Economics Bulletin

Volume 29, Issue 2

Linear and nonlinear monetary approaches to the exchange rate of the Philippines peso-Japanese yen

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Abstract

This study provides evidence of nonlinear long-run relationship between peso-yen exchange rate and its monetary determinants implied by the reduced-form flexible-price monetary model for the Philippines, using Breitung`s (2001) nonlinear cointegration testing procedures. The existence of such relationship is probably resulted from the strong and consistent bilateral trade relationship between the Philippines and Japan. Results from various monetary restrictions tests suggest that other forms of the related monetary model are not suitable in the determination of the peso-yen exchange rate.

Citation: Venus khim-sen Liew, (2009) "Linear and nonlinear monetary approaches to the exchange rate of the Philippines peso-Japanese yen", *Economics Bulletin*, Vol. 29 no.2 pp. 1320-1329.
Submitted: Mar 14 2009. **Published:** June 05, 2009.

1. INTRODUCTION

Most previous studies regarding the long-run validity of the monetary approach to exchange rate determination applied data from developed and industrialized countries. For instance, the long-run validity of the monetary models are examined for the case the five major United States dollar (USD) based exchange rates of British pound, Canadian dollar, French franc, German mark and Japanese yen are examined in MacDonald and Taylor (1991, 1993, 1994) and Diamantis *et al*. (1998). Recently, Rapach and Wohar (2002) re-examine the monetary model for USD based exchange rates for 14 industrialized countries. Less attention is paid for developing countries like the Philippines. Lee *et al.* (2007) and Long and Samreth (2008) remain the only few studies which provide empirical evidence supportive of the monetary exchange rate model for this country. Notably, these studies considered the USD dollar based peso (peso-USD) only.

This note contributes to the literature by adding another study for the case of Philippines using Japanese yen based peso (peso-yen) with the linear and nonlinear testing approaches. Japan has been traditionally the second largest trading partner (after the US) of the Philippines and these two nations recorded a total bilateral trade value of 14745 million of USD, as compared to US with 17012 million of USD in 2006 (ASEAN-Japan Centre, 2007). The trade relation between Japan and the Philippines date back to around the year 1600. As of today, Japan remains a major source of development funds, trade, investment, and tourism (Wikipedia, 2008). With such a strong and consistent bilateral trade relationship between the Philippines and Japan it is expected that the monetary model should hold for the peso-yen as well. However, as no known study has provided empirical evidence in this matter yet, there is a need to fill up this literature gap. The main objective of this study is to examine if the monetary model is also valid for the peso-yen. Besides, recent literature on exchange rate has over-whelmingly suggested the presence of nonlinear relationship between exchange rate and fundamentals. Liew *et al.* (2009a), for instance, pointed out that nonlinearity in exchange rate adjustment could arise be due to market frictions, costs of arbitrage in international goods, the effects of official foreign exchange rate intervention or perhaps the effects of the use of technical analysis in the foreign exchange market. Liew (2004a) and Liew *et al.* (2004a, b) and Liew *et al.* (2009b) contain empirical evidence on nonlinear relationship between exchange rate and relative prices, for the case of ASEAN countries. In this direction, the current study also aims to explore the possibility of the existence of nonlinear relationship between exchange rate and the monetary variables. Breitung's (2001) nonlinear cointegration testing procedures are included in the empirical analysis to cater for this possibility.

The remainder of this study is structured as follow. The testing procedures are explained in Section 2. The empirical results are presented and discussed in Section 3. Section 4 concludes this study.

2. TESTING PROCEDURES

This study follows MacDonald and Taylor (1991; Miyakoshi, 2000) in testing the following reduced-form flexible-price monetary model using the Johansen and Juselius (1990) cointegration procedure[1]:

$$s_t = \beta_1 m_t + \beta_2 m_t^* + \beta_3 y_t + \beta_4 y_t^* + \beta_5 i_t + \beta_6 i_t^* + \mu_t , \qquad (1)$$

where s_t represents the spot peso-yen exchange rate. m_t, p_t, y_t and i_t denote the Philippines money supply, price level, income and interest rate. The corresponding Japanese variables are denoted with an asterisk. μ_t is a white noise.

If cointegration relationship is detected, the model has long-run validity. As such, various monetary restrictions may be tested in the Vector Error Correction Model (VECM) framework. See MacDonald and Taylor (1991; 1994) and Long and Samreth (2008) for brief discussion on these restrictions. Lee *et al.* (2007) also perform these restrictions using the VECM framework.

Prior to the establishment of any long-run relationship between nominal exchange rate and its monetary determinants, it is required to ensure that all variables are integrated of order one [denoted as $I(1)$]. KPSS test due to Kwaitkowski *et al.* (1992) is adopted for this purpose. Under the KPSS test, the null hypothesis of stationary series is tested against the alternative hypothesis of non-stationary series. As compared to the commonly adopted Dickey-Fuller procedures, KPSS results will indicate that a series is non-stationary only when there is strong evidence for it (Dutt and Ghosh, 2000).

As suggested by Lee *et al.* (2007), this study also conducts the nonlinear test to validate the model. The following Breitung's (2001) multivariate rank test statistic for cointegration is computed:

$$B_T^*[k] = T^{-3} \sum_{t=1}^{T} (\tilde{u}_t^R)^2 \, / \, \hat{\sigma}_{\Delta\tilde{u}}^2 , \qquad (2)$$

where $\tilde{u}_t^R = R(e_t) - \sum_{j=1}^{k} \tilde{b}_j R(x_{jt})$, ($k$=6 in this case) in which $\tilde{b}_1, \ldots, \tilde{b}_k$ are the least squares estimates from a regression of $R(e_t)$ on $R(x_{1t}), \ldots, R(x_{kt})$, where x_j's are the monetary determinants and $\tilde{u}_t^R$ are the estimated residuals. Meanwhile, $\hat{\sigma}_{\Delta\tilde{u}}^2$ =

[1] Long and Samreth (2008) also estimate this version but the Autoregressive Distributed Lag (ARDL) approach is adopted. See MacDonald and Taylor (1994) and Lee *et al.* (2007), for instance, for alternative specifications of monetary models.

$T^{-2}\sum_{t=2}^{T}(\tilde{u}_t^R - \tilde{u}_{t-1}^R)^2$ is introduced to circumvent the possible correlation among the series. Liew *at al.* (2009a, b) first apply this test to detect the nonlinear relationship between exchange rate and relative prices.

The null hypothesis of no cointegration between e_t and x_{jt} (j=1,2,...6) (invalid monetary model) is rejected in favor of the alternative hypothesis of cointegration (valid monetary model) if the test statistic is smaller than critical value. If cointegration is detected, Breitung's (2001) rank sum test is in line to differentiate nonlinear from linear cointegration. The score test statistic $T \cdot R^2$ is computed from the following regression:

$$\tilde{u}_t = d_0 + \sum_{i=1}^{p} d_{1i} e_{t-i} + \sum_{j=1}^{k} d_{2j} x_{jt} + \sum_{j=1}^{k}\sum_{i=-p}^{p} d_{3ij} \Delta x_{jt-i} + \sum_{j=1}^{k} d_{4j} R(x_{jt}) + \eta_t \qquad (3)$$

where T is the sample size, R^2 is the coefficient of determination of regression (3), and $\tilde{u}_t$ denotes the residuals of regressing y_t on a constant and x_t, adjusted for autocorrelation and endogenous regressors based on Stock and Watson (1993), with p =1 in this case. $T \bullet R^2$ is asymptotically chi-squared distributed with one degree of freedom.

3. EMPIRICAL RESULTS

The data are obtained from International Financial Statistics compiled by International Monetary Fund, and run from January 1977 (1977M1) through March 2006 (2006M3). The peso-yen exchange rate is employed in this study. The Japan and the Philippines and Japan interest rates are respectively represented by 3-month treasury bill rate and money market rate. For both countries, the gross domestic product (GDP)[2], M2 (narrow money plus quasi money), consumer price index, are used to measure income, money supply and price level. All variables are employed in the logarithmic form.

The KPSS test results (see Appendix) suggest that, at 5% significance level, all variables including the peso-yen exchange rate are not stationary in their levels but are stationary after first differencing, implying that they are integrated of order 1. As such, the cointegration test is then performed. As the cointegration test results are sensitive to the lag length of the VAR system as well as the specification of the deterministic components, the optimal lag length must be carefully chosen for the VAR. For instance, Miyakoshi (2000), which employs monthly data, set the maximum lag length at 13 months and the optimal lag length is selected based on

[2] Monthly GDP are interpolated from annually GDP data in the spirit of Bahmani-Oskooee (2002).

Schwartz Information criterion (SC)[3]. Following MacDonald and Taylor (1991, 1994), who choose the optimal lag length from a 13-lag VAR system for their monthly data, this study adopts the likelihood ratio (LR) statistic for decision. Besides, three specifications of deterministic components, namely Model 2 which includes intercept in the cointegration equation, Model 3 which include trends in the levels and Model 4 which allows for trend in the cointegration equation are estimated for the purpose of selection. Johansen (1992) suggests the selection of the optimal model based on the Pantula Principle. Table 1 reports the Trace test results of the Johansen and Juselius (1990) cointegration procedures. Cheung and Lai (1993) point out that trace test is more robustness than the maximum eigenvalue test of the same procedures.

Based on the LR statistic, the VAR model of order 13, denoted as VAR(13), is optimal. Thus, VAR(13) specification is estimated for Models 2, 3 and 4. According to the Pantula principle, the null hypothesis of r=0 can be rejected at 5% significance level for Models 2, 3 and 4. Thus, the procedure is carried out for $r \leq 1$. Now, the null hypothesis is not rejected for the first time in Model 4. As such, Model 4 is the appropriate specification of the cointegration test by the Pantula principle. Based on this model, there is one cointegrating equation by the trace test at 5% significance level. This implies that there is a long-run relationship between the peso-yen exchange rate and its monetary determinants thereby validating the reduced-form flexible-price monetary model under consideration.

Table 1. Cointegration tests

Hypothesis		**Model 2**	**Model 3**	**Model 4**
Null	**Alternative**			
$r = 0$	$r = 1$	162.340*(131.70)	145.330*(124.24)	154.681*(146.76)
$r \leq 1$	$r = 2$	115.120*(102.14)	98.989*(94.15)	108.326(114.90)
$r \leq 2$	$r = 3$	82.715*(76.07)	67.114(68.52)	75.674(87.31)
$r \leq 3$	$r = 4$	53.954* (53.12)	42.846 (47.21)	51.358 (62.99)
$r \leq 4$	$r = 5$	33.693(34.91)	24.337(29.68)	32.815(42.44)
$r \leq 5$	$r = 6$	16.711(19.96)	12.160(15.41)	17.675(25.32)
$r \leq 6$	$r = 7$	4.675(9.24)	3.450(3.76)	6.422(12.25)

Notes: The VAR order of 13 is shown to be optimal based on the LR statistics. The 5% critical values are included in parentheses. Asterisk indicates rejection of the null hypothesis at 5% significance level.

The model's residual is checked for the whiteness (as indicated by the absence of autocorrelation, see Dutt and Ghosh, 2000) and the diagnostic results indicate that there is no autocorrelation at lag 1 through 24 by the Lagrange Multiplier (LM) test, implying that the requirement of white-noise residuals is met. It is noted here that

[3] See Liew (2004b), for instance, for study on the appropriate use of lag length selection criteria.

based on the SC (Miyakoshi, 2000), a VAR of order 1 is chosen, and Model 4 is also selected as appropriate by the Pantula principle. In addition, 2 cointegrating equations are implied by trace test. However, the model's residuals are not white noise[4]. Thus, the decision is based on LR statistic, in which the residuals of selected model could meet the assumption of white noise.

Having established the validity of the monetary model, it would be interesting to perform some tests for the commonly scrutinized monetary restrictions in the VECM framework. The results as summarized in Table 2 indicate that all restrictions including the proportionality of exchange rate and money supplies (H_1) and the restriction of equal and opposite coefficients for domestic and foreign incomes (H_2) and interest rates (H_3) can be rejected at 5% significance level by the likelihood ratio (LR) test. The findings in this study are in line with Lee *et al.* (2007) and Long and Samreth (2008), in which all restrictions are rejected for the peso-USD case. Apparently, these findings on the case of the Philippines, when taken together, suggest that the monetary exchange rate model has long-run valid for both the USD and yen denominated peso, although the monetary restrictions are not met. MacDonald and Taylor (1991) and Miyakoshi (2000) provide similar evidences for the USD based UK and Korea currency respectively.

Table 2. Monetary restrictions tests

Hypothesis	LR	Probability
$H_1 : \beta_1 = -\beta_2 = 1$	5.294*	0.024
$H_2 : \beta_3 + \beta_4 = 0$	7.268*	0.008
$H_3 : \beta_5 + \beta_6 = 0$	7.858*	0.005
$H_4 : H_1 \cap H_2$	7.488*	0.024
$H_5 : H_1 \cap H_3$	14.905*	0.001
$H_6 : H_2 \cap H_3$	18.446*	0.000
$H_7 : H_1 \cap H_2 \cap H_3$	18.783*	0.000

Note: Asterisk indicates the rejection of null hypothesis 5% significance level.

For complementary, the Breitung's (2001) tests for cointegration and nonlinearity are conducted and the results are reported in Table 3. It is observed that, consistent with the test results obtained from the above linear testing framework, peso-yen is cointegrated with the monetary determinants by the multivariate rank test implying long-run validity of the monetary model. However, further examination through the rank sum nonlinearity test indicates that the detected cointegration relationship is nonlinear in dynamic.

[4] Results are not shown but are available upon request from the author.

Table 3. Breitung's cointegration and nonlinearity test

Variable	Multivariate Rank Test, $B_T^*[6]$	Rank Sum Nonlinearity Test, $T \bullet R^2$
$s_t, m_t, m_t^*, y_t, y_t^*, i_t, i_t^*$	0.007*	26.079*
5% Critical Value	0.009	3.841

Note: Asterisk indicates the rejection of null hypothesis 5% significance level.

4. CONCLUSIONS

This note provides evidence of long-run validity supportive of the reduced-form flexible-price monetary model for peso-yen exchange rate using the cointegration procedure. The existence of long-run relationship between peso-yen and its monetary determinants is probably resulted from the strong and consistent bilateral trade relationship between the Philippines and Japan. Nonetheless, various popular monetary restrictions tests are conducted and none of the restrictions could be accepted. Of special interest is the rejection of H_1, which indicates the non-neutrality of money. Besides, rejection of H_3 reveals that uncovered interest parity condition required for the forward-looking version of the monetary model is not met. Moreover, the non-acceptance of $H_7 : H_1 \cap H_2 \cap H_3$ suggests that flexible-price monetary model does not hold in the restrictive form. That is, $e_t = (m_t - m_t^*) + \beta_1 (y_t - y_t^*) + \beta_2 (i_t - i_t^*) + \upsilon_t$ as considered in Dutt and Ghosh (2000), where $(m_t - m_t^*), (y_t - y_t^*)$ and $(i_t - i_t^*)$ are the relatives of monies, incomes and interest rates respectively, is not suitable for the modeling of peso-yen exchange rate.

Notably, evidence of nonlinear long-run relationship between exchange rate and its monetary determinants for the Philippines is found in this study. The major implication of the findings of this study is that while the monetary model under examination is found valid for the peso-yen exchange rate of nonlinearity must be taken into consideration. In addition, while other reasons have been suggested in the literature on the failure of the monetary restrictions of various forms, such as the neutrality of money, the uncovered interest parity condition and the proportionality assumption may exist in the nonlinear rather than the linear perspective. This provides avenues for future research.

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APPENDIX

KPSS Order of Integration Test Results

Variable	Level	First Difference	Integration Order
e_t	2.163*	0.239	I(1)
m_t	2.077*	0.073	I(1)
i_t (T)	0.293*	0.067	I(1)
g_t	0.948*	0.065	I(1)
m_t^*	2.211*	0.358	I(1)
i_t^*	1.794*	0.198	I(1)
g_t^*	0.556*	0.077	I(1)

Notes: Variable with (T) indicates that the test allows for stationarity around a linear trend in the level. The inclusion or exclusion of T is decided based on formal statistically procedures. The 5% critical values for KPSS tests without and with trend are 0.463 and 0.146 accordingly. Asterisk indicates significant at the 5% level. The null hypothesis of stationary series is rejected in favor of the alternative of non-stationary series if the test statistic is greater than the critical value.