Divisia monetary model of exchange rate determination: the case of Philippines

Abstract. In literature, inferior performance still prevails as one of the unresolved issues with regard to the monetary model of exchange rate. A money demand function that is unstable can contribute to the inferior performance of the model. One of the causes for an unstable money demand function is the application of the simple sum monetary aggregate in the estimation. Therefore, an alternative measurement of money, the Divisia monetary aggregate, is applied in the estimation of the monetary model of exchange rate. The results show that cointegration exists between monetary fundamentals and the exchange rate in the Divisia model. Consequently, to estimate the exchange rate for the Philippines, the Divisia monetary aggregate can be used as an alternative money supply.

Keywords: Divisia Monetary Aggregate; Monetary Policy; Exchange Rate; Autoregressive Distributed Lag; Monetary Model of Exchange Rate

JEL Classification: E41; E52; C22

Acknowledgements: Financial support from University of Malaysia Sarawak (UNIMAS) via Dana Principal Investigator research grant: 03(DPI21)985/2013(04) is gratefully acknowledged.

DOI: https://doi.org/10.21003/ea.V172-02
1. Introduction

Various economic activities and policy designs are interconnected with the exchange rate movements. As trade openness induces economic growth (Poh et al., 2018), traceability of exchange rate movements is critical as it may influence economic growth as well as trade activities. For instance, the fluctuations of China's currency can cause external trade disparities (Gligorić, 2011). Furthermore, to achieve financial soundness, the reduction of tractability exchange rate regime is necessary (Stoica and Ihnatov, 2016). Consequently, the investigation of the factors determining the exchange rate movements is of high importance. A remarkable model that transpired in the 1970s to define exchange rates based on monetary phenomena is the monetary exchange rate model. This model requires money demand to serve as a channel of transmission, and thus the key concern is to retain stability along with a well-specified money demand function. Financial de-regulation contributes to the instability of the demand for money as the emergence of interest-bearing monetary assets during this period generates various return rates. Therefore, the conduct of the monetary model of exchange rate may be affected by the unstable demand for money function.

To estimate a demand for money function, a conventional or a simple sum monetary aggregate is utilised. The simple sum monetary aggregate has turned out to be flawed as the construction of this money assumes that all monetary assets with various monetary services carry equal weight. Conversely, Barnett (1980) proposed Divisia monetary aggregates that consider monetary services delivered by different monetary assets. When the Divisia measurement of money was used for the estimations of demand for money, stable demand for money functions was derived by Puah and Hiew (2010), Leong et al. (2010) and Sianturi et al. (2017). The superiority of Divisia monetary aggregates was also discovered by Lee et al. (2009) when performing a long-run analysis for Malaysia and the Philippines using the monetary model of exchange rate. The directed currency directed from the Divisia measurement of money to the exchange rate was proved to be strong by Ghosh and Bhadury (2017). Considering the outstanding performance of Divisia monetary aggregates from the empirical standpoint, a comparison of the performance of the Divisia measurement of money to its simple sum counterpart in the monetary exchange rate model for the Philippines is worth investigating.

The monetary transmission mechanism is emphasised in the study of monetary policy by Puah and Hiew (2017). One of the transmission mechanisms of monetary policy in the Philippines is the exchange rate channel, in which the execution of inflation targeting relies on the evolutions of the exchange rate. As market forces responsible for the determination of exchange rates, the Philippines needs to keep an eye on foreign exchange market circumstances to prevent intense alterations in exchange rates that may deteriorate the inflow targeting performance (Guinigundo, 2008). Co-movement of the trends of exchange rates and foreign exchange flows were identified during the implementation of the strategy of inflation targeting (Guinigundo, 2014). Consequently, it is critical to classify the movements of exchange rates for the Philippines via the monetary model of exchange rate. The ASEAN-5 panel monetary model of exchange rate was derived by Tunggal et al. (2018). However, the extent to which the monetary fundamentals can determine the exchange rate for individual country can only be identified via the segregation of the data for the Philippines.

Different estimation methods were employed in previous research such as panel cointegration (Basher and Westlund, 2009), the nonlinear approach (Liew, 2009), the co-integrated structural vector autoregressive (Loria, Sánchez and Salgado, 2010) and the Markov switching model (Wu, 2015). The vast majority of those studies were carried out in developed countries. Pesaran and Shin (1999) and Pesaran et al. (2001) originated the autoregressive distributed lag (ARDL) procedure, which granted a beneficial approach to estimate the monetary exchange rate model by using a Divisia monetary aggregate in the developing countries context like the Philippines. The ARDL procedure also enables the detection of cointegrating vectors with the existence of multiple cointegration vectors (Nkoro and Uko, 2016). This procedure is still a pragmatic approach used for the estimation in various financial and economic studies (Waziri et al., 2018; Abaidoo, 2018; Okunade et al., 2018; Shaki et al., 2018). Monetary fundamentals also were found related to exchange rate using the ARDL in Indonesia (Leong et al., 2018) and thus the investigation is sensible for the Philippines.

2. Description of data and methodology

Exchange rates are expressed in nominal terms as the home country currency per one US dollar. The M2 is utilised as the money measurement for money supply. Income is proxied by the gross domestic product (GDP), while the money market rate (MMR) is used as a proxy for the short-term interest rate. The summary of variables and data used for the estimation is provided in Table 1.

The quarterly data utilised ranged from 1987Q1 to 2016Q4. The rationale to employ 1987Q1 as the commencement period for the estimation was due to the reason that the Philippines underwent a momentous external economic situation, which was characterised by accelerated imports and industrial growth at the end of 1987 because of world crude oil price reductions (Solon and Floro, 1993). Different issues of the International Financial Statistics Yearbook, the CEIC database and the Federal Reserve Bank of St. Louis were used to source the data required for the study. All data is expressed in a natural logarithm, excluding the interest rate approach.

The monetary model of the exchange rate fundamental equation is expressed as (Neely and Sarno, 2002):

\[ e_i = (m_i - m_i^0) - \beta (y_i^0 - y_i^0) + \beta (y_i - y_i^0) + \mu_i, \]

(1)

To ensure the assumption of purchasing power parity (PPP) holding continuously in the long run, Equation (1) is rewritten as:

\[ e_i = \beta (m_i - m_i^0) - \beta (y_i^0 - y_i) + \beta (y_i - y_i^0) + \mu_i, \]

(2)

The CEIC data represents the data compiled by the Euromoney Institutional Investor Company.
where $w_t$ is the M2 money supply, $y_t$ designates real GDP, and $i_t$ denotes MMR. For $w_t$, Model 1 employs the simple sum M2 monetary aggregate, whereas Model 2 utilises the Divisia M2 monetary aggregate. The nominal exchange rate is indexed by $r_t$. The asterisks represents the corresponding variables for the foreign country, which is US.

The long-run relationship between the variables is examined by using the restricted ARDL model of Equation (2), which is formulated in the following equation:

$$
\Delta c_t = \gamma_{10} + \sum_{i=1}^{P} \gamma_{1i} \Delta w_{t-i} + \sum_{i=0}^{Q} \gamma_{3i} \Delta y_{t-i} + \sum_{i=0}^{Q} \gamma_{4i} \Delta d_{t-i} + \sum_{i=0}^{Q} \gamma_{5i} \Delta r_{t-i} + \mu_t,
$$

(3)

where $\Delta$ depicts the first difference operator, $\gamma_{10}$ stands for the drift component and $\mu_t$ designates the residual of white noise. $\Delta w_{t-i}$, $\Delta y_{t-i}$ and $\Delta r_{t-i}$ exemplify the money supply differential, the real income differential and the relative short-term interest rate, respectively.

The estimated integration model of Equation (3) is used to generate the lagged correction term $(EC_{t-1})$ in the error-correction model as follows:

$$
\Delta c_t = \gamma_{10} + \sum_{i=1}^{P} \gamma_{1i} \Delta w_{t-i} + \sum_{i=0}^{Q} \gamma_{3i} \Delta y_{t-i} + \sum_{i=0}^{Q} \gamma_{4i} \Delta d_{t-i} + \sum_{i=0}^{Q} \gamma_{5i} \Delta r_{t-i} + \phi EC_{t-1} + \mu_t,
$$

(4)

where the speed of adjustment to correct the disequilibrium in the short run to attain long-run equilibrium is evaluated by using a parameter of $\phi$. The value of $\phi$ falls in the range from -1 to 0. If a statistically significant $EC_{t-1}$ is found, a long-run causality running from the explanatory variables towards the dependent variable prevails.

### 3. Empirical Findings

As the ARDL approach permits the variables under estimation to have different orders of integration, unit root testing is not compulsory for the estimation of the ARDL approach. Nevertheless, a unit root test is conducted to verify the variables are not in I(2), which can affect the validity of the computed $F$-statistics provided by Pesaran et al. (2001) and Narayan (2005) (Akmal, 2007). The Augmented Dickey-Fuller test and the Phillips-Perron test were performed in this study and there was no I(2) variable detected. Therefore, the ARDL approach is eligible for estimation.

The preliminary findings of the long-run relationship were identified using the bounds test. At this stage, the $F$-statistic is used to identify the presence of cointegration between the exchange rate and the monetary fundamentals. The results of the bounds test are presented in Table 2. The $F$-statistic values for Models 1 and 2 are 3.3183 and 3.6582, respectively. These values are smaller than those by Pesaran et al. (2001) and Narayan (2005) with critical values at the 5 percent significance level, indicating a long-run relationship between the variables does not exist.

However, a better way to ascertain cointegration is through the error correction term (EC), in which the EC must be significant and the sign of the coefficient of the EC must be negative (Kremers et al., 1992). Consequently, the error correction model is used to reconfirm the presence of a long-run relationship between the variables. The estimates of the short-run coefficients are presented together with the lagged EC ($EC_{t-1}$) in Table 3. The lagged ECs for Models 1 and 2 are statistically significant at the 5 percent level. All the lagged ECs also possess negative signs of coefficients. Accordingly, we conclude that cointegration relationships exist among the variables in each model. The estimated coefficient of the EC for Model 1 is -0.03. This value indicates that about 3% of the previous period disequilibrium in Model 1 is corrected in the current period. The speed of adjustment of Model 2 is relatively faster than Model 1 with a value of -0.04. Thus, about 4% of the disequilibrium in the previous quarter is corrected in the current quarter. The results of the diagnostic tests are also presented in Table 3. Both models passed all the diagnostic tests. In addition, both models were also stable when CUSUM and CUSUMSQ were applied.

### ARDL estimates and model diagnostic tests results

#### Model 1 (5,1,5,0) ARDL Estimates

| Regressors | Coefficients | t-statistics | Regressors | Coefficients | t-statistics |
|------------|--------------|-------------|------------|--------------|-------------|
| $\Delta C$ | Constant | 0.0271 | 0.6579 | Constant | -0.0397 | -0.3635 |
| $\Delta C$ | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC$ | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC_{t-1}$ | -0.1566*** | -2.1980 | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC_{t-2}$ | -0.3020*** | -4.0433 | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC_{t-3}$ | -0.2601*** | -3.3210 | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC_{t-4}$ | 0.4724*** | 5.8104 | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC_{t-5}$ | -0.1945*** | -2.7785 | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC_{t-6}$ | -0.2050*** | -3.0248 | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC_{t-7}$ | -0.2439*** | -3.6045 | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC_{t-8}$ | 0.5184*** | 8.0182 | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC_{t-9}$ | -0.0013*** | -1.7686 | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC_{t-10}$ | -0.0299*** | -1.8632 | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
| $\Delta LEXC_{t-11}$ | -0.0040** | -1.0554 | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |

#### Panel (2): Diagnostic Tests for ARDL Estimation Results

| Serial Correlation | 3.8492 [0.427] | Serial Correlation | 2.6441 [0.619] |
| Functional Form | 0.0708 [0.930] | Functional Form | 0.0350 [0.844] |
| Normality | 0.4782 [0.787] | Normality | 2.4973 [0.267] |
| Heteroskedasticity | 1.4654 [0.226] | Heteroskedasticity | 1.2885 [0.256] |
| CUSUM of Squares | Stable | CUSUM of Squares | Stable |
| CUSUM of Squares | Stable | CUSUM of Squares | Stable |
| CUSUM of Squares | Stable | CUSUM of Squares | Stable |
| CUSUM of Squares | Stable | CUSUM of Squares | Stable |

Notes: The Regressor is LEXC. Asterisks (**), (*) indicate null hypotheses and are rejected at the 1%, 5% and 10% significance levels, respectively. Serial Correlation denotes the Lagrange Multiplier (LM) test of residual serial correlation while the Functional Form designates Ramsey’s RESET test utilizing the square of fitted values. The Normality test is based on skewness and kurtosis of residuals tests. The Heteroskedasticity test is based on the regression of squared residuals on squared fitted values. The figures in (...) and […] represent the lag length selection based on SBC criteria and probabilities, respectively.

Source: Compiled by the authors
Since long-run relationships exist in the monetary models, the estimation of the parameters was carried on. The results of the estimated long-run coefficients are presented in Table 4. The results of Model 1 show that LDRGDP is statistically significant at the 1 percent level. On the other hand, LDSM2 and DMMR are insignificant although the estimated sign of the coefficient is correct. For Model 2, LDRGDP is statistically significant at the 1 percent level. LDSM2 is statistically significant at the 5 percent level and DMMR is statistically significant at the 10 percent level.

When comparing Models 1 and 2, all of the exchange rate determinants in Model 2 are significant. Therefore, Model 2 can be used to explain the exchange rate movement in the Philippines. The superior performance of Divisia money is consistent with the findings of Lee et al. (2009). The monetary model of exchange rate is expressed as:

\[ e_t = -0.9623 + 0.2563(m_t - m_{t-1}) - 0.7987(y_t - y_{t-1}) - 0.0544(r_t - r_{t-1}). \]  

(5)

Based on Equation (5), the signs of the coefficients for the monetary stability differential and the real income differential are consistent with a priori theory of the monetary model of exchange rate. If the local money supply is relatively higher than its foreign counterpart, the local currency will depreciate. Thus, the money supply differential is positively related to the exchange rate. A one percent increase in the relative money supply can lead to a 0.2563 percent depreciation of the exchange rate. The negative sign and the size of the coefficient for the real income differential signify that a one-percent increase in relative real income can lead to the appreciation of the exchange rate by 0.7987 percent. When relative real income rises, there is an excess demand for local money supply. Local residents tend to reduce their expenditure in order to increase real money balances and subsequently prices will be reduced until money market equilibrium is achieved. Then, local currency appreciates.

Expenditure and prices will increase and therefore domestic currency depreciates. The negative sign of the relative interest rate is inconsistent with a priori theory of a flexible-price monetary model and designates that the prices are sticky in the short run. A one-percent increase in the relative short-term interest rate, the exchange rate will appreciate by 0.0544 percent. When the money supply falls, the short-term interest rate rises as prices are sticky. The sensitivity of the interest rate\(^4\) justifies the usefulness of Divisia monetary aggregates in the Philippines since the alterations of asset holdings are reflected in Divisia monetary via the opportunity costs.

Due to the existence of the sticky-price effect via the relative short-term interest rate, Model 2 can be considered as a sticky-price monetary model although the flexible-price monetary model was initially proposed. Therefore, the sticky-price monetary model that applied the Divisia monetary aggregate emerged as the most parsimonious model used to explain exchange rate movements in the Philippines.

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\(^4\) Capital inflows such as short- and long-term credits as well as currency transactions are interest-sensitive bank flows in East Asia and are the main constituents of the capital inflows in the Philippines (Cavoli and Rajan, 2009).

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### Tab. 4: Estimated long-run coefficients

| Regressors | Coefficients | t-statistics | Regressors | Coefficients | t-statistics |
|-----------|--------------|--------------|-----------|--------------|--------------|
| Constant  | 0.9623       | 0.6177       | Constant  | 0.9623       | -0.9179      |
| LDSM2     | 0.1666       | 1.0536       | LDOM2     | 0.2563**     | 2.2490       |
| LDRGDP    | -0.7268***   | -3.0192      | LDRGDP    | -0.7987***   | -3.9771      |
| DMMR      | 0.1427       | 1.5740       | DMMR      | 0.0544       | -1.7562      |

Notes: The Regressor is LEXC. Asterisks (***) and (*) indicate null hypotheses and are rejected at the 1%, 5% and 10% significance levels. The figures in (...) represent the lag length selection based on SBC criteria.

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### Tab. 5: Philippines Granger Causality Test Results

|            | Model 1 |            | Model 2 |            |
|------------|---------|------------|---------|------------|
| Source: Compiled by the authors |

|                | Model 1 | Model 2 |
|----------------|---------|---------|
| F-statistics   | p-value | F-statistics | p-value |
| LDSM2          | 31.9143 | [0.006]** | LDDM2   | 1.7253 | [0.189] |
| LDRGDP         | 8.8722  | [0.003]** | LDRGDP  | 17.3465 | [0.000]** |
| DMMR           | 3.1279  | [0.077]*  | DMMR    | 0.0040  | [0.949] |

Notes: Asterisks (***) and (*) designate null hypotheses and are rejected at the 1%, 5% and 10% significant levels. The figures in [...] represent the probabilities.

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The direction of causality between the variables in the short run is carried out for Model 1 and Model 2 using the Granger causality test. The results of the Granger causality test are presented in Table 5. For Model 2, only LDRGDP exhibits an impact on the exchange rate in the short run. On the other hand, LDSM2, LDRGDP and DMMR do Granger cause LEXC in the short run in Model 1.

### 4. Conclusions

The long-run validity of the monetary exchange rate model indicates that monetary fundamentals can serve as important determinants for the exchange rate and can be used as stabilisation tools for the exchange rate by the monetary authorities of the Philippines. Also, market participants can use these macro-economic variables to monitor the exchange rate movement.

Besides, as the exchange rate is linked to the monetary fundamentals, in the long run, the authorities may consider the use of monetary fundamentals to determine exchange rate movements for monitoring inflation targeting. Through the exchange rate channel, the exchange rate is used to affect the weighted domestic oil price and the average peso price of non-oil imports, in which these prices possess positive effects on the inflation rate (Guinigundo, 2008).

The positive sign of the money supply differential for the Philippines designates that the domestic currency will depreciate if there is a rise in domestic money supply relative to its US counterpart. To strengthen the domestic currency, monetary contraction should be implemented for the Philippines.

The Divisia monetary aggregates that emerged during the era of financial liberalisation and innovation outperformed the simple sum monetary aggregates in explaining the exchange rate for the Philippines. This is because the capital inflows in the Philippines were characterised by the interest-sensitive bank flows (Cavoli and Rajan, 2009). As a result, financial market participants who are interest-sensitive tend to hold higher return assets by substituting lower return assets with higher return assets. Divisia monetary aggregates that assign different weights for monetary assets based on the opportunity costs can better elucidate the characteristics of an interest-sensitive market and have become significant for the Philippines. Hence, authorities may wish to consider the use of Divisia monetary aggregates as an alternative money measure in approximating the exchange rate for the Philippines. The superiority of Divisia monetary aggregates also sheds light on the value of monetary targeting instead of other targeting tools for monetary policy in the Philippines.
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