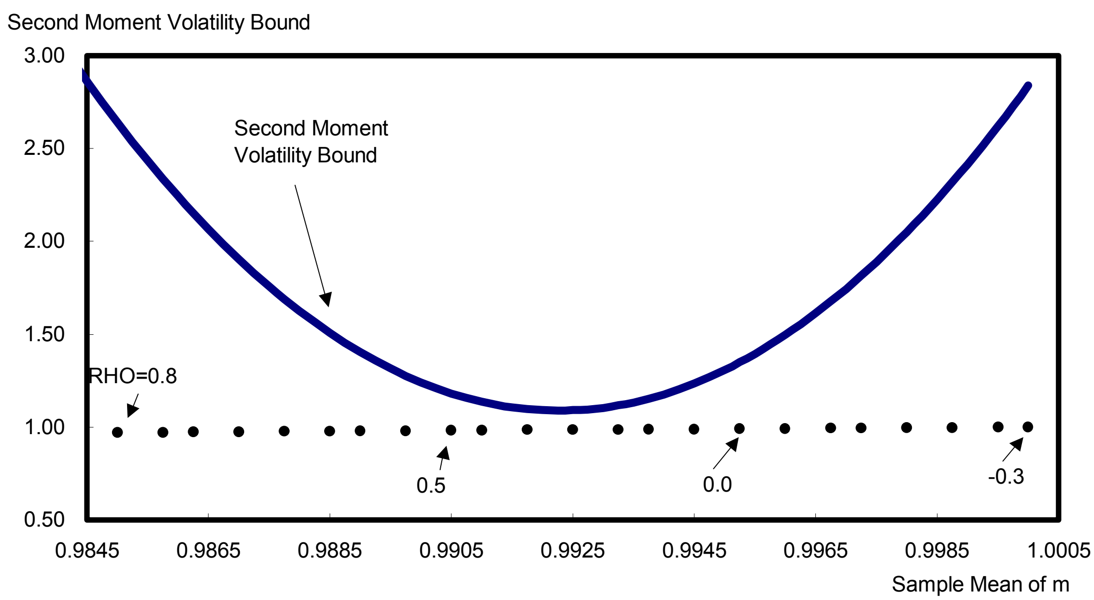
B. Money-Based CAPM

(i) Money-in-the-Utility Model



Note: ● indicates the pair of the mean and the second-moment of the stochastic discount factor computed for various each value of γ when β =0.9957 and ρ =0.7214, which corresponds to the estimated parameters in the case of the standard C-CAPM using the seasonal-adjusted data. Also, CAD is used for the money stock data.

(ii) Cash-in-Advance Model



Note: ● indicates the pair of the mean and the second-moment of the stochastic discount factor computed for various each value of ρ when β =0.9957, which corresponds to the estimated parameters in the case of the standard C-CAPM using the seasonal-adjusted data. Also, CAD is used for the money stock data.