On the Validity and Stability of the Consumption-based Capital Asset Pricing Model Considering Land Prices

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ABSTRACT

This paper examines the Consumption-based Capital Asset Pricing Model (C-CAPM) allowing land assets to enter directly into the instantaneous utility function, in order to identify deep parameters of a representative agent's preference in GMM estimation of Euler equations. A sup-predictive test is used to verify the stability of deep parameters. This model permits the identification of deep parameters in simultaneous estimation of Euler equations in stocks and land.

Key words: C-CAPM, Land pricing, Sup-predictive test

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1. Introduction

It is important to consider land assets when analyzing Japanese household assets. In this paper, we apply a Consumption-based Capital Asset Pricing Model (C-CAPM)[1] considering land pricing, whereas previous studies have mainly focused on financial assets. It may be more appropriate to include land assets as well as financial assets in C-CAPM in view of the following facts. The *2014 National Survey of Family Income and Expenditure* (Statistics Bureau, Ministry of Internal Affairs and Communications) reports that real estate (estimated value of houses, residential and house land) accounts for 64.5 percent and financial assets account for 32.3 percent of total household's net assets in Japan. This ratio indicates that land assets are the main factor in determining the asset allocation of Japanese households. Iwata and Shimotsu (1996) and Nakano and Saito (1998) apply the existing models to Japanese land return data. They suggest that it does not substantially improve the fit of C-CAPM in Japan[2].

However, some previous works argue that models considering consumption and real estate work better than standard models in terms of predictability and validity. Piazzesi et al. (2007) and Lustig et al. (2005) are recent works that employ C-CAPM incorporating real estate variables. Piazzesi et al. (2007) develop the 2-good model consisting of housing and non-housing. They consider the intra and intertemporal elasticity of substitution in the model. They show that housing share can be used to forecast excess returns, and that the risk of composition, share of housing to the expenditures, resolves the risk-free rate puzzle. Lustig et al. (2005) emphasize the role of housing as a collateral asset and show that the model considering housing collateral works better than standard C-CAPM. They state that housing collateral has time-varying risk sharing and that the estimated liquidity shocks decrease when housing collateral is abundant; therefore, it weakens the consumption-correlation puzzle.

Cocco (2004) also verifies the effects of housing investment. Cocco (2004) states that housing investment has an important role in accounting for the patterns of variation in the composition of assets and the level of stockholdings. In this work, housing investment provides some constraints on younger and poorer investors; they have limited financial wealth to invest in stocks. Therefore, they state that house price risk transposes stockholdings, especially with low net wealth.

Aono and Iwaisako (2013) state that performance of the consumption-wealth ratio from Japanese data is weaker than that from U.S. data in terms of stock return prediction. However, it is also shown that the source of predictability for Japanese stock return has been limited to data since the beginning of the 1990s. Then, their verifications utilizing Japanese aggregation data also show that the consumption-wealth ratio dealing with household real estate wealth has better performance than the consumption-wealth ratio with only financial wealth[3].

In this paper, we examine C-CAPM considering land pricing by allowing land assets to enter directly into the instantaneous utility function. In Piazzesi et al. (2007), they consider the intra and intertemporal elasticity of substitution containing housing and non-housing. Among the previous studies, Piazzesi et al. (2007)'s model itself is similar to ours; however, we focus on not only housing but also land assets, and investigate the relationship between financial assets, government bonds and stock, in Japan. In addition, we perform the test for stability of parameters and check the robustness of estimated parameters in addition to the t-test and J-test. These are points of difference between previous studies and ours.

Presumptive arguments for 'Land in utility' (hereafter, LIU) follow. Land makes up a large proportion of total household's net assets in Japan, in spite of the fact that land prices in Japan have slid over the long term since the bursting of the bubble economy in the early 1990s. This implies that land assets are prevailing factors in the total portfolio of Japanese households even with the falling land prices.

Here, our first issue in this study is the concept of asset in utility. The money-in-utility model (hereafter, the MIU model) is generally known as an asset in the utility model. When we suggest the LIU model in this study, we attempt to characterize this model through comparison with the MIU model, which is already well-established.

Based on the medium of exchange and the measure of value in the roles of money, the source of money utility can be regarded as service flows from the liquidity of money. And here, land assets can also be considered as a factor which theoretically produces service flow. Although land assets have a proportionally lower liquidity, these can be substituted for consumption in the sense that they allow agents to consume in the future. As will be shown, the marginal utility of land is included in the stochastic discount factor as the marginal rate of substitution between consumption and land assets in this model. This means that a parameter on substitution between consumption and land is introduced into the parameterization of service flows in the period utility. We set service flow X as $X = c^{\omega}l^{1-\omega}$ where c is non-durable consumption (and service) and l denotes land assets holding. This model implies that people obtain service flow not only from consumption, but also from land assets. This setting of the model, non-separability of c and l, is a key factor in solving the identification problem on relative risk aversion of consumption since this case implies that there is a substitution relationship between c and l. The formulation of an agent's preference can be used to address this identification problem of the deep parameters in the estimation of stochastic Euler equations, which is one of the main purposes of this investigation[4].

Money can serve as a store of value besides the two roles above. On the basis of this role, the social status of agents can be affected by the quantity of their money holdings to no small extent.

In this context, Ono (1994) suggests the possibility that the utility generated by holding money is not saturated[5]. Furthermore, Cole, Mailath and Postlewaite (1992) claim that agents find social value in holding assets in the situation where they care about their relative position in society as well as their level of wealth. Now, land assets can play much the same role as money and other financial assets in the store of value. Moreover, considering the myth of ever-rising land prices in postwar Japan, land assets can be a source of utility in the sense that agents see social value in holding land assets itself.

Moreover, in our opinion, land assets can be substituted for consumption potentially and psychologically. For example, it is assumed that there is a substitution relationship between assets and consumption in the concept of wealth effect. This effect makes people increase their consumption as appraisal values of their assets increase, even if they do not sell their assets. This psychological effect is a wealth effect of consumption.

From a portfolio perspective, land assets can act as a buffer against the price volatility of financial assets. Lustig et al. (2005) regard housing collateral as insurance, and this is similar to the concept of “buffer.” Financial assets including stocks have higher liquidity than land assets. Land assets, however, have a relatively stable price structure except in specific circumstances such as speculative bubbles in real estate. All indications are that land assets can be an argument of agents’ utility function.

As mentioned above, when we set the LIU model, we perform a comparison with MIU not only from the viewpoint of a mean of exchange, but also in terms of a mean of store of value in this paper. We do not regard land assets as a mean of exchange like money.

In this empirical research, the sup-predictive test proposed by Ghysels, Guay and Hall (1997) is used to verify the stability of deep parameters in Hansen (1982)’s Generalized Method of Moments (GMM) estimation of this model. Hamori, Kitasaka and Tanizaki (1996) state that the predictive test is more powerful than the overidentifying restrictions test in terms of the small sample performance, and it can be said that this stability test is important to check the robustness.

Then, the results obtained in this paper can be summarized as follows. Our model consists of two equations. The results of single-equation estimation using financial asset returns do not show good performance. And the results of simultaneous-equations estimation show that preference parameters are significantly and stably estimated within the range of each sign condition, using returns on the Tokyo Stock Exchange Stock Price Index (TOPIX) and land return. The overidentifying restriction is also satisfied. These results imply that it is important to consider jointly both stocks and land in the analysis of a Japanese household’s portfolio. In our study, it is shown that land assets and their earning rate have important roles when we consider the capital asset pricing model with Japanese data. The price of this asset is unlikely to drop below a certain level. Thus, land assets seem to play the role of a buffer which assures holding of risky assets to the investor in Japan. These are the main findings of our investigation.

Due to the high weight of land in the total household's assets and role of land assets in Japan, we can state two implications for practitioners. First, practitioners in the financial sector have to consider land and real estate when they develop the portfolio for households in Japan. Second, we have to pay attention to alteration of the land taxation system, since it might affect the household's asset holding.

This paper is organized as follows. Section 2 presents C-CAPM considering land assets. Section 3 describes the consumption and return data used in this empirical investigation. Section 4 presents the empirical results of this model, while Section 5 discusses these results. Section 6 concludes the paper.

2. Model

In the economy, a representative agent is assumed to hold land assets in order not only to use them, but also because they are inherently desirable. Let us assume that a representative consumer chooses consumption, financial asset holding and land asset holding, in order to maximize the lifetime expected utility subject to budget constraints. Then, the maximization problem for this representative agent is formulated as follows:

$$\max_{c_t, a_{t+1}, l_{t+1}} \quad E_0\left\{\sum_{t=0}^{\infty} \beta^t u(c_t, l_t)\right\}, \tag{1}$$

$$s.t. \quad a_{t+1} + l_{t+1} = (1 + r_t)a_t + (1 + r_t^l)l_t + w_t - c_t, \tag{2}$$

where $\beta \in (0, 1)$ is the subjective discount factor, $E_t(\cdot)$ is the expectation operator conditional on the information available at time t, $u(\cdot)$ is the instantaneous utility function, c_t is the real consumption in period t, a_t is the quantity of a financial assets at the beginning of period t (the end of period $t-1$), l_t is the quantity of land assets at the beginning of period t, r_t is the net return on financial assets between period t and $t-1$, $r^l{}_t$ is the net return on land assets between period t and $t-1$, and w_t is the labor income (real wage) in period t.

Additionally, the notation for the derivative of instantaneous utility function is used as follows:

$$u_c(c_t, l_t) \equiv \partial u(c_t, l_t)/\partial c_t > 0, \;\; u_{cc}(c_t, l_t) \equiv \partial^2 u(c_t, l_t)/[\partial c_t]^2 < 0,$$

$$u_l(c_t, l_t) \equiv \partial u(c_t, l_t)/\partial l_t > 0,\ \ u_{ll}(c_t, l_t) \equiv \partial^2 u(c_t, l_t)/[\partial l_t]^2 < 0.$$

The optimal first-order conditions yield the following Euler equations:

$$a:\ E_t\left[\beta\frac{u_c(c_{t+1}, l_{t+1})}{u_c(c_t, l_t)}(1 + r_{t+1}) - 1\right] = 0,\ \ for\ \ t \in [0, \infty), \tag{3}$$

$$l:\ E_t\left\{\beta\frac{u_c(c_{t+1}, l_{t+1})}{u_c(c_t, l_t)}\left[\left(1 + r^l_{t+1}\right) + \frac{u_l(c_{t+1}, l_{t+1})}{u_c(c_{t+1}, l_{t+1})}\right] - 1\right\} = 0,\ \ for\ \ t \in [0, \infty). \tag{4}$$

Therefore, equation (3) determines the return (price) on financial assets, and equation (4) provides the return (price) on land assets in equilibrium.

Now, the instantaneous utility function can be specified as

$$u(c_t,l_t) = \frac{1}{1-\gamma}\left(c_t^{\omega} l_t^{1-\omega}\right)^{1-\gamma},\ \ 0 < \omega < 1\ \ and\ \ \gamma > 0. \tag{5}$$

The service flows from consumption and land can be represented as

$$x_t \equiv c_t^{\omega} l_t^{1-\omega},$$

where parameter ω represents substitution between consumption and land in the service flows. In other words, ω means *mental* weight on consumption in x_t, while $1 - \omega$ exhibits *internal* weight on land assets in x_t. Parameter γ is the RRA for x_t, since function (5) is defined as the nested CRRA function in x_t[6].

Under the parameterization of utility function (5), Euler equations (3) and (4) can be rewritten as follows:

$$a:\ E_t\left[\beta\left(\frac{c_{t+1}}{c_t}\right)^{\omega(1-\gamma)-1}\left(\frac{l_{t+1}}{l_t}\right)^{(1-\omega)(1-\gamma)}(1 + r_{t+1}) - 1\right] = 0,\ \ for\ \ t \in [0, \infty), \tag{6}$$

$$l:\ E_t\left\{\beta\left(\frac{c_{t+1}}{c_t}\right)^{\omega(1-\gamma)-1}\left(\frac{l_{t+1}}{l_t}\right)^{(1-\omega)(1-\gamma)}\left[1 + r^l_{t+1} + \frac{1-\omega}{\omega}\left(\frac{c_{t+1}}{l_{t+1}}\right)\right] - 1\right\} = 0,\ \ for\ \ t \in [0,\infty), \tag{7}$$

which serve as the basis for the empirical work. In what follows, equation (6) is called

'Model 1,' and equation (7) is called 'Model 2.' In Section 4, Euler equations (6) and (7) are estimated using GMM, and the stability of estimated parameters is verified using the sup-predictive test of Ghysels et al. (1997).

3. Data

The data set for this study consists of quarterly observations on Japanese variables from 1980: Q1 to 2020: Q3 (estimation begins in 1980: Q4). The data in this analysis are seasonally adjusted using the X-12-ARIMA (Autoregressive Integrated Moving Average) method (the US Census Bureau).

Real consumption data are taken from the *Annual Report on National Accounts* (ARNA) (Cabinet Office, Government of Japan). As for per capita consumption data in this model, we use real expenditure on nondurables and services that are divided by the total population (with intercensal adjustment), which is reported in the *Population Census* (Statistics Bureau, Ministry of Internal Affairs and Communications). The current 2011-base data, which have been released since 1994, are connected to the 2000-base data by means of the growth rate.

Nominal land assets of households (including private unincorporated enterprises) are taken from ARNA, and are divided by the total population in order to obtain per capita data. In a similar way, the current 2011-base data are estimated retrospectively by the growth rate of 2000-base data. Since the original series in ARNA are annual data, quarterly land data are calculated by applying a cubic spline interpolation method.

The inflation rate in this model is obtained by using the Consumer Price Index (CPI; All items, except fresh food), which is published by the Statistics Bureau (Ministry of Internal Affairs and Communications). Land return data are given by the growth rate of the Urban Land Price Index (ULPI) (Japan Real Estate Institution). Quarterly ULPI data are computed by using the cubic spline interpolation method because of the original half-yearly data. The financial asset return data in this paper are the yield on newly issued 10-year Japanese government bonds and the returns of TOPIX, which are given as not annual but quarterly returns along with the other variables.

4. Estimation and Stability Test

In this section, we perform the estimation and parameter stability test for Models 1 and 2. We employ GMM as an estimation procedure; however, we show the estimation result of each model and that of simultaneous models. Here, we utilize two types of consumption data; non-durable goods + services (CNDS) and non-durable goods only (CND). In addition, we compare the case with the returns of Japanese government bonds (10 years) and those of TOPIX as returns of

Table 1. Estimate Results with Model 1

Model 1 (GB10 CND)

Parameter		Estimate	S.Error	t-Stat.	P-value
OMEGA		1.408	0.329	4.285	[.000]
GAMMA		0.168	0.601	0.280	[.780]
CHISQ(3)	(J-test)		17.119	Upper tail area 0.001	
Sup-Pred.	test		14.310	(B/P 1993Q4 when p = 2 and q − p = 3)	

Model 1 (GB10 CNDS)

Parameter		Estimate	S.Error	t-Stat.	P-value
OMEGA		9.754	217.130	0.045	[.964]
GAMMA		0.976	0.603	1.620	[.105]
CHISQ(3)	(J-test)		14.734	Upper tail area 0.002	
Sup-Pred.	test		13.700	(B/P 1993Q3 when p = 2 and q − p = 3)	

Model 1 (TOPIX CND)

Parameter		Estimate	S.Error	t-Stat.	P-value
OMEGA		13.690	500.056	0.027	[.978]
GAMMA		0.835	6.475	0.129	[.897]
CHISQ(3)	(J-test)		1.555	Upper tail area 0.670	
Sup-Pred.	test		9.060	(B/P 2010Q1 when p = 2 and q − p = 3)	

Model 1 (TOPIX CNDS)

Parameter		Estimate	S.Error	t-Stat.	P-value
OMEGA		5.246	28.273	0.186	[.853]
GAMMA		0.308	4.818	0.064	[.949]
CHISQ(3)	(J-test)		1.005	Upper tail area 0.800	
Sup-Pred.	test		11.170	(B/P 2012Q4 when p = 2 and q − p = 3)	

Note: Instrumental variables are 1-period lag of c_t/c_{t-1}, l_t/l_{t-1}, r_t, r_t^l and constant.
Critical values of sup-predictive test (possible breakpoint (B/P) π ∈ (0.2,0.8)) are 16.80 (10%:*), 19.20 (5%:**) and 23.56 (1%:***) when p = 2 and q − p = 3. Here, p is the number of parameters and q number of instrument variables (See Table 4 in Ghysels et al. (1997)).

financial assets. Although Model 2 does not include financial assets, the differences are reflected in the choice of instrument variables. In total, we show 12 cases here. Instrument variables are 1-period lag of c_t/c_{t-1}, l_t/l_{t-1}, r_t, r^l_t and constant in all cases. Here, the level of significance is 10%, and we set $\beta = 0.999$ following Ogaki and Reinhart (1998).

Estimation results of Model 1 are shown in Table 1. Firstly, we investigated the case with the rate of Japanese government bonds (JGB). With CNDS, point estimates of γ and ω are 0.976 and 9.754: both are positive but insignificant. Here, ω is much larger than 1. This implies that point estimate does not satisfy the condition of $0 < \omega < 1$. J-test statistics is 14.734 (*P*-value is 0.002) and we can reject the null of over-identification; however, we cannot reject the null hypothesis of stable parameters with the sup-predictive test. Considering only CND, the point estimate of ω is 1.408. It is positive and significant, but it does not satisfy the condition of $0 < \omega < 1$. And estimated γ is insignificant. J-test statistics is 17.119 (*P*-value is 0.001) and we can reject the null. The result of the sup-predictive test indicates the acceptance of null of stable parameters.

Then, we verify the case utilizing TOPIX as the earnings ratio of financial assets. With CNDS, the point estimators of γ and ω are 0.308 and 5.246; however, they are not significant. J-test statistics is 1.005 (*P*-value is 0.800) and it indicates the acceptance of null. The result of the sup-predictive test shows the acceptance of null of stable parameters. With CND, we obtain similar results: point estimators of both parameters are insignificant and *J*-test statistics is 1.555 (*P*-value is 0.670), which implies acceptance of null of over-identification. And the result of the sup-predictive test shows that the parameters are stable.

Then, these empirical results imply that since almost estimated parameters are not significant, although parameters are stable in all cases, and it can be said that Model 1 does not fit C-CAPM with Japanese data.

The empirical results with Model 2, which considers net return on land assets, are shown in Table 2. Here, returns on financial assets (GB10 and TOPIX) are included only in the set of instruments. First, we show the case utilizing GB10 as the rate of return of financial assets. With CNDS, point estimates of γ and ω are 1.052 and 0.878, and only ω is significant; however, *J*-test statistics is 18.857 (*P*-value is 0.000) and null of over-identification is rejected with a 1% level of significance. The sup-predictive test statistics is 3.960 and it implies acceptance of the null of stable parameter. With CND, point estimates of γ and ω are 3.285 and 0.694, and both are positive and significant. But *J*-test statistics implies rejection of null (*J* is 14.042 and *P*-value is 0.003). The sup-predictive test statistics is 30.01, and the null of stable parameters is rejected.

With TOPIX and CNDS, the point estimate of γ is 2.378, and that of ω is 0.847, and both are positive and significant; however, *J*-test statistics is 14.646 (*P*-value is 0.002), which implies rejection of null. The sup-predictive test statistics is 25.04, which shows rejection of the null of stable parameters. With TOPIX and CND, we obtain similar results; point estimates of γ and ω are positive and significant (γ: 3.524, ω: 0.710), null of over-identifying is rejected (*J*-test statistics is 10.454 and *P*-value is 0.015) and the null of stable parameters is rejected (the sup-predictive test statistics is 41.24).

These empirical results with Model 2 imply that estimated parameters are significant and satisfy the sign restriction ($\gamma > 0$, $0 < \omega < 1$) except for the case with GB10 and CNDS; however, over-identifying conditions are not satisfied. And parameters are not stable except for case with CNDS. So, Model 2 alone cannot explain the relationship between the asset price and consumption, either.

Finally, we estimate the simultaneous model, which consists of Models 1 and 2. The estimation results are shown in Table 3. With GB10 and CNDS, the point estimate of γ is 1.877 and that of ω is 0.858. The sup-predictive test implies acceptance of null of stable parameters; however, J-test statistics are 22.735 (*P*-value is 0.004), which implies rejection of the null of

Table 2. Estimate Results with Model 2

Model 2 (GB10 CND)

Parameter	Estimate	S.Error	t-Stat.	P-value
OMEGA	0.694	0.072	9.672	[.000]
GAMMA	3.285	0.774	4.244	[.000]
CHISQ(3)	(J-test)	14.042	Upper tail area 0.003	
Sup-Pred.	test	30.01***	(B/P 1990Q1 when p = 2 and q − p = 3)	

Model 2 (GB10 CNDS)

Parameter	Estimate	S.Error	t-Stat.	P-value
OMEGA	0.878	0.020	44.866	[.000]
GAMMA	1.052	0.893	1.178	[.239]
CHISQ(3)	(J-test)	18.857	Upper tail area 0.000	
Sup-Pred.	test	3.960	(B/P 1990Q1 when p = 2 and q − p = 3)	

Model 2 (TOPIX CND)

Parameter	Estimate	S.Error	t-Stat.	P-value
OMEGA	0.710	0.088	8.097	[.000]
GAMMA	3.524	0.947	3.719	[.000]
CHISQ(3)	(J-test)	10.454	Upper tail area 0.015	
Sup-Pred.	test	41.24***	(B/P 1990Q4 when p = 2 and q − p = 3)	

Model 2 (TOPIX CNDS)

Parameter	Estimate	S.Error	t-Stat.	P-value
OMEGA	0.847	0.023	36.081	[.000]
GAMMA	2.378	0.739	3.218	[.001]
CHISQ(3)	(J-test)	14.646	Upper tail area 0.002	
Sup-Pred.	test	25.04***	(B/P 1990Q1 when p = 2 and q − p = 3)	

Note: Instrumental variables are 1-period lag of c_t/c_{t-1}, l_t/l_{t-1}, r_t, r_t^l and constant.
Critical values of sup-predictive test (possible breakpoint (B/P) π ∈ (0.2,0.8)) are 16.80 (10%:*), 19.20 (5%:**) and 23.56 (1%:***) when p = 2 and q − p = 3. Here, p is the number of parameters and q number of instrument variables (See Table 4 in Ghysels et al. (1997)).

over-identification.

With GB10 and CND, we obtain the same results. Estimated γ is 2.428 and ω is 0.665, J-test statistics is 23.466 (*P*-value is 0.003) and the sup-predictive test statistics is 82.58; over-identification and parameter stability are rejected. Although estimated γ and ω are positive and significant and sign constraints ($\gamma > 0$, $0 < \omega < 1$) are satisfied, we cannot identify this model according to the J-test and sup-predictive test.

Then, we verify the case with TOPIX. Estimated results are shown in Table 3. With CNDS, the point estimate of γ is 2.859 and that of ω is 0.829. They are positive and significant, and sign constraints ($\gamma > 0$, $0 < \omega < 1$) are satisfied. J-test statistics is 12.873 (*P*-value is 0.116) and it cannot reject the null of over-identification. The sup-predictive test statistics is 22.330, and it shows acceptance of the null of parameter stability. With CND, we obtain the same results. The point estimate of γ is 3.256 and that of ω is 0.661; they are positive and significant, and sign constraints are also satisfied. J-test statistics is 13.190 (*P*-value is 0.105) and the sup-predictive

Table 3. Estimate Results with Model 1 and Model 2

Model 1 & 2 (GB10 CND)

Parameter	Estimate	S.Error	t-Stat.	P-value
OMEGA	0.665	0.026	25.423	[.000]
GAMMA	2.428	0.447	5.431	[.000]
CHISQ(8)	(J-test)	23.466	Upper tail area 0.003	
Sup-pred.	test	82.58***	(B/P 1990Q3 when p = 2 and q − p = 8)	

Model 1 & 2 (GB10 CNDS)

Parameter	Estimate	S.Error	t-Stat.	P-value
OMEGA	0.858	0.016	54.379	[.000]
GAMMA	1.877	0.319	5.892	[.000]
CHISQ(8)	(J-test)	22.735	Upper tail area 0.004	
Sup-Pred.	test	23.150	(B/P 1990Q4 when p = 2 and q − p = 8)	

Model 1 & 2 (TOPIX CND)

Parameter	Estimate	S.Error	t-Stat.	P-value
OMEGA	0.661	0.054	12.173	[.000]
GAMMA	3.256	0.715	4.552	[.000]
CHISQ(8)	(J-test)	13.190	Upper tail area 0.105	
Sup-Pred.	test	19.030	(B/P 2012Q1 when p = 2 and q − p = 8)	

Model 1 & 2 (TOPIX CNDS)

Parameter	Estimate	S.Error	t-Stat.	P-value
OMEGA	0.829	0.023	36.043	[.000]
GAMMA	2.859	0.531	5.387	[.000]
CHISQ(8)	(J-test)	12.873	Upper tail area 0.116	
Sup-Pred.	test	22.330	(B/P 2012Q2 when p = 2 and q − p = 8)	

Note: Instrumental variables are 1-period lag of c_t/c_{t-1}, l_t/l_{t-1}, r_t, r_t^l and constant.
Critical values of sup-predictive test (possible breakpoint (B/P) π ∈ (0.2,0.8)) are 26.56 (10%:*), 29.40 (5%:**) and 35.23 (1%:***) when p = 2 and q − p = 8. Here, p is the number of parameters and q number of instrument variables (See Table 4 in Ghysels et al. (1997)).

test statistics is 19.030. These imply that the null of over-identification and that of the stability of parameters cannot be rejected.

Then, these empirical results indicate that the simultaneous model with TOPIX can be estimated properly[7].

5. Discussion

In the previous section, we estimate Euler equations consisting of equations (6) and (7). Only the simultaneous model with TOPIX is estimated properly; estimated parameters are positive, significant and satisfy the sign restriction. Here, we consider the goodness of fit of this simultaneous model. Parameter ω denotes the weight of consumption expenditure in the service flow of time utility, which consists of consumption and land. The point estimate of ω is 0.661 with CND, and this estimate is 0.829 with CNDS.

In both cases, higher weight is put on consumption expenditure. And estimated γ is around 3.0

in both cases: CNS and CNDS. In this model, γ is the relative risk aversion of service flow, and this is a large value as a relative risk aversion. These results imply consumption behavior and land tenure are not affected much by the interest rate and economic performance. Meanwhile, it is difficult for a general household to sell/purchase their land tenure according to the economic performance, and estimated γ becomes a large value.

In this paper, we suppose that households obtain utility from consumption and land and estimate C-CAPM utilizing earning rates of financial assets and land. In Models 1 and 2, both consumption expenditure and land tenure are considered, however, the earning rate of financial assets is considered only in Model 1 and that of land only in Model 2. Therefore, each model alone cannot explain the relationships among consumption, land tenure and earning rates; it is shown that the simultaneous model improves the interpretability of the model.

Usually, the analysis subjects of capital asset pricing models are the choice of risk-free assets and risk assets as financial assets. According to empirical analysis based on the simultaneous model, however, the relationship between net return on risk-free assets, GB10, and that on land assets is not strong; however, net return on risk assets, TOPIX, is strongly related to that on land assets. These empirical results suggest the position of land in Japanese households. As mentioned before, land estate occupies 64.5 percent of the total net assets of households. The land price fluctuates, but hardly reaches zero. Therefore, it can be thought that land assets support the purchases of risk assets, e.g. stock investment.

On the other hand, the case with GB10 has a low power to explain asset pricing even with the simultaneous model. This point is supported by findings of previous studies[8]. Evidently, this low interpretability has to do a lot with the sample period including a low-interest rate era. Under the low-interest rate policy, we cannot realize much profit with financial products whose main return is interest, e.g. bank deposits and government bonds. Thus, we consider that rates of net return do not influence households' decisions of intertemporal consumption. Considering that we utilize C-CAPM in this study, this feature we mentioned before causes insignificant empirical results with GB10. Moreover, we can obtain revenues from stocks and land to some degree even under the zero-interest rate policy. Then we can say that the retention of land and stocks has a certain effect on consumption behavior through the mechanism explained by C-CAPM. Therefore, we can obtain desirable results of empirical analysis with the simultaneous model considering the earning rate on TOPIX and land[9].

Finally, we show some implications for practitioners. As mentioned previously, land assets have an important role: the buffer for the risk asset holding. They are also heavily correlated with the high weight of land in the total assets in Japan. Therefore, when practitioners in the financial sector develop the financial products for households in Japan, it is important for them to consider real assets: land and real estate. In addition, their asset holdings may be affected by alteration of the land taxation system. Then, we have to pay attention to the amendment of related laws.

6. Conclusion

In this study, we estimate C-CAPM considering consumption expenditure and land tenure in Japan. In the model we employ, we consider the rate of earnings on financial assets and that from land, and this model consists of two kinds of Euler equations (Models 1 and 2). The estimations we perform indicate that the simultaneous model is applicable to C-CAPM.

When we utilize the simultaneous model, we cannot reject the null of over-identification with return on equity investment (TOPIX) as a return on financial assets, the point estimates are plausible and stable; however, in the case of government bonds (GB10) as financial assets, the null of over-identification is rejected, and the point estimates are not stable with CND (non-durable consumption).

We estimate this model employing GMM, and show that the null hypothesis of over-identification is not rejected with the J-test. Moreover, we employ the sup-predictive test to check the stability of parameters, and we cannot reject the null hypothesis: parameters estimated by GMM are stable. Hamori et al. (1996) show that the predictive test has better small sample properties than the J-test. Therefore, we can confirm the robustness of the model we employ.

These empirical results show that land assets and their earning rate have important roles when we consider the capital asset pricing model with Japanese data. In Japan, land occupies about 64% of Japanese household assets, and the price of this asset is unlikely to drop below a certain level. Namely, land assets play the role of a buffer, which supports risk asset holding, e.g. equity holding, by households. The possession of land assets assures holding of risk assets to the investor in Japan. These are the main findings of our investigation.

The case with returns on government bonds is less appropriate; and the low interest rate era influences these empirical results. In the sample period we employ, a low interest rate policy was enforced. Then, gains from financial assets with interest, e.g. government bonds, are insufficient to influence consumption expenditure by households. On the other hand, the rates of return on equities and land fluctuate to a degree. Thus, they influence the consumption behavior, and we can obtain plausible results with the case considering TOPIX.

From the above empirical results, we can obtain important implications when we verify the asset pricing model. In Japan, people tend to regard land as an important asset and the weight of land among household assets is still high at present.

By the 1980s, land prices were continuing to rise and the myth that they would always continue to rise was believed in Japan: so-called *Tochi-Shinwa* (Real estate myth). Our empirical results show that the earning rates of equity and land are correlated; we can confirm the importance of the role of land assets.

We can state two implications that seem to concern practitioners. First, due to the high weight of land in the total assets in Japan, practitioners in the financial sector have to consider land and real estate when they develop the portfolio for households in Japan. Second, we have to pay attention to alteration of the land taxation system. Since it is considered that land has an important role in investment by Japanese households, the land taxation system may affect the household's asset holding.

In future, we would like to examine relative risk aversion and the wealth effect. In this paper, we estimate deep parameters (ω and γ) and verify their stability. In the model we employ here, we support the claim that relative risk aversion is constant and relies on the power utility function; however, we are confronted by problems brought about by asset pricing models. It would be interesting to examine these kinds of problems by calibration. Moreover, we would like to reconsider the robustness of the empirical results obtained in this study by employing other utility functions (e.g. CES utility function).

Appendix. Sup-predictive test

Here, we show details of the sup-predictive test statistics developed by Ghysels et al. (1997).

Let $g_1(\hat{\theta}_1)$ be the moment condition in the first subsample and $g_2(\hat{\theta}_1)$ be the moment condition in the second subsample. And $\hat{\theta}_1$ is the parameter estimated only in the first subsample. Here, n_1 is the size of the 1st subsample and n_2 is the size of the 2nd subsample. Then the predictive test statistics PR is

$$PR = \left[\sqrt{n_2}g_t(\hat{\theta}_1)\right]'(\hat{V}_2)^{-1}\left[\sqrt{n_2}g_t(\hat{\theta}_1)\right],$$

where

$$\hat{V}_2 = S_2 + \frac{n_2}{n_1}\hat{D}_2(D_1'S_1^{-1}D_1)\hat{D}_2$$

$$S_i = n_i g_i(\hat{\theta}_1)g_i(\hat{\theta}_1)' \qquad i = 1, 2$$

$$D_1 = \frac{\partial g_1(\hat{\theta}_1)}{\partial \theta'}$$

$$\hat{D}_2 = \frac{\partial g_2(\hat{\theta}_1)}{\partial \theta'}.$$

In the sup-predictive test, we calculate PR with each sample split point $\pi T + 1$ (T: full sample) and the PR for each π is written as $PR(\pi)$. Here π satisfies $\pi \subset (0,1)$. We assume that $\pi \in (0.2,0.8)$ in this paper. Among each $PR(\pi)$, we choose the $PR(\pi^*)$ that satisfies $PR(\pi^*) = \sup PR(\pi)$. We regard π^* as a possible point of break, and test it under the null hypothesis of no structural break in parameters[10].

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NOTES

1. C-CAPM was first developed by Lucas (1978) and Breeden (1979).
2. In empirical analysis of C-CAPM, earlier studies, including Hansen and Singleton (1982, 1983), reported that C-CAPM is not consistent with U.S. financial market data. Mehra and Prescott (1985) showed that the estimates of the relative risk aversion measure (RRA), proposed by Arrow (1951) and Pratt (1964), are too low to explain the large equity premium. This is known as the 'equity premium puzzle' or 'Mehra-Prescott puzzle.' These results are attributed to the specification of power utility, that is, the constant relative risk aversion (CRRA) preference. Accordingly, several studies have developed alternative models considering habit formation (Sundaresan 1989; Abel 1990; Constantinides 1990; Heaton 1995), separating risk aversion and intertemporal substitution (Epstein and Zin 1989, 1991; Weil 1989). However, no model resolves the Mehra-Prescott puzzle completely.
3. In some works, other factors are also considered. For example, Tuzel (2010) focuses on the link between firms' composition of assets and stock return. Here, it is assumed that firms hold real estate and other capital. And their theoretical verifications show that firms with high real estate holdings are vulnerable to negative productivity shock; consequently, they are riskier and have higher expected returns. This work also shows that empirical evidence

also supports this theoretical implication.

4. Japanese studies on C-CAPM report contrasting results in empirical analyses using Japanese asset market data. While Hamori (1992) shows good performance of C-CAPM, Fukuta (1993) and Tanigawa (1994) report negative and insignificant estimates of RRA in GMM estimation of this model. The latter indicates that it is difficult to identify each ‘deep parameter’ in utility specification, including the rate of subjective time preference, RRA and so forth, when we estimate nonlinear Euler equations.
5. According to Ono (1994), using the MIU dynamic model under insatiable liquidity preference, there is a case where persistent unemployment occurs in the steady state. Ono, Ogawa and Yoshida (2004) empirically find that insatiability of liquidity preference is better supported than satiability of liquidity preference.
6. RRA was originally proposed in terms of wealth or money by Arrow (1951) and Pratt (1964).
7. After the theoretical work of Stock and Wright (2000), GMM estimation considering weak identification has been utilized in many empirical studies. For examples of GMM estimation and weak identification, see Stock, Wright and Yogo (2002). In this paper, we do not consider this problem, however, we obtained the desired results.
8. For example, see Fukuta (1993).
9. As an additional empirical investigation, we estimate the simultaneous model which consists of three equations: Models 1 with GB10, one with TOPIX and Model 2. However, the validity of this model is not supported by J-test and sup-predictive test in both cases with CNS and CDNS.
10. The critical values are shown in Ghysels et al. (1997). The critical values depend on the number of parameters and instrumental variables.

REFERENCES

Abel, A. B. (1990). Asset Prices under Habit Formation and Catching up with the Joneses. *American Economic Review*, 80(2), 38–42.

Aono, K., & Iwaisako, T. (2013). The consumption–wealth ratio, real estate wealth, and the Japanese stock market. *Japan and the World Economy*, 25–26, 39–51.

Arrow, K. J. (1951). Alternative Approaches to the Theory of Choice in Risk-taking Situations. *Econometrica*, 19(4), 404–437.

Breeden, D. T. (1979). An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities. *Journal of Financial Economics*, 7(3), 265–296.

Cocco, Joao F. (2004). Portfolio Choice in the Presence of Housing. *The Review of Financial Studies*, 18(2), 535–567.

Cole, H. L., Mailath, G. J., & Postlewaite, A. (1992). Social Norms, Savings Behavior, and Growth. *Journal of Political Economy*, 100(6), 1092–1125.

Constantinides, G. (1990). Habit Formation: A Resolution of the Equity Premium Puzzle. *Journal of Political Economy*, 98(3), 519–543.

Epstein, L. G., & Zin, S. E. (1989). Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: A Theoretical Framework. *Econometrica*, 57(4), 937–969.

Epstein, L. G., & Zin, S. E. (1991). Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: An Empirical Analysis. *Journal of Political Economy*, 99(2), 263–286.

Fukuta, Y. (1993). Nihon no Rishi-ritsu no Kikan Kouzou Bunseki: Shouhi Shisan Kakaku Model no Saikentou (The term structure of interest rates in Japan-A re-examination of the consumption-based asset pricing model). *Keizai Kenkyu* (*Economic Review*, Institute of Economic Research, Hitotsubashi University), 44-3, 221–232. (In Japanese)

Ghysels, E., Guay, A., & Hall, A. (1997). Predictive Tests for Structural Change with Unknown Breakpoint. *Journal of Econometrics*, 82, 209–233.

Hamori, S. (1992). Test of C-CAPM for Japan: 1980–1988. *Economics Letters*, 38(1), 67–72.

Hamori, S., Kitasaka, S., & Tanizaki, H. (1996). On a Test for Structural Stability of Euler Conditions Parameters Estimated via Generalized Method of Moments Estimators: Small sample properties. *Econometric Reviews*, 15(1), 97–116.

Hansen, L. P. (1982). Large Sample Properties of Generalized Methods of Moments Estimators. *Econometrica*, 50(4), 1029–1054.

Hansen, L. P., & Singleton, K. J. (1982). Generalized Instrumental Variables Estimation of Nonlinear Rational Expectations Models. *Econometrica*, 50(5), 1269–1286.

Hansen L. P., & Singleton, K. J. (1983). Stochastic Consumption, Risk Aversion, and the Temporal Behavior of Asset Returns. *Journal of Political Economy*, 91(2), 249–265.

Heaton, J. (1995). An Empirical Investigation of Asset Pricing with Temporally Dependent Preference Specifications. *Econometrica*, 63(3), 681–717.

Iwata, K., & Shimozu, K. (1996). Shisan-Kakaku to Shouhi: Taikyuu-zai, Shuukansei to Fukusuu-zai (Asset price and consumption: durability, habituation and multiple goods). *Kikan Juutaku Tochi Keizai* (*The Quarterly Journal of Housing and Land Economics*, Housing research & advancement foundation of Japan), 20, 9–20. (In Japanese)

Lucas, R. E., Jr. (1978). Asset Prices in An Exchange Economy. *Econometrica*, 46(6), 1429–1445.

Lustig, Hanno N., & Van Nieuwerburgh, Stijn G. (2005). Housing collateral, consumption insurance, and risk premia: an empirical perspective. *Journal of Finance*, 60(3), 1167–1219.

Mehra, R., & Prescott, E. C. (1985). The Equity Premium: A Puzzle. *Journal of Monetary Economics*, 15(2), 145–161.

Nakano, K., & Saito, M. (1998). Asset Pricing in Japan. *Journal of the Japanese and International Economies*, 12(2), 151–166.

Ogaki, M., & Reinhart, C. M. (1998). Measuring Intertemporal Substitution: the Role of Durable Goods. *Journal of Political Economy*, 106(5), 1078–1098.

Ono, Y. (1994). *Money, Interest, and Stagnation: Dynamic Theory and Keynes's Economics*. Oxford: Clarendon Press.

Ono, Y., Ogawa, K., & Yoshida, A. (2004). The Liquidity Trap and Persistent Unemployment with Dynamic Optimizing Agents: Empirical evidence. *Japanese Economic Review*, 55(4), 355–371.

Piazzesi, M., Schneider, M., & Tuzel, S. (2007). Housing, consumption and asset pricing. *Journal of Financial Economics*, 83, 531–569.

Pratt, J. W. (1964). Risk Aversion in the Small and In the Large. *Econometrica*, 32(1–2), 122–136.

Stock, J. H., & Wright, J. H. (2000). GMM with Weak Identification. *Econometrica*, 68(5), 1055–1096.

Stock, J. H., Wright, J. H., & Yogo, M. (2002). A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments. *Journal of Business & Economic Statistics*, 20(4), 518–529.

Sundaresan, S. M. (1989). Intertemporally Dependent Preferences and the Volatility of Consumption and Wealth. *Review of Financial Studies*, 2(1), 73–88.

Tanigawa, Y. (1994). Shouhi Data wo Motiita Shisan-kakaku no Jisshou Bunseki (Japanese evidence on consumption-based capital asset pricing model). *Okayama Daigaku Keizai-gakkai Zasshi* (*Okayama Economic Review*, The Economic Association of Okayama University), 25-3, 315–332. (In Japanese)

Tuzel, S. (2010). Corporate Real Estate Holdings and the Cross-Section of Stock Returns. *The Review of Financial Studies*, 23(6), 2268–2302.

Weil, P. (1989). The Equity Premium Puzzle and the Risk-free Rate Puzzle. *Journal of Monetary Economics*, 24(3), 401–421.