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Hideki Nakamura

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Testing the Structural Stability of Risk Aversion in the Foreign Exchange Market

Hideki Nakamura*

Institute of Socio-Economic Planning, University of Tsukuba

Abstract

This paper empirically investigates the structural stability of risk aversion in a model in which risk premia exist in forward foreign exchange. To maximize his or her lifetime utility, a representative Japanese investor invests in a riskless bond denominated in each major currency. We test the Euler equations for structural stability with respect to the risk aversion parameter. The results show that risk aversion is invariant from 1973 to 1991.

Correspondence: Hideki Nakamura

Institute of Socio-Economic Planning, University of Tsukuba

Tsukuba, Ibaraki 305, Japan

E-mail: hnakamur@shako.sk.tsukuba.ac.jp

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1. Introduction

After the breach of the Smithsonian Agreements, major currencies moved to the floating system and foreign exchange markets have experienced several shocks. These shocks may affect the tastes of investors. This paper empirically investigates the structural stability of risk aversion in a model which implies the existence of risk premia in forward foreign exchange markets.

Empirical research on risk premia in foreign exchange markets usually relies on a discrete-time intertemporal asset pricing model such as that of Lucas (1982).[1] In this model, a representative investor maximizes his or her lifetime utility subject to sequential budget constraints. The first-order necessary conditions equate the marginal utility of consumption at time t to conditional expectation at time t of discounted future returns weighted by the marginal utility of consumption at time $t+k$. These conditions can be used in international finance by considering covered and uncovered returns from investing in a nominally riskless bond denominated in foreign currency. The equilibrium conditions contain a risk aversion parameter for the investor, implying the existence of risk premia.

In responce to Lucas's (1976) critique, econometric inference has moved to estimate 'taste and technology' parameters which are generally assumed to be invariant across time. However, there is a possibility of structural change of these parameters. Empirical studies should test for such structural instability.[2]

[1] For example, Mark (1985) and Modjtahedi (1991).

[2] Ghysels and Hall (1990a) and Hamori (1992) tested the structural stability of Euler

This paper considers a representative Japanese investor and test the structural stability of risk aversion in the foreign exchange market. Three possible split points for the risk aversion parameter, January 1979, April 1984, and September 1985, are examined. About the first, that is, at the end of 1970s, the liberalization of foreign exchange transactions was carried out in the Tokyo foreign exchange market. The second is the date when the rule of real demand of forward foreign exchange was removed in Japan. The last is the date of the Plaza accord. We also try all split points in the range from July 1978 to March 1986 to detect another points of structural change. The results show that the risk aversion of Japanese investor is invariant between 1973 to 1991.

In section 2 we specify the model, the estimation and the test employed are explained in section 3, and the results are shown in section 4. Section 5 summarizes the paper. Appendix A indicates the data which we used and gives descriptive statistics for the variables appearing in the Euler equations. The results of the augmented Dickey-Fuller unit root test which investigated the stationarity of variables are given in Appendix B.

2. Model and Investor's Optimization Problem

A representative Japanese investor has a time additive utility which implies constant relative risk aversion and excludes a risk taker. She maximizes her expected lifetime utility:

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equations. Hamori (1992) analyzed preference parameters obtained from Japanese financial market data.

$$E_0[\sum_{t=0}^{\infty} \beta^t U(\frac{C_t}{P_t})], \tag{1}$$

where

$U(\cdot) \equiv \frac{\alpha}{1-\phi}(\frac{C_t}{P_t})^{1-\phi}$: the utility function, $\alpha > 0$ and $\phi \geq 0$,

β: the subjective discount factor and $0 < \beta < 1$,

C_t: the nominal consumption at time t,

P_t: the price level at time t,

and $E_0 \equiv E[\cdot \mid I_0]$: the expectation operator conditioned on the information set at time zero.[3]

To maximize her lifetime utility she invests in a nominally riskless bond denominated in each major currency to cover the exchange risk:

$$C_t + \sum_{i \in \Lambda}(N_t^i q_t^i S_t^i + H_t^i q_t^i S_t^i) =$$
$$\sum_{i \in \Lambda}\{N_{t-3}^i q_{t-3}^i S_t^i(1 + {}_{t-3}R_t^i) + H_{t-3}^i q_{t-3t-3}^i F_t^i(1 + {}_{t-3}R_t^i)\} + Y_t, \tag{2}$$

where

$\Lambda \equiv \{g, uk, us\}$ and g, uk and us are respectively the abbreviations of Germany, U.K. and U.S.A.,

N_t^i: the demand for ith currency-denominated uncovered bond at time t,

H_t^i: the demand for ith currency-denominated covered bond at time t,

${}_{t-3}R_t^i$: the nominal rate of return on a bond denominated in ith currency from time $t-3$ to t,

${}_{t-3}F_t^i$: the forward price of ith currency bought at time $t-3$ to be delivered at time t and ${}_{t-3}F_t^i$ is measured in yen,

[3] $\phi = 0$ is not excluded *a priori* because this study tests for this case.

S_t^i: the spot price of ith currency in terms of yen,

and Y_t: the exogenous income at time t.

We only consider the forward contract of three month maturity in order to reduce the orthogonality conditions to be estimated because Hansen and Singleton (1982) stated that using more orthogonality conditions may lead to estimators with less desirable small sample properties.[4]

After some manipulation, the first-order necessary conditions for the above constrained maximization problem are derived:

$$E_t[(\frac{\frac{C_{t+3}}{P_{t+3}}}{\frac{C_t}{P_t}})^{-\phi_0}\frac{P_t}{P_{t+3}}\frac{(S_{t+3}^i - {}_tF_{t+3}^i)}{S_t^i}] = 0,$$

$$i = g, uk, us, \quad and \quad t = 0, 1, 2, \cdots, \qquad (3)$$

where ϕ_0 is the true value of ϕ.[5]

These are the Euler equations which are familiar to studies of foreign exchange risk premia, see, for example, Mark (1985). Mathematically, these equations represent the orthogonality conditions between the vector of variables included in the information set I_t and $(\frac{\frac{C_{t+3}}{P_{t+3}}}{\frac{C_t}{P_t}})^{-\phi_0}\frac{P_t}{P_{t+3}}\frac{(S_{t+3}^i - {}_tF_{t+3}^i)}{S_t^i}$.

We test the structural stability of risk aversion, ϕ, and risk averseness of a investor.

3. Estimation and test

The estimation and the specification test of the Euler equations (3) are performed by the GMM proposed by Hansen (1982). The GMM technique

[4]Moreover, it is difficult to obtain the data of forward exchange rates other than three month maturity.

[5]See Huang (1989).

only requires that the variables which appear in the orthogonality conditions be stationary and ergodic. Some advantages of this method are that neither the specification of the entire economic environment nor that of variable's distribution is needed.[6]

To implement the GMM technique it is necessary to identify a set of instruments, $z_t \subseteq I_t$. Because there is little guidance in picking up instruments, we assume that an investor knows the lagged variables which appear in the Euler equations (3).[7]

$$IS1 \equiv \{1, \frac{\frac{C_t}{P_t}}{\frac{C_{t-3}}{P_{t-3}}}, \frac{P_{t-3}}{P_t}\frac{(S_t^{us} - {}_{t-3}F_t^{us})}{S_{t-3}^{us}}\},$$

$$IS2 \equiv \{1, \frac{\frac{C_{t-1}}{P_{t-1}}}{\frac{C_{t-4}}{P_{t-4}}}, \frac{P_{t-4}}{P_{t-1}}\frac{(S_{t-1}^{us} - {}_{t-4}F_{t-1}^{us})}{S_{t-4}^{us}}, \frac{\frac{C_t}{P_t}}{\frac{C_{t-3}}{P_{t-3}}}, \frac{P_t}{P_{t-3}}\frac{(S_t^{us} - {}_{t-3}F_t^{us})}{S_{t-3}^{us}}\},$$

$$IS3 \equiv \{1, \frac{\frac{C_t}{P_t}}{\frac{C_{t-3}}{P_{t-3}}}, \frac{P_{t-3}}{P_t}\frac{(S_t^{us} - {}_{t-3}F_t^{us})}{S_{t-3}^{us}}, \frac{P_{t-3}}{P_t}\frac{(S_t^{g} - {}_{t-3}F_t^{g})}{S_{t-3}^{g}}, \frac{P_{t-3}}{P_t}\frac{(S_t^{uk} - {}_{t-3}F_t^{uk})}{S_{t-3}^{uk}}\}.$$

The sample period is chosen to be March 1973 through December 1991. The period is taken monthly. The starting period corresponds to the start of the floating exchange rates system. The last period corresponds to the availability of data. Three possible split points, January 1979, April 1984, and September 1985, are examined. At about the first, the liberalization of exchange transaction was carried out in the Tokyo foreign exchange market and the transaction volume of spot and forward exchange increased rapidly in the market. The second is the date when the rule of real demand of

[6]Hansen and Singleton (1982) and Ogaki (1992) explained the GMM and gave practical guidance.

[7]Mark (1985) and Modjtahedi (1991) also used the lagged variables of Euler equations.

forward foreign exchange was removed in Japan. This removal stimulated speculation in the foreign exchange market. The last is the date of the Plaza accord. The dollar depreciated considerably against other major currencies from this period.

The hypotheses of stability of the Euler equations (3) are described as follows:

$$H_1 : E_t[v_{t,t+3}; \phi_0] = 0, t = t_0, \cdots, t_4, \quad versus \quad A_1 :$$

$$E_t[v_{t,t+3}; \phi_0] = 0, t = t_0, \cdots, t_1 - 1, \quad E_t[v_{t,t+3}; \phi_0] \neq 0, t = t_1, \cdots, t_4, \quad (4.1)$$

$$H_2 : E_t[v_{t,t+3}; \phi_0] = 0, t = t_0, \cdots, t_4, \quad versus \quad A_2 :$$

$$E_t[v_{t,t+3}; \phi_0] = 0, t = t_0, \cdots, t_2 - 1, \quad E_t[v_{t,t+3}; \phi_0] \neq 0, t = t_2, \cdots, t_4, \quad (4.2)$$

$$H_3 : E_t[v_{t,t+3}; \phi_0] = 0, t = t_0, \cdots, t_4, \quad versus \quad A_3 :$$

$$E_t[v_{t,t+3}; \phi_0] = 0, t = t_0, \cdots, t_3 - 1, \quad E_t[v_{t,t+3}; \phi_0] \neq 0, t = t_3, \cdots, t_4, \quad (4.3)$$

where $v_{t,t+3}$ is a 3×1 vector, and each t_0, t_1, t_2, t_3 and t_4 respectively denotes 1973.6, 1979.1, 1984.4, 1985.9 and 1991.9, however, t_0 denotes 1973.7 for $IS2$.

These hypotheses are tested using the statistic proposed by Ghysels and Hall (1990b).[8] The test is based on examining whether the parameter estimate of one subsample can be used to predict over the other subsample. The split point is moved sequentially over the dates from July 1978 to March 1986 to detect any other points of structural change.

The hypothesis testing of risk averseness is described as follows:

$$H_4 : \phi = 0, \quad versus \quad A_4 : \phi > 0. \quad (5)$$

[8]Ghysels and Hall (1990a) and Hamori (1992) used the technique proposed by Ghysels and Hall (1990b) to test structural stability.

The null hypothesis H_4 is equivalent to a risk neutral investor and no risk premium for forward foreign exchange. According to Otani (1993), we can obtain properties of portfolio choice problem arising in general equilibrium with financial assets when an agent is risk averse. The hypothesis H_4 is tested by the D-statistic which is similar to the likelihood ratio test.[9]

Before examining the results, we briefly describe our computer program for the GMM estimation.[10] Numerical minimization of the distance function was accomplished with the Gauss-Newton algorithm of the Time Series Processor (TSP) computer package, version 4.2A. The convergence criterion was set at the default. For the initial value of the weighting matrix, nonlinear three-stage least squares estimates were used. The Parzen kernel proposed by Gallant (1987) was used because the weighting matrix in this study had autocorrelation terms of the second order.[11] We define $\phi \equiv |\psi|$ and ψ was estimated without restriction.

4. Results

The nominal per capita consumption and the price level were seasonally adjusted to avoid nonstationarity due to seasonality. The adjustment was

[9] To guarantee positiveness of D-statistic, the weighting matrix which was converged under the alternative hypothesis was used for the weighting matrix under the null hypothesis when the D-statistic was computed. Modjtahedi (1991) used this technique.

[10] The appendix for the computation of statistic is available upon request.

[11] The Bartlett kernel proposed by Newey and West (1987a) was also applied. The main conclusion did not change. Andrews (1991) showed by Monte Carlo simulation that the Parzen kernel may have better small sample performance than the Bartlett kernel.

conducted by the seasonal adjustment program of Bell Laboratories (sabl) procedure which is contained in the S system.[12]

The results are reported in tables 1, 2, 3 and 4. Table 1 reports the results of GMM estimation of the entire sample period. Tables 2, 3 and 4 each indicate the results of the GMM estimation of one split subsamples.

Table 1. GMM estimation results:1973.6(1973.7 for $IS2$)-1991.9

$inst$	$\hat{\phi}$	$se(\hat{\psi})$	$Jst(df)$	Pv	D
$IS1$	13.91	15.62	16.99*(8)	0.030	1.77
$IS2$	17.93	12.21	19.70(14)	0.140	3.08#
$IS3$	13.03	13.17	26.35*(14)	0.023	2.26

Note: The sample size is 220 for each $IS1$ and $IS3$ and 219 for $IS2$.

Table 2. GMM estimation results:73.6(73.7 for $IS2$)-78.12(I), 79.1-91.9(II)

$inst$	s	$\hat{\phi}$	$se(\hat{\psi})$	$Jst(df)$	Pv	D	$TS(df)$	$Pv(TS)$
$IS1$	I	15.21	15.66	9.99(8)	0.266	2.31		
$IS1$	II	27.44	13.79	10.97(8)	0.204	3.58#	11.28(9)	0.257
$IS2$	I	13.45	10.78	13.92(14)	0.456	3.00#		
$IS2$	II	21.27	12.81	16.62(14)	0.277	3.15#	16.85(15)	0.328
$IS3$	I	7.09	13.74	17.28(14)	0.242	0.63		
$IS3$	II	22.39	11.56	20.19(14)	0.124	5.36*	20.44(15)	0.156

Note: The sample size of subsample I is 67 for each $IS1$ and $IS3$ and 66 for $IS2$. The size of subsample II is 153 for all instruments.

[12]The calendar effect was removed. The results were similar when seasonally adjusted data in which the calendar effect was not removed were used.

Table 3. GMM estimation results:73.6(73.7 for $IS2$)-84.3(I), 84.4-91.9(II)

$inst$	s	$\hat{\phi}$	$se(\hat{\psi})$	$Jst(df)$	Pv	D	$TS(df)$	$Pv(TS)$
$IS1$	I	0	\	11.77(8)	0.162	0		
$IS1$	II	17.34	22.35	9.76(8)	0.282	1.47	10.40(9)	0.319
$IS2$	I	0	\	15.16(14)	0.367	0		
$IS2$	II	20.52	17.89	12.69(14)	0.551	2.57	13.73(15)	0.546
$IS3$	I	2.19	11.42	23.56#(14)	0.052	0.07		
$IS3$	II	16.09	18.38	15.83(14)	0.324	1.87	16.25(15)	0.366

Note: The sample size of subsample I is 130 for each $IS1$ and $IS3$ and 129 for $IS2$. The size of subsample II is 90 for all instruments.

Table 4. GMM estimation results: 73.6(73.7 for $IS2$)-85.8(I), 85.9-91.9(II)

$inst$	s	$\hat{\phi}$	$se(\hat{\psi})$	$Jst(df)$	Pv	D	$TS(df)$	$Pv(TS)$
$IS1$	I	7.27	12.85	12.99(8)	0.112	0.56		
$IS1$	II	17.81	24.67	12.99(8)	0.112	1.90	13.12(9)	0.157
$IS2$	I	5.42	11.68	16.06(14)	0.309	0.37		
$IS2$	II	29.18	18.96	18.80(14)	0.173	6.45*	19.62(15)	0.187
$IS3$	I	4.53	11.76	20.67(14)	0.110	0.31		
$IS3$	II	17.75	15.33	16.83(14)	0.266	3.25#	17.02(15)	0.318

Note: The sample size of subsample I is 147 for each $IS1$ and $IS3$ and 146 for $IS2$. The size of subsample II is 73 for all instruments. *inst* is the set of instruments, $\phi \equiv |\psi|$, s specifies the subsample, the hat above a parameter indicates that it is an estimate, $se(\cdot)$ is the asymptotic standard error of the estimate, Jst is the value of the J-statistic which is asymptotically distributed as a χ^2 random variable with df degrees of freedom under the null hypothesis that the Euler equations (3) hold,

Pv is the P-value for Jst, D is the value of D-statistic which tests the hypothesis (5) and is asymptotically distributed as a χ^2 random variable with 1 degree of freedom under the null hypothesis that $\phi = 0$ holds, TS is the value of statistic which tests each hypothesis (4.1), (4.2) and (4.3) and is asymptotically distributed as a χ^2 random variable with df degrees of freedom under the null hypothesis of no structural change, and #, * and ** represent rejection at the upper 10, 5 and 1 % significance level respectively.

The constrained estimation with nonnegative ϕ worked well except for two cases. Because the estimate of ϕ converged to zero before satisfying the convergence criterion in each of $IS1$ and $IS2$ in subsample I when the split point was 1984.4, ϕ was set to zero *a priori*. When the estimate of nonlinear three-stage least squares did not converge, ϕ was set to 20 at the initial value of the weighting matrix.[13]

The results of table 1 imply that the estimation of the entire sample period may not be appropriate. The model specification was rejected at the 5% significance level in each $IS1$ and $IS3$ and the risk aversion estimate was significant at the 10% significance level only in $IS2$. These results are similar to those of Mark (1985) and Modjtahedi (1991).

Each of tables 2, 3 and 4 indicates that three possible shocks may not affect risk aversion of investor. No was the model specification rejected at the 10% significance level. Generally speaking, the estimate, $\hat{\phi}$, of subsample II was significant at the 10% level except for the case that the split point was 1984.4 and the estimate of subsample I was not significant. To include a part

[13]Similar results were obtained when the initial value of ϕ was 10.

of the beginning of the entire sample period may not be appropriate because the transactions of spot and forward foreign exchange was not carried out actively in those periods. Though $\hat{\phi}$ of subsample I was not significant, the standard error of the estimate was large relatively to the estimated value and the difference of risk aversion estimates between two subsamples, I and II was not significant.

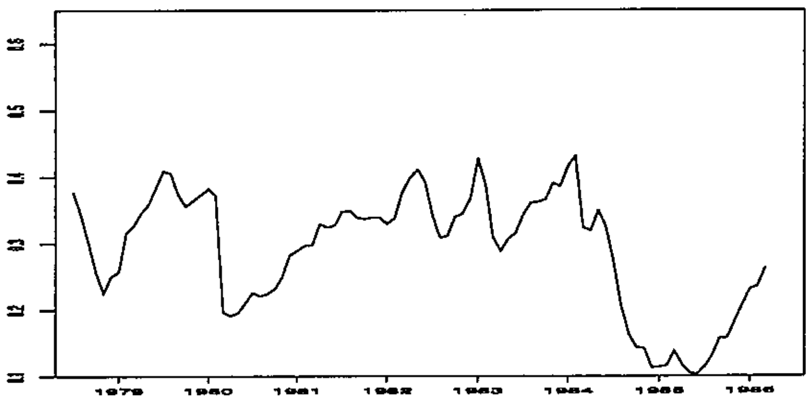

Figure 1: P-values of IS1 case

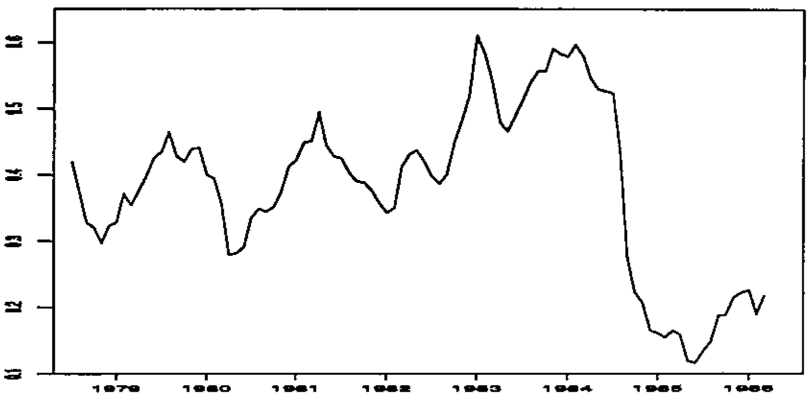

Figure 2: P-values of IS2 case

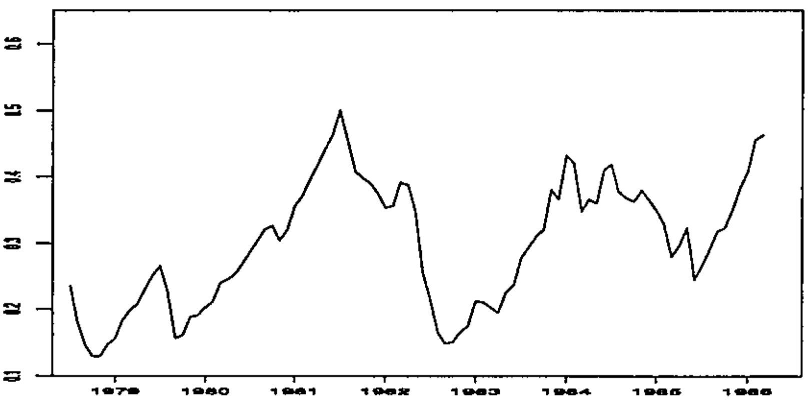

Figure 3: P-values of IS3 case

The results which the split point was moved through July 1978 to March 1986 were shown in each figure 1, 2 and 3.[14] Each figure represents the P-values of TS statistic which tested the structural stability when the in-

[14]Because it was difficult for some cases to get the nonlinear three-stage least squares

strument $IS1$, $IS2$ and $IS3$ was used respectively. For all instruments the P-values did not reach even at 0.1 across time although there were some points which the P-values were near 0.1. Therefore we may conclude that the risk aversion of Japanese investor is invariant from 1973 to 1991.

5. Concluding Remarks

This paper showed that the risk aversion of Japanese investor in the foreign exchange market is invariant from 1973 to 1991. Hamori (1992) reported that preference parameters of Japanese investor remain invariant during 70s and 80s. Although each specification of this paper and Hamori (1992) differs considerably, risk aversion obtained from Japanese investor may be robust to shocks.

We should consider the following points for our future research.

It is preferable to estimate and test the model including the forward contracts of foreign exchange other than of three month maturity. Because a similar specification for U.S. investor was estimated by Mark (1985) and Modjtahedi (1991), it may be interesting to test the structural stability of risk aversion for U.S. investors and compare results between Japan and U.S..

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estimate which was converged, the initial value of ϕ for the GMM estimation was set at 20. When the initial value was 10, the results were similar.

Appendix A: Data and Descriptive Statistics

This appendix indicates the data which we used and the descriptive statistics of variables appearing in the Euler equations (3) are reported in table 5. The sources of data are denoted by brackets, [ ]. OECD is the abbreviation of OECD Main Economic Indicators. Each variable which is enclosed by the parenthesis, ( ), represents the original one, that is, the variable before being seasonally adjusted, transformed to the price of currency in terms of yen or calculated from spread to forward exchange rate. The exchange rates measured in yen were computed from the dollar prices of three currencies.

(C_t): living expenditure per household divided by persons per household, [Monthly Report on the Family Income and Expenditure Survey],

(P_t): consumer prices, all items, 1985=100, not seasonally adjusted [Monthly Report of Consumer Price Index, Management and Coordination Agency],

S_t^{us}: U.S. dollar exchange rate, spot, yen per dollar, end of month [Economic Statistics Monthly, Bank of Japan],

$({}_{t-3}F_t^{us})$: U.S. dollar exchange rate, forward (3 months), yen per dollar, end of month [Economic Statistics Monthly, Bank of Japan],

(S_t^g): U.S. dollar exchange rate, spot, cents per DM, end of month [OECD],

$({}_{t-3}F_t^g)$: U.S. dollar exchange rate, forward (3 months), cents per DM, end of month [OECD],

(S_t^{uk}): U.S. dollar exchange rate, spot, cents per pound, end of month [OECD],

$({}_{t-3}F_t^{uk})$: U.S. dollar exchange rate, forward (3 months), cents per pound, end of month [OECD].

The data of (C_t) and (P_t) were taken from Nikkei Needs tape.

Table 5. Descriptive statistics

variable	*max*	*min*	*mean*	*st.dev*
$\frac{C_{t+3}}{P_{t+3}} / \frac{C_t}{P_t}$	1.0686	0.9363	1.0041	0.0202
$\frac{P_t}{P_{t+3}} \frac{(S^{us}_{t+3} - {}_tF^{us}_{t+3})}{S^{us}_t}$	0.1650	-0.1578	-0.0028	0.0615
$\frac{P_t}{P_{t+3}} \frac{(S^{g}_{t+3} - {}_tF^{g}_{t+3})}{S^{g}_t}$	0.1952	-0.1374	-0.0027	0.0567
$\frac{P_t}{P_{t+3}} \frac{(S^{uk}_{t+3} - {}_tF^{uk}_{t+3})}{S^{uk}_t}$	0.1486	-0.2098	-0.0076	0.0577

Note: The sample size is 223, *max, min* and *st.dev* are respectively the maximum, minimum and standard deviation.

Appendix B: Results of the Augmented Dickey-Fuller Unit Root Test

This appendix provides the results of the augmented Dickey-Fuller unit root test to investigate the stationarity of variables appearing in the Euler equations (3).

We assume that a variable X_t which is tested follow an autoregressive (AR) model of order p. An $AR(p)$ model can be written as follows:

$$\Delta X_t = \mu + \alpha_0 X_{t-1} + \sum_{i=1}^{p-1} \alpha_i \Delta X_{t-i} + u_t, \tag{6}$$

where u_t is a disturbance term and is assumed to be independently, identically, and normally distributed with $E(u_t) = 0$ and $Var(u_t) = \sigma^2$.

The hypothesis is given as

$$H: \quad \mu = 0 \quad and \quad \alpha_0 = 0 \quad versus \quad A: \quad \mu \neq 0 \quad and \quad \alpha_0 < 0.$$

The null hypothesis H implies that X_t has a unit root.

The unit root test command of the SHAZAM computer package, version 7.0 was used. The lag length, $\hat{p}$, was chosen optimally by successively solving for the value of p from 1 to 12 and picking out the one with the smallest Shwarz Bayesian Information Criterion (SBIC).[15] Geweke and Meese (1981) showed that the SBIC results in a consistent estimate of p and performs rather well in moderate sized samples.

The results are reported in table 6. For all variables and tests the null hypothesis of a unit root was rejected at the 1% significance level. Therefore we may conclude that the stationarity assumption is valid.

[15] When $p = 1$, the equation (6) becomes $\Delta X_t = \mu + \alpha_0 X_{t-1} + u_t$.

Table 6. Augmented Dickey-Fuller test results

variable	$\hat{p}$	$t(\hat{\alpha}_0)$	F
$\frac{C_{t+3}}{P_{t+3}} / \frac{C_t}{P_t}$	9	-6.31^{**}	19.95^{**}
$\frac{P_t}{P_{t+3}} \frac{(S_{t+3}^{us} - {}_tF_{t+3}^{us})}{S_t^{us}}$	12	-4.00^{**}	7.99^{**}
$\frac{P_t}{P_{t+3}} \frac{(S_{t+3}^{g} - {}_tF_{t+3}^{g})}{S_t^{g}}$	7	-4.06^{**}	8.24^{**}
$\frac{P_t}{P_{t+3}} \frac{(S_{t+3}^{uk} - {}_tF_{t+3}^{uk})}{S_t^{uk}}$	5	-4.98^{**}	12.41^{**}

Note: The sample size of X_t is 223, the hat above a parameter represents that it is an estimate, $t(\hat{\alpha}_0)$ is the t-value statistic, F is the F-value one, ** indicates the rejection at the 1% significance level, for the first test the rejection region was set at the lower side and at the upper side for the second one, the critical values were taken from the tables of Fuller (1976) and Dickey and Fuller (1981).

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