The Monetary Model of Exchange Rate: Evidence from the Philippines Using ARDL Approach

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Abstract

In this paper, we re-examine the validity of both short and long run monetary models of exchange rate for the case of the Philippines by using new approach called Autoregressive Distributed Lag (ARDL) to cointegration. From our analysis, some findings are obtained. First, there are robust short and long run relationships between variables in the monetary exchange rate model. Second, the stability of the estimated parameters is confirmed by CUSUM and CUMSUQ stability tests. Third, the Purchasing Power Parity (PPP) condition is not hold for the Philippines. Last, all the monetary restrictions are rejected. Therefore, this result seems to suggest that the estimation result of the monetary model of exchange rate, in which monetary restrictions are assumed to be satisfied beforehand, might suffer from a number of deficiency; it is not appropriate to estimate the exchange rate model before the monetary restrictions are confirmed as also mentioned in Haynes and Stone (1981).

Keywords: Exchange rate model, ARDL approach to cointegration

JEL classification: F31, F33

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1. Introduction

In recent years, although the long run model of exchange rate determination has been the subject of interest for many researchers, there have been only limited studies conducted for the case of Asian countries. To our knowledge, those studies are Makrydakis (1998) and Miyakoshi (2000) for Korea, Chin et al. (2007) for the Philippines, Husted and MacDonald (1999) and Chinn (2000a, b) for selected Asian countries. However, these studies adopted the conventional likelihood-based approach to cointegration proposed by Johansen and Julius (1990)[1]. This approach requires the same order of integration of all variables in the system, which is hardly satisfied.

The purpose of this paper is to fill the gap in the literature by contributing another study for the case of the Philippines using a state-of-the-art econometric technique, namely Autoregressive Distributed Lag (ARDL) to cointegration. Previous studies on long run relationship between exchange rate and the monetary variables suffer from a number of deficiencies. By using Johansen-Juselius cointegration technique, the power of explanation might not be good enough because of the assumption that all variables are I(1). Using Johansen-Juselius technique, in order to conduct the cointegration test, all variables need to be integrated at the same order. However, many of the previous studies did not find strong evidence that all variables in the system have the same order of integration[2]. Therefore, to solve this problem, in this paper we employ ARDL approach to cointegration, a relatively recent econometric technique developed by Pesaran et al. (1996, 2001) to estimate the long run relationship among variables. This approach tests the cointegration relationship without requiring the same order of integration of all variables. Hence, it can be viewed as more discerning in its ability to reject a false null hypothesis.

Regarding cointegration and stability issues, taking the research on money demand function as the case, Bahmani-Oskooee and Chomsisengphet (2002) examined the money demand function in industrial countries. They found that even there is evidence of cointegration relationships in those selected countries, when incorporating the CUSUM (Cumulative Sum of Recursive Residuals) and CUSUMQ (Cumulative Sum of Square of Recursive Residuals) stability tests into cointegration procedure[3], some signs of instability are found in the cases of

[1] Studies for countries besides Asian counties such as MacDonald and Taylor (1991, 1994a, 1994b), Hwang (2001), Tawadros (2001) also adopt the conventional likelihood-based approach to cointegration.

[2] MacDonald and Taylor (1991), for the case of Germany, Japan, and the UK, found the evidence that some series may be stationary around a trend. However, they assumed that all series are I(1). In Makrydakis (1998) for the case of Korea, all variables are assumed to be integrated of degree 1 to avoid the conflicting inference from the result of not being the same in the degree of integration of all variables. Miyakoshi (2000), for the case of Korea, found that there is some evidence that the series may be I(0) or I(2). Therefore, they assumed that all series are I(1) in order to be able to make the cointegration test.

[3] CUSUM and CUSUMQ stability tests are originally developed by Brown et al. (1975).

Switzerland and the UK. This means that cointegration relationship does not imply the stability of the estimated model; appropriate stability tests need to be conducted additionally after cointegration is established. Relying on this, unlike the previous studies on exchange rate determination model, in this paper the stability tests, which are CUSUM and CUSUMQ, are also conducted in order to investigate the stability of the estimated model as the information on the stability of exchange rate model is very important for policy makers in dealing with exchange rate policy designing.

The outline of the remainder of this paper is as follows. Section 2 provides the explanation on theoretical framework. In section 3, we present the empirical analysis, in particular, the estimation model, methodology process, and the estimation results. Finally, in section 4, some conclusions are drawn.

2. Theoretical Framework

Based on the conventional macroeconomic framework, the purchasing power parity (PPP) condition and the money demand functions of domestic and foreign countries are assumed to take the forms as below[4]:

$$\frac{M}{P} = L(Y, i), \tag{1}$$

$$\frac{M^*}{P^*} = L(Y^*, i^*), \tag{2}$$

$$E = \frac{P}{P^*}, \tag{3}$$

where M represents domestic money balances; P is domestic price level; Y is domestic real income; i denotes domestic interest rate; E is the exchange rate of domestic currency per unit of foreign currency; and the corresponding variables for foreign country are denoted by asterisks. Therefore, we have the monetary approach of exchange rate determination as follows.

$$E = \frac{M}{L(Y,i)} \frac{L(Y^*, i^*)}{M^*} \tag{4}$$

Following the standard Cagan-Style log-linear relationships for the money demand function[5],

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[4] Monetary model of exchange rate requires the presumption of stable money demand functions of both domestic and foreign country (foreign country, here, refers to the US). For the study of money demand functions, see, for example, Bahmani-Oskooee and Rehman (2005) for the Philippines, Narayan (2008) for the US. In these studies, they found that the money demand functions are stable in both the Philippines and the US.

[5] Specifically, money demand function take the following form, $L(Y, i) = Y^a \exp^{-bi}$, where $a, b > 0$.

and takes the logarithm of the equation, the flexible-price monetary approach of exchange rate (FLMA) can be presented as follows,

$$e = m - m^* - \alpha y + \beta y^* + \gamma i - \eta i^* , \quad (5)$$

where $\alpha, \beta, \gamma, \eta > 0$, e, $m(m^*)$, and $y(y^*)$ are logarithm values of E, M (M^*), and Y (Y^*) respectively.

3. Empirical Analysis

3.1. Data

The data of the analysis in this paper are obtained from International Financial Statistics (IFS) CD-ROM (2007) released by International Monetary Fund (IMF). We use quarterly data that span from 1981Q1 to 2006Q3 due to the availability of the data for the Philippines. Exchange rates are quarterly average of Philippine currency per unit of US dollar (line RF.ZF). Money balances are seasonally adjusted M1 in line 34.BZF for the Philippines and line 59MACZF for the US. The nominal GDP data are obtained from line 99B.ZF for the Philippines and 99B.CZF for the US. These data are converted into real GDP using GDP deflator (line 99BIPZF for the Philippines and line 99BIRZF for US) and are seasonally adjusted by Eviews. Philippine and US interest rates are respectively money market rate and Federal Funds rate in line 60BZF. It is confirmed from the Augmented Dickey Fuller (ADF) unit root test that among all variables in the system, both interest rate data of domestic and foreign countries are I(0).[6] These results support the inappropriateness of using Johansen-Jesulius cointegration method to conduct the analysis; at the same time, the result also suggests that ARDL approach to cointegration is suitable for implementing the analysis.

3.2. Estimation Model and Methodology

The reduced form of equation (5) may be written as below for estimation:

$$e_t = c + \beta_1 m_t + \beta_2 m_t^* + \beta_3 y_t + \beta_4 y_t^* + \beta_5 i_t + \beta_6 i_t^* + \varepsilon_t , \quad (6)$$

where c is constant term and ε_t is a disturbance term. Theoretically, it is expected that: $\beta_1 = -\beta_2 = 1$, $\beta_3, \beta_6 < 0$ and $\beta_4, \beta_5 > 0$.

[6] The results of the unit root test could be provided upon request.

The flexible-price monetary model of exchange rate determination can be expressed as unrestricted error correction version of ARDL model as below:

$$
\begin{aligned}
\Delta e_t = \alpha &+ \sum_{i=1}^{n} \gamma_i \Delta e_{t-i} + \sum_{i=1}^{n} \delta_i \Delta m_{t-i} + \sum_{i=1}^{n} \zeta_i \Delta m^*_{t-i} + \sum_{i=1}^{n} \eta_i \Delta y_{t-i} + \sum_{i=1}^{n} \theta_i \Delta y^*_{t-i} + \sum_{i=1}^{n} \vartheta_i \Delta i_{t-i} \\
&+ \sum_{i=1}^{n} \xi_i \Delta i^*_{t-i} + \lambda_1 e_{t-1} + \lambda_2 m_{t-i} + \lambda_3 m^*_{t-1} + \lambda_4 y_{t-1} + \lambda_5 y^*_{t-1} + \lambda_6 i_{t-1} + \lambda_7 i^*_{t-1} + \varepsilon_t
\end{aligned} \quad (7)
$$

Before testing the model, we present a brief discussion of the ARDL approach to cointegration. As mentioned in Pesaran and Pesaran (1997), there are two steps for implementing the ARDL approach to cointegration procedure. First, we test the existence of the long run relationship between the variables in the system. In particular, the null hypothesis of having no integration or long run relationship among variables in the system, $H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = \lambda_7 = 0$, is tested against the alternative hypothesis $H_1 : \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq \lambda_6 \neq \lambda_7 \neq 0$ by judging from the F-statistics. Since the distribution of this F-statistics is non-standard irrespective of whether the variables in the system are I(0) or I(1), we use the critical values of the F-statistics provided in Pesaran and Pesaran (1997) and Pesaran et al. (2001). In there, there are two sets of critical values, when all variables are I(0) or I(1). For each application, the two sets provide the bands covering all the possible classifications of the variables into I(0) or I(1), or even fractionally integrated ones. If the computed F-statistics is higher than the appropriate upper bound of the critical value, the null hypothesis of no integration is rejected; if it is below the appropriate lower bound, the null hypothesis cannot be rejected, and if it lies within the lower and upper bounds, the result is inconclusive.

Secondly, after the existence of the cointegration between variables is confirmed, the lag orders of the variables are chosen using Akaike Information Criteria (AIC). After the lag order is selected, the error correction representation and long run model are estimated. Then, the stability tests, namely Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Square of Recursive Residuals (CUSUMQ) tests are conducted. Finally, the popular monetary restriction hypotheses are tested.

3.3. Estimation Results

Following the processes of the analysis methodology, by using the Microfit 4.1 (Oxford University Press) for computation, the estimation results are presented as follows. In the first step, F-statistics for judging whether there is a long run relationship among variables in the system is estimated. Generally, if the prior information about the direction of long run relationship among variables is not available, to confirm this direction, F-tests of the unrestricted error correction version of ARDL models in which each of the variables in turn is dependent variable, should be implemented. Table 1 provides the results of F-statistics when the lag order is set to 6. F_e, F_m, F_{m*}, F_y, F_{y*}, F_i, and F_{i*} respectively represent the F-statistics of the models in which each of e, m, $m*$, y, $y*$, i, and $i*$ is dependent variables in turn. From Table 1, it is obvious that only the F-statistics of the model that has exchange rate, e, as the dependent variable (F_e= 3.9564) is bigger than the critical value (CV) of the case that all variables are I(1) both in 10% and 5%.[7] This result supports the direction of long run (cointegration) relationship when exchange rate is dependent variable. It also indicates that the null hypothesis of no long run relationship can be strongly rejected. Therefore, it is evident that there is long run relationship among variables in the model, and we then can pursue to the next step of the analysis.

In the second step, we estimate the equation (7) and select the lag orders of the variables in the system based on AIC. Based on F-test result of the first step, the maximum lag order is set up to 6 in this second step. Table 2 provides the results of the lag order selection of the variables, which is ARDL(2,3,0,0,2,0,2), and the results of the diagnostic tests of the short run model.[8] In Table 2, the results show that, in short run, at least one of the lagged variables of all variables in the system is statistically significant at 5% or 1% with the signs as expected. Specifically, m_{t-3}, $y*_{t-2}$, i_t are positively significant at 5%, 1%, 1% respectively, and $m*_t$, y_t, $i*_{t-2}$ are negatively significant at 5%. From the result of the adjusted coefficient of determination ($\overline{R}^2 = 0.9952$) it is clear that the overall goodness of fits of the estimated equations is very high. Moreover, the diagnostic test results indicate that the short run model passes all of the serial correlation, functional form, and heteroscedasticity tests. In other words, the model is well specified without any problem of serial correlation and heteroscedasticity. Therefore, we can argue that the estimated short-run model performs well.

Table 3 provides the result of the error correction representation of estimated ARDL model. The result indicates that the error correction term, EC_{t-1} has the right sign (negative) and is statistically significant. This is the evidence of cointegration relationship among variables in the model. Particularly, the estimated value of EC_{t-1} is −0.2924, implying that the speed of adjustment to the long run equilibrium in response to the disequilibrium caused by the short run shocks of the previous period is 29.24%.

To test the stability of the model, we employ the tests of CUSUM and CUSUMQ. Figure 1

[7] Note that when domestic interest rate, i, is dependent variable F-statistics, F_i is also higher than 10% CV. However, it falls within 5% CV.

[8] With the selected maximum lag order the estimation sample is adjusted to be 1982Q3 to 2006Q3.

and 2 provide the graphs of CUSUM and CUSUMQ tests respectively. From the figures, it is obvious that the plots of both CUSUM and CUSUMQ are within 5% of critical bands. This implies that the estimated model is stable.

Table 4 indicates the result of the long run relationship of the variables in the model. It shows that all of the variables, (m_t, m^*_t, y_t, y^*_t, m_t, m^*_t) are strongly statistically significant and have the right signs $(+,-,-,+,+,-)$ as expected.[9] These indicate that there exists the long run stability of the monetary model of exchange rate in the Philippines. Therefore the estimated result of the long run model is shown as below:

$$\underset{(t-value)}{e} = \underset{(-3.47)}{-29.39} + \underset{(5.01)}{0.08m} - \underset{(-1.72)}{0.02m^*} - \underset{(-3.18)}{0.61y} + \underset{(4.45)}{1.62y^*} + \underset{(4.63)}{1.97i} - \underset{(-5.36)}{4.83i^*}$$

Finally, the results of the popular monetary restrictions are shown in Table 5. The results suggest that all the monetary restriction hypothesis tests are rejected. Since $H_1 : \beta_1 = -\beta_2 = 1$ is rejected we can conclude that the effect of money supply changes of domestic and foreign country does not have the same effect (in absolute value) on exchange rate; hence, the exclusion of money balance variables in the exchange rate determination model might be inappropriate. Besides, this rejection also implies that, although the long run relationship in the exchange rate model is satisfied, the PPP condition is not held for Philippine case. Moreover, the rejections of $H_2 : \beta_3 + \beta_4 = 0$ and $H_3 : \beta_5 + \beta_6 = 0$ imply that the long run effect of income and interest rate changes of both domestic and foreign country do not have the same effect in term of absolute value; as a result, it is not appropriate to exclude income and interest rate variables when estimating the exchange rate model. Furthermore, since all the hypotheses are rejected, it is also inappropriate to estimate the exchange rate model by assuming that the coefficients of the domestic and foreign countries are equal (in absolute value).[10]

4. Conclusions

In this paper, we re-examine the monetary model of exchange rate for the case of the Philippines by employing the recently developed econometric method known as Autoregressive Distributed Lag (ARDL) approach to cointegration. This state-to-the-art method has the advantage over Johansen-Jesulius cointegration method because it does not require the classification of the variables in the system into I(1). In this paper, we found that the requirement that all the variables in the system are I(1) is not satisfied as interest rate

[9] Except m^*_t which is significant only at 10% level.

[10] This result supports the evidence found in Haynes and Stone (1981).

variable of both domestic and foreign countries are I(0).

From the estimation results, in the short run, it is found that all variables in the estimated model have significant effect on the exchange rate with consistent coefficient signs as in conventional economic theory. In the long run, the results imply that there is long run relationship among variables of the monetary model of exchange rate for Philippine case. The error correction term is strongly significant with the right sign (negative); this means that there is cointegration relationship (long run relationship) among variables of estimated model. Furthermore, the results suggest that except the variable of foreign money balances which is significant only at 10%, all variables are strongly significant with the signs as expected. Additionally, the stability of estimated model is supported by the stability tests of CUSUM and CUSUMQ. Therefore, our results indicate that there exists a significantly, both statistically as well as economically, stable monetary model of exchange rate determination for Philippine case.

Finally, the popular monetary restrictions are also tested in this paper. The restriction tests suggest that though the long run stability is confirmed for monetary exchange rate model, the PPP condition is not satisfied for Philippine case. Moreover, since the rest of the tests are also rejected, it seems that money, income and interest rate are the important factors for determining the exchange rate in the monetary model of exchange rate. Similarly, the result also suggests that it is inappropriate to assume that incomes and interest rates of domestic and foreign country have the same effects (in absolute value) when estimating exchange rate model.

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Tables and Figures

Table 1: F-statistics of Bound Tests, 10% CV[2.035, 3.153], 5% CV[2.365, 3.553]

Lag Order	F-statistics
6	F_e (7, 46)= 3.9564**, F_m (7, 46)= 1.4453, F_{m*} (7, 46)=2.4024, F_y (7, 46)=1.7687, F_{y*} (7, 46)=2.1455, F_i (7, 46)=3.4490*, F_{i*} (7, 46)=1.6346

Note: *, **, and *** are respectively significant of 10%, 5%, and 1%.

Table 2: Autoregressive Distributed Lag Estimation Result
(Dependent Variable: Exchange Rate, e_t)

Variables	ARDL(2,3,0,0,2,0,2) selected based on AIC
e_{t-1}	0.9833 (0.0845)***
e_{t-2}	−0.2758 (0.0840)***
m_t	0.0039 (0.0052)
m_{t-1}	0.0015 (0.0070)
m_{t-2}	0.0053 (0.0070)
m_{t-3}	0.0127 (0.0058)**
m^*_t	−0.0070 (0.0033)**
y_t	−0.1787 (0.0757)**
y^*_t	−1.6684 (0.7044)**
y^*_{t-1}	−0.1177 (1.0787)
y^*_{t-2}	2.2606 (0.7505)***
i_t	0.5763 (0.0961)***
i^*_t	0.4348 (0.7531)
i^*_{t-1}	−0.1098 (1.0763)
i^*_{t-2}	−1.7388 (0.6670)**
c	−8.5965 (3.7196)**
$\overline{R}^2$	0.9952
DW-statistics	1.9915
SE of Regression	0.0324
Diagnostic tests	Serial Correlation F(4, 77)= 0.24806[0.910] Functional Form F(1, 80)= 0.74543[0.391] Heteroscedasticity F(1, 95)= 0.0023222[0.962]

Note: *, **, and *** are respectively significant of 10%, 5%, and 1%.
The numbers in parentheses are standard errors.
The numbers in bracket are p-value of the tests.

Table 3: The Error Correction Representation for the selected ARDL model

(Dependent Variable: Difference of Exchange Rate, Δe_t)

Regressor	**ARDL(2,3,0,0,2,0,2) selected based on AIC**
Δe_{t-1}	0.2758 (0.0840)***
Δm_t	0.0039 (0.0052)
Δm_{t-1}	−0.0180 (0.0058)***
Δm_{t-2}	−0.0127 (0.0058)**
$\Delta m^*{}_t$	−0.0070 (0.0033)**
Δy_t	−0.1787 (0.0757)**
$\Delta y^*{}_t$	−1.6684 (0.7044)**
$\Delta y^*{}_{t-1}$	−2.2606 (0.7505)***
Δi_t	0.5763 (0.0961)***
$\Delta i^*{}_t$	0.4348 (0.7531)
$\Delta i^*{}_{t-1}$	1.7388 (0.6674)**
Δc	−8.5965 (3.7196)**
EC_{t-1}	−0.2924 (0.0550)***
$\overline{R}^2$	0.56024
$EC_t = e_t - 0.0803 m_t + 0.0239 m_t^* + 0.6110 y_t - 1.6223 y_t^* - 1.9705 i_t + 4.8338 i_t^* + 29.39c$	

Note: *, **, and *** are respectively significant of 10%, 5%, and 1%.
The numbers in parentheses are standard errors.

Table 4: Long Run Estimation Result

(Dependent Variable: Exchange Rate, e_t)

97 observations used for estimation from 1982Q3 to 2006Q3		
Regressor	**Expected Sign**	**ARDL(2,3,0,0,2,0,2) selected based on AIC**
m_t	+	0.0803 (0.0160)***
$m^*{}_t$	−	−0.0239 (0.0138)*
y_t	−	−0.6110 (0.1917)***
$y^*{}_t$	+	1.6223 (0.3639)***
i_t	+	1.9705 (0.4249)***
$i^*{}_t$	−	−4.8338 (0.9007)***
c		−29.3921 (8.4623)***

Note: *, **, and *** are respectively significant of 10%, 5%, and 1%.
The numbers in parentheses are standard errors.

Table 5: Long Run and Monetary Restrictions Hypothesis Tests Result

Hypothesis	Result	Meaning
H_0 : no long run relationship	Rejected	There is long run relationship in the system.
$H_1 : \beta_1 = -\beta_2 = 1$	Rejected	PPP condition is not hold.
$H_2 : \beta_3 + \beta_4 = 0$	Rejected	Income has effect on exchange rate.
$H_3 : \beta_5 + \beta_6 = 0$	Rejected	Interest rate has effect on exchange rate.
$H_4 : H_1 \cap H_2$	Rejected	Both H_1 and H_2 are rejected.
$H_5 : H_1 \cap H_3$	Rejected	Both H_1 and H_3 are rejected.
$H_6 : H_2 \cap H_3$	Rejected	Both H_2 and H_3 are rejected.
$H_7 : H_1 \cap H_2 \cap H_3$	Rejected	H_1, H_2, and H_3 are rejected.

Figure 1: Plot of Cumulative Sum of Recursive Residuals (CUSUM)

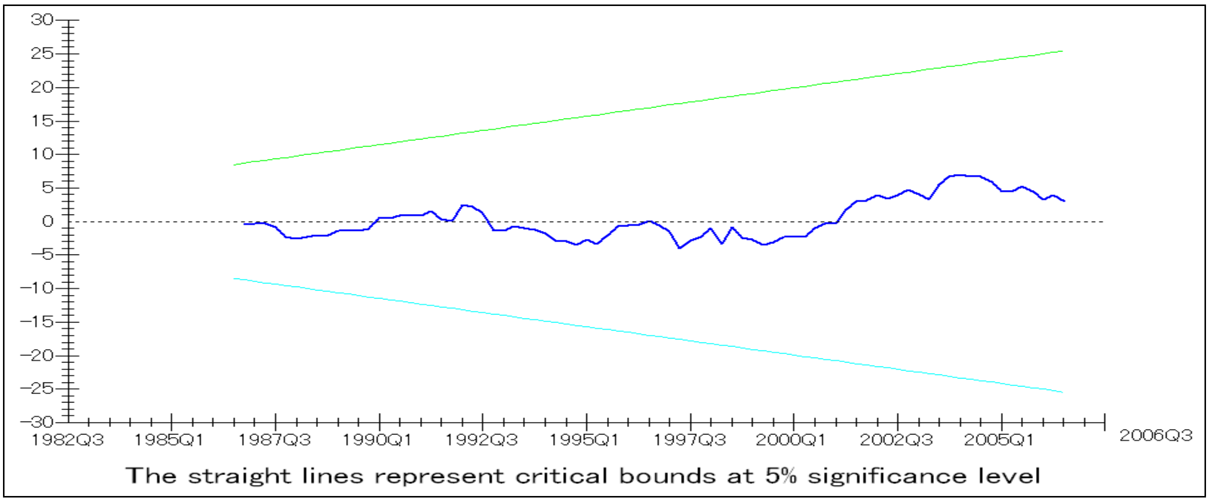

Figure 2: Plot of Cumulative Sum of Square of Recursive Residuals (CUSUMQ)