Financial Engineering and the Japanese Markets **2**: 123–137, 1995.

On the Test of the Globalization of the Japanese Equity Market under the Kreps–Porteus Preference★

SHIGEYUKI HAMORI
Faculty of Economics, Kobe University, 2-1, Rokkodai, Nada-Ku, Kobe-City, 657 Japan

Abstract. This paper analyzes empirically the globalization of the Japanese equity market, based on the Kreps–Porteus preference model developed by Epstein (1988) and Epstein and Zin (1990, 1991). Empirical results show that the model performs well. The results are robust to the choice of the combination of assets and instruments.

1. Introduction

This paper investigates empirically the globalization of the Japanese equity market, based on the Kreps–Porteus preference developed by Epstein (1988) and Epstein and Zin (1990, 1991). Whether asset markets are internationally integrated is an important empirical question in financial economics, and thus there are many papers that analyze the international asset pricing relationship. Solnik (1974) and Stehle (1977) have tested the Sharp (1964) and Lintner (1965) type asset pricing model for international data. Wheatley (1988) has applied the Lucas (1978) and Breeden (1979) type consumption-based asset pricing model to international data. Campbell and Hamao (1989) have analyzed the long term relationship between the United States and Japan. Furthermore, Harvey (1991) has applied the conditional version of the Sharp–Lintner asset pricing model to international data. This paper uses the stock returns of Germany, Japan, the UK and the USA, and investigates whether international stock returns are consistent with the constraints described by the Kreps–Porteus preference [See Kreps and Porteus (1978)].

Since the seminal work by Lucas (1978) and Breeden (1979), the relationship between asset returns and fundamental macroeconomic variables, such as the consumption stream, has been intensively analyzed. The early research tended to assume that utility is separable across time and state. However, Hansen and Singleton (1982, 1983) and Mehra and Prescott (1985) found that this type of model

★An earlier version of this paper was read at the 1994 annual meeting of the Japanese Association of Financial Econometrics and Engineering held at Tsukuba University. The author would like to give thanks to the participants. He also expresses his gratitude to the editor T. Kariya, two anonymous referees and R. Parry for their helpful comments. This research is partly supported by a grant in aid from the Postal Life Insurance Foundation of Japan.

was not consistent with US data[1]. One of the weak points of this model is that there is one-to-one correspondence between the measure of relative risk aversion and the intertemporal elasticity of substitution. Epstein (1988) and Epstein and Zin (1990, 1991) introduced the Kreps–Porteus preference in order to relax this constraint. In this framework, the pricing kernel becomes a function of not only consumption growth but also the market return[2]. This setting incorporates both the standard C-CAPM and the static CAPM as its special cases[3]. This paper extends this model to the open economy and analyzes the globalization of the equity market in Japan.

Strict capital controls on Japan's asset markets existed until the 1980's. As a result, it was difficult for Japanese investors to include foreign assets as a part of their portfolio. However, a new foreign exchange law was enacted in 1980 which removed the controls over many types of capital flows. Thus Japanese financial markets should have become internationally integrated in the 1980's. If asset markets have actually been globalized, the Japanese consumption stream should be consistent with international asset returns. Empirical results in this paper show that the Japanese equity market has clearly become internationally integrated. The GMM estimates of preference parameters are significant and reasonable. The overidentifying restrictions are not rejected at the conventional significance level. The null hypothesis that consumption growth is sufficient for use as the pricing kernel is rejected. Furthermore, the preference parameters are stable during the sample period.

The organization of this paper is as follows: the basic framework of the Kreps–Porteus preference model is presented and Euler equations are derived in the next section; data and empirical techniques are summarized in Section 3; empirical results are reported in Section 4. Some concluding remarks are made in the last section.

2. Basic Model

Following Epstein and Zin (1990, 1991), a summary of the basic model can be made. For an agent making a decision in period t, current consumption (c_t) is known with certainty, but future consumption levels and thus future utility are generally uncertain. A consumer computes a certainty equivalent of random future utility, and combines it with current consumption via an aggregator function W to compute utility at time t, i.e.,

$$u_t = W(c_t, \mu_t[u_{t+1}]), \tag{1}$$

where u_t is the utility at time t, and $\mu_t[u_{t+1}]$ is the certainty equivalent of random future utility[4]. The t subscript of $\mu_t[\ ]$ indicates that future utility is evaluated conditionally on the information available at time t. This form of utility is the specification studied by Kreps and Porteus (1978) and is a generalization of the recursive structure introduced by Koopmans (1960) in a stochastic setting.

Let us specify W and μ_t as follows:

$$\begin{aligned} W(c,z) &= (c^\rho + \beta z^\rho)^{1/\rho}, \quad 0 \neq \rho < 1, \quad 0 < \beta < 1, \\ &= \log(c) + \beta \log(z), \quad \rho = 0, \end{aligned} \tag{2}$$

$$\begin{aligned} \mu_t[u_{t+1}] &= [E_t(u_{t+1}^{1-\gamma})]^{1/(1-\gamma)}, \quad 0 < \gamma, \quad \gamma \neq 1, \\ &= \exp[E_t(\log u_{t+1})], \quad \gamma = 1. \end{aligned} \tag{3}$$

where $E_t(\ )$ shows the expectations operator based on the information available at time t. Substituting equations (2) and (3) into (1) yields

$$u_t = [c_t^\rho + \beta(E_t u_{t+1}^{1-\gamma})^{\rho/(1-\gamma)}]^{1/\rho}, \quad 0 \neq \rho < 1, \quad 0 < \gamma \neq 1, \tag{4}$$

which recursively defines the utility.

Suppose there is one stock in each country and there are N assets in total. This implies that we look at the value-weighted index of each country. Then, a representative consumer chooses a consumption and asset holding in order to maximize the objective function, (4) subject to the budget constraint described by,

$$\sum_{i=1}^{N} e_{it} q_{it} Q_{it+1} + p_t c_t = \sum_{i=1}^{N} e_{it}(q_{it} + d_{it}) Q_{it} + p_t y_t, \tag{5}$$

where p_t is the price level of the consumption goods at time t; e_{it} is the exchange rate of the i-th country at time t $(i = 1, 2, \ldots, N)$; q_{it} is the price of the i-th asset at time t $(i = 1, 2, \ldots, N)$; Q_{it} is the quantity of the i-th asset at time t $(i = 1, 2, \ldots, N)$; d_{it} is the dividend of the i-th asset at time t $(i = 1, 2, \ldots, N)$; and y_t is the labor income at time t. The left-hand side and the right-hand side of the budget constraint, (5), respectively show the outlay and revenue. Solving this yields the following Euler equations:

$$E_t\left[\beta^\alpha \left(\frac{c_{t+1}}{c_t}\right)^{\alpha(\rho-1)} R_{Mt+1}^{\alpha}\right] \quad \text{for consumption} \tag{6}$$

$$E_t\left[\beta^\alpha \left(\frac{c_{t+1}}{c_t}\right)^{\alpha(\rho-1)} R_{Mt+1}^{\alpha-1} R_{it+1}\right] = 1 \quad \text{for } i = 1, 2, \ldots, N \tag{7}$$

where $\alpha = (1-\gamma)/\rho$, R_{it+1} is the real return on the i-th asset defined by $R_{it+1} = e_{it+1}(q_{it+1} + d_{it+1}) p_t / e_{it} q_{it} p_{t+1}$, and R_{Mt+1} is the real return on the market portfolio.

Restricting $\alpha = 1$ (or $-\gamma = \rho - 1$) in equation (7) yields the Euler equations of the standard C-CAPM as follows:

$$E_t\left[\beta \left(\frac{c_{t+1}}{c_t}\right)^{-\gamma} R_{it+1}\right] = 1 \quad \text{for } i = 1, 2, \ldots, N. \tag{7'}$$

Equation (7′) shows that the consumption growth is sufficient for use as the pricing kernel, whereas restricting $\alpha = 0$ in equation (7) yields the Euler equations corresponding to the static CAPM as follows:

$$E_t\left[\frac{R_{it+1}}{R_{Mt+1}}\right]=1 \quad \text{for } i=1,2,\ldots,N. \tag{7''}$$

Equation (7″) shows that the market return is sufficient as the pricing kernel. It should be noted that both the consumption growth and the market return are necessary as the pricing kernel in the Kreps–Porteus preference.

To see the implication for the risk premium in this setting, let us assume that there is one risk-free asset and N-1 risky assets. Then, for risky assets, it holds that

$$c_t^{\alpha(\rho-1)}=E_t[(\beta c_{t+1}^{\rho-1})^{\alpha} R_{Mt+1}^{\alpha-1} R_{it+1}] \quad \text{for } i=1,2,\ldots,N-1. \tag{8}$$

For the risk-free asset, it holds that

$$c_t^{\alpha(\rho-1)}=E_t[(\beta c_{t+1}^{\rho-1})^{\alpha} R_{Mt+1}^{\alpha-1} R_{ft+1}] \tag{9}$$

where R_{ft+1} is the return on the risk-free asset. It then follows from equations (8) and (9) that

$$E_t[c_{t+1}^{\alpha(\rho-1)} R_{Mt+1}^{\alpha-1}(R_{it+1}-R_{ft+1})]=0 \quad \text{for } i=1,2,\ldots,N-1, \tag{10}$$

and thus

$$E_t[R_{it+1}-R_{ft+1}]E_t[c_{t+1}^{\alpha(\rho-1)} R_{Mt+1}^{\alpha-1}] + Cov_t[c_{t+1}^{\alpha(\rho-1)} R_{Mt+1}^{\alpha-1}, \quad R_{it+1}-R_{ft+1}]=0. \tag{11}$$

Rearranging equation (11) yields

$$E_t[R_{it+1}-R_{ft+1}]=-\frac{Cov_t[c_{t+1}^{\alpha(\rho-1)} R_{Mt+1}^{\alpha-1}, \quad R_{it+1}-R_{ft+1}]}{E_t[c_{t+1}^{\alpha(\rho-1)} R_{Mt+1}^{\alpha-1}]}. \tag{12}$$

Equation (12) shows that risk premium is a nonlinear function of consumption, individual asset reruns and the market return. If $\alpha=1$, individual asset returns and consumption determine the risk premium, which corresponds to the restriction of the standard C-CAPM. If $\alpha=0$, individual asset returns and the market return determine the risk premium, which corresponds to the restriction of the static CAPM.

3. Data and Empirical Techniques

The sample period for the estimation is February 1980 through March 1992. This paper uses monthly data, and thus the number of observations in each sample is 146. Per capita real consumption in Japan and the real stock returns of Germany, Japan, the UK and the USA are employed. The one month Gensaki rate (hereafter, the short term interest rate: STIR) is also used as the risk-free asset[5]. [See Appendix for details.] This paper uses two categories of consumption data. One is nondurables, and the other is nondurables and services. Equity return data are drawn from Morgan Stanley Capital International (MSCI) index. Morgan Stanley also calculates a value-weighted world equity index. For the market portfolio, this paper uses the world stock index [See Harvey (1991)][6]. If the market is internationally integrated, the world index instead of the domestic index is the appropriate measure to use as the market portfolio. All returns are calculated in terms of Japanese currency. Consumption series are seasonally adjusted to avoid the nonstationarity caused by seasonality[7]. This paper uses the generalized method of moments (GMM) estimation technique proposed by Hansen (1982) and Hansen and Singleton (1982). Let us define the econometric disturbances as follows:

$$u_{Mt+1} = \beta^{\alpha}\left(\frac{c_{t+1}}{c_t}\right)^{\alpha(\rho-1)} R^{\alpha}_{Mt+1} - 1, \tag{13}$$

$$u_{it+1} = \beta^{\alpha}\left(\frac{c_{t+1}}{c_t}\right)^{\alpha(\rho-1)} R^{\alpha-1}_{Mt+1} R_{it+1} - 1, \quad i = 1, 2, \ldots, N, \tag{14}$$

where $\theta = [\alpha, \beta, \rho]$ is a parameter vector. Then, equations (6) and (7) imply that $E_t[u_{t+1}(\theta)] = 0$ where $u_{t+1}(\theta) = [u_{Mt+1}, u_{1t+1}, \ldots, u_{Nt+1}]'$. Let Z_t denote an R-dimensional vector of instrumental variables that are in an agent's information set and can be observed by the econometrician, and let the function $g_{t+1}(\theta)$ be defined as

$$g_{t+1}(\theta) = u_{t+1}(\theta) \otimes Z_t \tag{15}$$

where $\otimes$ is the Kronecker product and $g_{t+1}(\theta)$ is a $(N+1) \times R$ dimensional vector. It follows from equation (15) that

$$E[g_{t+1}(\theta)] = 0 \tag{16}$$

where $E[\bullet]$ is the unconditional expectations operator. Equation (16) shows $(N+1) \times R$ orthogonality conditions for estimating 3 unknown parameters. If the model underlying equation (16) is correctly specified, then the following function

$$g_T(\theta) = \frac{1}{T} \sum_{t=1}^{T} g_t(\theta) \tag{17}$$

should be close to zero for a large value of T, where T is the sample size. Therefore the GMM estimator of θ, $\hat{\theta}$ is chosen to minimize the function $J_T(\theta)$ given by

$$J_T(\theta) = g_T(\theta)' W_T \, g_T(\theta) \tag{18}$$

where W_T is an $(N+1) \times R$-by-$(N+1) \times R$ symmetric positive definite matrix, which is allowed to depend on sample information.

Hansen (1982) shows that the weighting matrix W_T can be optimally chosen in the sense of constructing an estimator with the smallest asymptotic covariance for an estimator $\hat{\theta}$, W_0, among the choices of estimates employing alternative choices of weighting matrices W_T:

$$W_0 = [E\{g_{t+1}(\theta) g_{t+1}(\theta)'\}]^{-1}. \tag{19}$$

The resulting asymptotic covariance matrix Σ is given by $(D_0' W_0 D_0)^{-1}$, where $D_0 = E[\{\partial u_{t+1}(\theta)/\partial\theta\} \otimes Z_t]$, which has full rank. D_0 and W_0 can be consistently estimated by using

$$D_T = \frac{1}{T}\sum_{t=1}^{T} \frac{\partial u_{t+1}(\theta)}{\partial\theta} \otimes Z_t, \tag{20}$$

and

$$W_T = \left[\frac{1}{T}\sum_{t=1}^{T} g_{t+1}(\hat{\theta}) g_{t+1}(\hat{\theta})'\right]^{-1}. \tag{21}$$

Because a consistent estimator θ_T for θ is needed to compute W_T in actual applications, this optimal procedure requires a suboptimal choice of W_T in minimizing equation (18) to obtain $\hat{\theta}$. Under regularity conditions specified in Hansen (1982), it is shown that if the random sequence of matrices $\{W_T\}$ converges almost surely to a constant $(N+1)\times R$ dimensional nonsingular symmetric matrix W_0, the GMM estimator $\hat{\theta}$ is strongly consistent, and $\sqrt{T}(\hat{\theta}-\theta)$ converges in distribution to a normally-distributed random vector with mean zero and covariance matrix Σ.

Since the GMM estimation procedure sets the 3 linear combinations of the $(N+1)\times R$ orthogonality conditions to minimize equation (18), there remains $(N+1)\times R$-3 linearly independent orthogonality conditions that are not used in estimation[8]. If the model is correctly specified, these $(N+1)\times R$-3 remaining conditions also should be zero. It can be shown that T times the minimized value of equation (18) for an optimal choice of W_T is asymptotically distributed as a chi-square with $(N+1)\times R$-3 degrees of freedom:

$$T J_T(\hat{\theta}) = T g_T(\hat{\theta})' W_T * g_T(\hat{\theta}) \xrightarrow{D} \chi^2((N+1)\times R-3) \tag{22}$$

where $\hat{\theta}$ is a GMM estimator and W_T^* is a consistent estimator of W_0. We use the chi-square statistic in equation (22) to test the overidentifying restrictions of the model.

The restriction on preference parameters can be tested by the likelihood ratio type test, suggested by Eichenbaum, Hansen and Singleton (1988). The test statistic is

$$C_T = T[J_T(\hat{\theta}^r) - J(\hat{\theta}^u)] \tag{23}$$

where $\hat{\theta}^r$ is the estimated parameter vector under restriction and $\hat{\theta}^u$ is the estimated parameter vector without restriction. The test statistic, equation (23) is T times the difference between the minimized value of the objective function under restriction and the minimized value of the objective function without restriction. It is important that the same weighting matrix should be used for both restricted and unrestricted estimation. This test statistic has a chi-square distribution with the degrees of freedom equal to the number of restrictions.

The stability of the preference parameters can be also tested by the likelihood ratio type test, suggested by Gheysels and Hall (1990). This is an extension of the C-test described in equation (23). The test statistic, LR is defined as follows:

$$LR = T_1 J^1(\theta^r) + T_2 J^2(\theta^r) - T_1 J_2(\theta^u) \tag{24}$$

where T^i $(i=1,2)$ is the sample number of subsample $i\,(i=1,2)$; $J^i(i=1,2)$ is the objective function corresponding to subsample $i\,(i=1,2)$; θ^r is the restricted parameter; and θ^u is the unrestricted parameter. Then, this test statistic has a chi-square distribution with the degrees of freedom equal to the dimension of $g_{t+1}(\theta)$.

4. Empirical Results

Table 1 shows the mean, standard deviation, maximum and minimum values of each variable. Nondurables are used as the consumption category in the upper half of Table 1. The inflation rate of nondurables is used to deflate nominal returns. Nondurables and services are used as the consumption category in the lower half of Table 1. The inflation rate of nondurables and services is used to obtain the real return on each asset. Table 1 shows that mean of the asset returns and their standard deviation tend to be larger when nondurables are used as the consumption category.

Table 1. Basic statistics, February 1980 – March 1992

Variable	Mean	S. D.	Max.	Min.
		Nondurables		
GERMANY	1.0074	0.0683	1.2086	0.7818
JAPAN	1.0090	0.0580	1.2077	0.7940
UK	1.0090	0.0640	1.1543	0.7445
USA	1.0082	0.0605	1.1509	0.7475
WORLD	1.0069	0.0465	1.1076	0.7879
STIR	1.0036	0.0104	1.0362	0.9751
CRAT	1.0012	0.0155	1.0487	0.9336
		Nondurables and services		
GERMANY	1.0069	0.0675	1.2098	0.7807
JAPAN	1.0086	0.0571	1.2035	0.7990
UK	1.0086	0.0632	1.1538	0.7431
USA	1.0078	0.0597	1.1499	0.7461
WORLD	1.0065	0.0455	1.1067	0.7864
STIR	1.0031	0.0060	1.0214	0.9869
CRAT	1.0016	0.0164	1.0601	0.9588

Note:
GERMANY: the real return on German stocks (in Japanese yen); JAPAN: the real return on Japanese stocks (in yen); UK: the real return on UK stocks (in yen); USA: the real return on USA stocks (in yen); World: the real return on the world stock index (in yen); STIR: the real return on one-month Gensaki bond; CRAT: the real growth rate of per capita consumption (nondurables, or nondurables and services) in Japan.

However, the mean of the consumption growth rate and its standard deviation tend to be larger when nondurables and services are used.

The GMM technique requires that stochastic Euler equations be functions of stationary variables and that instrumental variables also be stationary. This paper applies the Dickey-Fuller test in order to see whether each variable has a stochastic trend or not[9]. These variables involve the growth rate of per capita real consumption and the real return on each asset. Table 2 reports the results. The optimal lag length is determined by the Schwarz criterion. The Schwarz criterion shows that the lag length is at most 3[10]. In every case, test statistics are large enough to reject the null hypothesis that each variable has a unit root.

Table 3a, Table 3b, and Table 4 show the empirical results based on the GMM[11]. The reported estimation results are qualitatively robust to choices over a number of alternative starting guesses for the model's parameters. There are three parameters to be estimated; (α, β, ρ)[12]. The measure of relative risk aversion is obtained based on the relationship: $\gamma = 1 - \alpha\rho$. The Euler equation of consumption, equation (6), is always included to estimate and test the model. For the market portfolio, this paper uses the world stock index (WORLD). If the market is internationally integrated, the world index instead of the domestic index is the appropriate measure for use as the market portfolio.

Table 2. Results of the unit root test, February 1980 – March 1992

Variable	Lag length	Test statistic
	Nondurables	
GERMANY	1	−8.454 (*)
JAPAN	0	−11.501 (*)
UK	1	−9.414 (*)
USA	0	−11.783 (*)
WORLD	1	−8.261 (*)
STIR	3	−10.147 (*)
CRAT	3	−11.469 (*)
	Nondurables and services	
GERMANY	1	−8.378 (*)
JAPAN	0	−11.572 (*)
UK	0	−13.615 (*)
USA	0	−11.925 (*)
WORLD	1	−8.092 (*)
STIR	2	−9.975 (*)
CRAT	2	−11.122 (*)

Note:
Test statistic is the t-value of a_0 based on the regression,

$\Delta Y_t = \mu + a_0 Y_{t-1} + \Sigma_{i=0}^{p} b_i \Delta Y_{t-i} + u_t$ for $p = 0, 1, 2, \ldots$, $(b_0 = 0)$;

Lag length is the optimal lag length (p) in the above equation determined by the Schwarz criterion; (*) shows that the null hypothesis that each variable has a unit root is rejected at the 1% significance level.

Table 3a. GMM results for the world index, each country's index, and the short term interest rate, February 1980 – March 1992 (nondurables)

Asset	Instrument	β	α	ρ	χ^2	p-value	DF	γ
GERMANY	inst1	0.995	−0.580	0.720	2.030	0.917	6.0	2.282
		(0.001)	(0.261)	(0.239)				
	inst2	0.996	−0.057	0.595	8.739	0.725	12.0	1.034
		(0.001)	(0.258)	(0.192)				
JAPAN	inst1	0.995	−2.971	0.448	4.205	0.649	6.0	2.331
		(0.002)	(0.615)	(0.532)				
	inst2	0.995	−1.226	0.573	7.166	0.846	12.0	1.702
		(0.001)	(0.186)	(0.114)				
UK	inst1	0.995	−0.675	0.663	2.316	0.888	6.0	1.450
		(0.001)	(0.271)	(0.214)				
	inst2	0.995	−0.430	0.798	10.230	0.596	12.0	1.343
		(0.001)	(0.139)	(0.175)				
USA	inst1	0.995	−0.275	0.651	2.044	0.916	6.0	1.179
		(0.001)	(0.286)	(0.431)				
	inst2	0.996	0.076	0.346	6.941	0.861	12.0	0.973
		(0.001)	(0.190)	(0.176)				

Note:
$\text{inst1} = \{1, c_t/c_{t-1}, R_{world\,t}\}$,
$\text{inst2} = \{1, c_t/c_{t-1}, R_{world\,t}, R_{it}, R_{stir\,t}\}$ *i = Germany, Japan, USA, UK.*
The numbers in parentheses are standard errors.

Table 3b. GMM results for the world index, each country's index, and the short term interest rate, February 1980 – March 1992 (nondurables and services)

Asset	Instrument	β	α	ρ	χ^2	p-value	DF	γ
GERMANY	inst1	0.994	3.712	0.222	3.607	0.730	6.0	0.176
		(0.001)	(0.825)	(0.037)				
	inst2	0.996	0.636	0.542	6.630	0.881	12.0	0.655
		(0.001)	(0.490)	(0.209)				
JAPAN	inst1	0.996	−0.445	0.502	4.521	0.606	6.0	1.223
		(0.001)	(0.951)	(0.324)				
	inst2	0.996	−0.904	0.579	6.275	0.902	12.0	1.523
		(0.001)	(0.266)	(0.108)				
UK	inst1	0.996	−0.064	0.595	8.643	0.195	6.0	1.038
		(0.001)	(0.597)	(0.298)				
	inst2	0.995	−0.753	0.964	13.270	0.350	12.0	1.725
		(0.001)	(0.095)	(0.124)				
USA	inst1	0.996	0.196	0.658	4.764	0.574	6.0	0.871
		(0.001)	(0.344)	(0.203)				
	inst2	0.996	0.438	0.586	5.557	0.937	12.0	0.743
		(0.001)	(0.243)	(0.120)				

Note:
$\text{inst1} = \{1, c_t/c_{t-1}, R_{world\,t}\}$,
$\text{inst2} = \{1, c_t/c_{t-1}, R_{world\,t}, R_{it}, R_{stir\,t}\}$ *i = Germany, Japan, USA, UK.*
The numbers in parentheses are standard errors.

Table 4. GMM results for the comprehensive system February 1980 – March 1992

Asset	Instrument	β	α	ρ	χ^2	p-value	DF	γ
				Nondurables				
ALL	inst1	0.995	−0.470	0.757	10.379	0.795	15.0	1.356
		(0.001)	(0.145)	(0.169)				
	inst2	0.996	−0.352	0.764	43.678	0.528	45.0	1.269
		(0.001)	(0.053)	(0.094)				
				Nondurables and services				
ALL	inst1	0.996	−0.223	0.893	18.492	0.238	15.0	1.199
		(0.001)	(0.093)	(0.125)				
	inst2	0.996	−0.210	0.914	47.443	0.373	45.0	1.192
		(0.001)	(0.036)	(0.060)				

Note:
inst1 $=\{1, c_t/c_{t-1}, R_{world\,t}\}$,
inst2 $=\{1, c_t/c_{t-1}, R_{world\,t}, R_{Germany\,t}, R_{Japan\,t}, R_{UK\,t}, R_{USA\,t}, R_{stir\,t}\}$.
The numbers in parentheses are standard errors.

Table 3a and Table 3b indicate the empirical results for the subset of the system. Table 3a shows the results when nondurables are used as the consumption category. Table 3b shows the results when nondurables and services are used as the consumption category. Here, the Euler equations corresponding to stock returns in each country, the world return, and the short term interest rate are combined. In the three equations' system with R information variables, there are $3R$ orthogonality conditions and 3 parameters; this implies that there are $3R$-3 degrees of freedom. As instrumental variables, this paper uses the following alternative sets:

$$\text{inst1} = \{1, c_t/c_{t-1}, R_{world\,t}\},$$

$$\text{inst2} = \{1, c_t/c_{t-1}, R_{world\,t}, R_{it}, R_{stir\,t}\} \quad i = Germany,\ Japan,\ USA,\ UK$$

The first set (inst1) includes the lagged variables of the arguments of the pricing kernel only, whereas the second set (inst2) includes the lagged variables of not only the arguments of the pricing kernel but also each asset return. The use of alternative instrumental variables enables us to check the robustness of empirical results. Table 3a and 3b show that the model performs well. The estimated subjective discount rate (β) is within the range of 0.995 to 0.996 for nondurables, and within the range of 0.994 to 0.996 for nondurables and services. The relative risk aversion measure (γ) is estimated between 0.973 and 2.331 in Table 3a, and between 0.176 and 1.725 in Table 3b. The parameter related to the intertemporal elasticity of substitution (ρ) is estimated as being within the range of 0.346 to 0.798 for nondurables, and within the range of 0.222 to 0.964 for nondurables and services. High p-values show that the model cannot be rejected at the conventional significance level.

The results for the comprehensive case incorporating the stock returns of Germany, Japan, the UK, the USA and the world index, and the short term interest rate are shown in Table 4. This test imposes all cross-asset restrictions that the preference parameters are the same for all assets, and thus the test is stronger. As instrumental variables, the following alternative sets are used:

$$\text{inst}\,1=\{1, c_t/c_{t-1}, R_{world\,t}\}$$

$$\text{inst}\,2=\{1, c_t/c_{t-1}, R_{world\,t}, R_{Germany\,t}, R_{Japan\,t}, R_{UK\,t}, R_{USA\,t}, R_{stir\,t}\}$$

The first set (inst1) includes the lagged variables of the arguments of the pricing kernel only, whereas the second set (inst2) includes the lagged variables of not only the arguments of the pricing kernel but also each asset return. In the six equations' system with R information variables, there are $6R$ orthogonality conditions and 3 parameters; this implies that there are $6R$-3 degrees of freedom. Table 4 shows that the model performs well. The subjective discount rate (β) is precisely estimated at 0.995 for nondurables, and 0.996 for nondurables and services. The estimated relative risk aversion measure (γ) is within the range of 1.192 to 1.356. The parameter related to the intertemporal elasticity of substitution (ρ) is estimated as being within the range of 0.757 to 0.914. These estimates are close to those obtained in three asset system. The chi-square test of the overidentifying restrictions provides evidence in favor of the model specification.

Next, let us analyze the characteristics of the pricing kernel in the model. Consider the following null hypothesis and the alternative:

$$H_0: \alpha=1,$$

$$H_A: \alpha\neq 1.$$

If the null hypothesis is true, the consumption growth rate is sufficient as the pricing kernel. The test is performed by the likelihood ratio type test. The test statistic has a chi-square distribution. The degrees of freedom are equal to the number of restrictions, which is one in this case. Table 5 indicates that the null hypothesis is

Table 5. Results of hypothesis testing, $H_0: \alpha=1$, $H_A: \alpha\neq 1$, all assets, February 1980 – March 1992

Asset	Instruments	χ^2	p-value	DF
		Nondurables		
All	inst1	47.238	0.000	1.0
	inst2	462.310	0.000	1.0
		Nondurables and services		
All	inst1	44.584	0.000	1.0
	inst2	877.717	0.000	1.0

Note:
$\text{inst1}=\{1, c_t/c_{t-1}, R_{world\,t}\}$,
$\text{inst2}=\{1, c_t/c_{t-1}, R_{world\,t}, R_{Germany\,t}, R_{Japan\,t}, R_{UK\,t}, R_{USA\,t}, R_{stir\,t}\}$.

Table 6. Results of hypothesis testing, H_0: $E[g^1_{t+1}(\theta)] = E[g^2_{t+1}(\theta)] = 0$, H_A: $E[g^1_{t+1}(\theta)] = 0$, $E[g^2_{t+1}(\theta)] \neq 0$, all assets; first sample: February 1980 – February 1986, second sample: March 1986 – March 1992

Asset	Instruments	χ^2	p-value	DF
		Nondurables		
All	inst1	20.018	0.332	18.0
		Nondurables and services		
All	inst1	17.247	0.834	18.0

Note:
inst1 = $\{1, c_t/c_{t-1}, R_{world\,t}\}$.

rejected in every case. Thus, the market portfolio is significantly included as a part of the pricing kernel.

Finally, let us analyze the stability of the preference parameters in this model. The null hypothesis and the alternative are as follows:

$$H_0: E[g^1_{t+1}(\theta)] = E[g^2_{t+1}(\theta)] = 0,$$
$$H_A: E[g^1_{t+1}(\theta)] = 0, \quad E[g^2_{t+1}(\theta)] \neq 0.$$

where $g^i_{t+1}(\theta)$ shows the value of $g_{t+1}(\theta)$ for the subsample $i\,(i = 1, 2)$. The sample period was simply divided into half, the first half being February 1980 through February 1986 and the second half being March 1986 through March 1992. If the null hypothesis is true, preference parameters are considered to be constant, which is one of the auxiliary assumptions of the asset pricing model. In the first half of the sample period, the stock price in Japan was relatively stable. However, in the latter half of the sample period, the Japanese stock market experienced a rapid rise in stock prices. Also, stock prices suddenly dropped in 1990. Thus, it is worth while seeing if the volatile movements in the second period have any relationship with the preference shift of consumers. The test is performed by the likelihood ratio type test. The test statistic has a chi-square distribution. The degrees of freedom are equal to the dimension of function $g_{t+1}(\theta)$, which is eighteen for inst1. Table 6 indicates that the null hypothesis is not rejected in every case. Thus, the preference parameters remained constant during the sample period[13]. Hamori (1992b) found that the preference parameters are stable during the 1970's and the 1980's in the standard C-CAPM. This result is consistent with the results obtained in Hamori (1992b).

5. Some Concluding Remarks

This paper empirically analyzes whether the Kreps–Porteus preference model developed by Epstein (1988) and Epstein and Zin (1990, 1991) is consistent with the international equity return in the Japanese market. Empirical results show that the model performs well. In the comprehensive asset system, the subjective discount rate is estimated between 0.995 and 0.996. The relative risk aversion parameter is estimated as being within the range of 1.192 to 1.356. The parameter related to the intertemporal elasticity of substitution is also precisely estimated as being within the range of 0.757 to 0.914. The chi-square test of the overidentifying restrictions provides evidence in favor of the model specification. Also, the return on the market portfolio is significantly included as a part of the pricing kernel. This paper further validates the model's conclusions by testing the maintained assumption of parameter constancy. The preference parameters are found to be stable during the sample period. These results show that the Japanese equity market clearly became globalized in the 1980's.

Appendix

The data sources are as follows:

Consumption

The consumption category is the seasonally adjusted value of nondurables, and nondurables and services. Per capita consumption is obtained by dividing the expenditure per household by the number of people per household. The data is obtained from the *Annual Report on Family Income and Expenditure Survey* (All Households) Statistics Bureau of the Management and Coordination Agency;

Consumer Price Index

Consumer price indices for nondurables, and nondurables and services are obtained from the *Annual Report on Family Income and Expenditure Survey* (All Households) Statistics Bureau of the Management and Coordination Agency;

Nominal stock return

Nominal stock returns are obtained from the Morgan Stanely Capital International Index;

Gensaki Rate

The one month Gensaki rate is obtained from the *Economic Statistics Annual* of the Bank of Japan.

Notes

[1] Hamori (1992a, 1993) shows that the standard C-CAPM is consistent with Japanese data in the 1980's.

[2] The pricing kernel is the intertemporal marginal rate of substitution, and is sometimes called a stochastic discount factor.

[3] The other approach to relax the separability of utility is to include the durability or habit persistent effect directly in the utility function. [See Dunn and Singleton (1986), Eichenbaum and Hansen (1990), Constantinides (1990), and Ferson and Constantinides (1991) for examples.]

[4] The certainty equivalent shows that the solution is the same as that which would obtain if there was no uncertainty, or if equivalently the individual held expectations of future utility with subjective certainty.

[5] A Gensaki transaction is based on a prior promise either to repurchase or to resell the same securities after a fixed time and at a fixed price. Although Gensaki transactions take the form of buying and selling

securities, they are similar to call and bill transactions in which securities function as collateral. Thus, Gensaki transactions are financial transactions with securities acting as catalysts. The Gensaki market is free, open market in which any corporation may participate.

[6] For the market portfolio, the Roll critique may be relevant. The Roll critique shows the difficulties of constructing the 'market portfolio' in empirical research. See Roll (1977).

[7] The adjustment is conducted by the X11 procedure.

[8] Note that there are three unknown parameters to be estimated.

[9] See Dickey and Fuller (1979, 1981) and Said and Dickey (1985).

[10] Note that the Schwarz criterion tends to economize the number of parameters in the model. If one uses an alternative information criterion, say AIC, then the lag length might be longer.

[11] This paper always includes the Euler Equation (6) linking the market return with consumption growth. To avoid a trivial solution, the following specification is employed in the actual estimation: $E_t[\{\beta^{\alpha}(c_{t+1}/c_t)^{\alpha(\rho-1)}R^{\alpha}_{Mt+1}-1\}/\alpha]=0$. See Epstein and Zin (1991).

[12] The GMM estimation results were found to be the most reliable when estimating $\{\alpha, \beta, \rho\}$. Otherwise, in many cases the numerical algorithm in GMM did not converge.

[13] Because of the limit of the computer memory, the case for inst2 could not be calculated.

References

Breeden, D.T. (1979) 'An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities,' *Journal of Financial Economics*, **7**, 265–296.

Campbell, J.Y. and Hamao, Y. (1989) 'Predictable Stock Returns in the United States and Japan: A Study of the Long-Term Capital Market Integration,' *NBER Working Paper*, no. 3191.

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

Dickey, D.A. and Fuller, W.A. (1979) 'Distribution of Estimators for Autoregressive Time Series with a Unit Root,' *Journal of the American Statistical Association*, **74**, 427–431.

Dickey, D.A. and Fuller, W.A. (1981) 'Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root,' *Econometrica*, **49**, 1057–1072.

Dunn, K.B. and Singleton, K.J. (1986) 'Modeling the Term Structure of Interest Rates under Non-Separable Utility and Durability of Goods,' *Journal of Financial Economics*, **17**, 27–55.

Eichenbaum, M.S. and Hansen, L.P. (1990) 'Estimating Models with Intertemporal Substitution Using Aggregate Time Series Data,' *Journal of Business and Economic Statistics*, **8**, 53–69.

Eichenbaum, M.S., Hansen, L.P. and Singleton, K.J. (1988) 'A Time Series Analysis of Representative Agent Models of Consumption and Leisure Choice under Uncertainty,' *Quarterly Journal of Economics*, **103**, 51–78.

Epstein, L.G. (1988) 'Risk Aversion and Asset Prices,' *Journal of Monetary Economics*, **22**, 179–192.

Epstein, L.G. and Zin, S.E. (1990) "First-Order' Risk Aversion and the Equity Premium Puzzle,' *Journal of Monetary Economics*, **26**, 387–408.

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

Ferson, W.E. and Constantinides, G.M. (1991) 'Habit Persistence and Durability in Aggregate Consumption Empirical Tests,' *Journal of Financial Economics*, **29**, 199–240.

Ghysels, E. and Hall, A. (1990) 'Are Consumption-based Intertemporal Asset Pricing Model Structural?,' *Journal of Econometrics*, **46**, 121–139.

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

Hamori, S. (1992b) 'On the Structural Stability of Preference Parameters Obtained from Japanese Financial Market Data,' *Economics Letters*, **40**, 459–464.

Hamori, S. (1993) 'Test of the International Equity Integration of Japan,' *Economics Letters*, **42**, 71–76.

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

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

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

Harvey, C. (1991) 'The World Price of Covariance Risk,' *Journal of Finance*, **46**, 111–157.

Koopmans, T.C. (1960) 'Stationary Ordinal Utility and Impatience,' *Econometrica*, **28**, 287–309.

Kreps, D.M. and Porteus, E.L. (1978) 'Temporal Resolution of Uncertainty and Dynamic Choice Theory,' *Econometrica*, **46**, pp. 185–200.

Lintner, J. (1965) 'The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets,' *Review of Economics and Statistics*, **47**, 13–37.

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

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

Roll, R. (1977) 'A Critique of the Asset Pricing Theory's Test: Part 1: On Past and Potential Testability of the Theory,' *Journal of Financial Economics*, **4**, 129–176.

Said, E.S. and Dickey, D.A. (1985) 'Hypothesis Testing in ARIMA (p. 1, q) Models,' *Journal of the American Statistical Association*, **80**, 369–374.

Sharp, W. (1964) 'Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk,' *Journal of Finance*, **19**, 425–442.

Solnik, B. (1974) 'The International Pricing of Risk: An Empirical Investigation of the World Capital Market Structure,' *Journal of Finance*, **29**, 48–54.

Stehle, R. (1977) 'An Empirical Investigation of the Alternative Hypothesis of National and International Pricing of Risky Assets,' *Journal of Finance*, **32**, 493–502.

Wheatley, S. (1988) 'Some Tests of International Equity Integration,' *Journal of Financial Economics*, **21**, 177–212.