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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
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Визначення валютного курсу за монетарною моделлю Divisia на прикладі Філіппін
Анотація. Низька ефективність є одним із невирішених питань, що стосуються монетарної моделі формування валютного курсу. Функція попиту на гроші, що не відзначається стабільністю, може позначатися на ефективності даної моделі. Однією з причин нестабільності функції попиту на гроші є використання простої монетарної сукупності при її оцінці. У зв'язку з цим при оцінці монетарної моделі формування валютного курсу можливе застосування монетарної моделі Divisia (Дівізія). Результати дослідження, проведеного авторами статті, вказують на існуючу коінтеграцію монетарних основ моделі Дівізія та обмінного курсу. На підставі цього був зроблений висновок, що для визначення валютного курсу для Філіппін може бути застосовано усереднений показник моделі Дівізія.
Ключові слова: Divisia; валютний курс; монетарна політика; усереднений показник моделі Дівізія.

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Определение валютного курса на основании монетарной модели Divisia на примере Филиппин
Аннотация. Низкая эффективность является одним из неразрешенных вопросов, касающихся монетарной модели формирования валютного курса. Не отличающаяся стабильностью функция спроса на деньги может сказываться на эффективности данной модели. Одной из причин нестабильности функции спроса на деньги является использование простой монетарной совокупности при его оценке. В связи с этим при оценке монетарной модели формирования валютного курса возможно применение монетарной модели Divisia (Дивизия). Результаты исследования, проведенного авторами статьи, указывают на существующую коинтеграцию монетарных основ модели Дивизия и обменного курса. На основании этого был сделан вывод относительно того, что для определения валютного курса для Филиппин может быть применен усредненный показатель модели Дивизия.
Ключевые слова: Divisia; валютный курс; монетарная политика; усредненный показатель модели Дивизия.

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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 deregulation 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 causality 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 emphasized in the study of monetary policy by Puah et al. (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 inflation 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[1] 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 Westerlund, 2009), the nonlinear approach (Liew, 2009), the cointegrated structural vector autoregressive (Loría, 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; Shakil 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.

Tab. 1: **Summary of variables and economic data**

Table Notation	Equation Notation	Variable	Description	Economic Data
EXC	*e*	Nominal exchange rate	US-based nominal exchange rate	Peso per US Dollar
DSM2	*dm*	Simple sum money supply differential	Difference of the Philippines money supply and US money supply	M2 for both the Philippines and the USA
DDM2	*dm*	Divisia money supply differential	Difference of the Philippines Divisia monetary aggregate and U.S. Divisia monetary aggregate	M2 Divisia monetary aggregates for both the Philippines and the USA
DRGDP	*dy*	Real income differential	Difference of the Philippines real income and US real income	Real GDP for both the Philippines and US. The real term is obtained by dividing GDP to consumer price index.
DMMR	*dr*	Relative short-term interest rate	Relative nominal interest rate	MMR for both the Philippines and the USA.

Source: Compiled by the authors

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[2] 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.

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

$$e_t = (m_t - m_t^*) - (by_t - b^* y_t^*) + (cr_t - c^* r_t^*) . \quad (1)$$

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

$$e_t = \beta_0 (m_t - m_t^*) - \beta_2 (y_t - y_t^*) + \beta_3 (r_t - r_t^*) + \mu_t . \quad (2)$$

[1] ASEAN stands for Association of Southeast Asian Nations, in which ASEAN-5 comprises Indonesia, Malaysia, Singapore, the Philippines and Thailand.

[2] The CEIC data represents the data compiled by the Euromoney Institutional Investor Company.

where m_t is the M2 money supply, y_t designates real GDP, and i_t denotes MMR. For m_t, Model 1 employs the simple sum M2 monetary aggregate, whereas Model 2 utilises the Divisia M2 monetary aggregate. The nominal exchange rate is indicated by e_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:

Tab. 2: **The Philippines bounds test for cointegration results**

Models		F-statistic [Lag Order]	
Model 1: LEXC, LDSM2, LDRGDP and DMMR		3.3183 [5]	
Model 2: LEXC, LDDM2, LDRGDP and DMMR		3.6582 [5]	
Critical values bounds of the F-statistic: unrestricted intercept and no trend (k=3)			
Significant Level	**Pesaran Critical Values**		**Narayan Critical Values**	
	$I(0)$	$I(1)$	$I(0)$	$I(1)$
90% level	2.72	3.77	2.823	3.885
95% level	3.23	4.35	3.363	4.515
99% level	4.29	5.61	4.568	5.960

Notes: Critical values are obtained from Pesaran et al. (2001), table Case III: unrestricted intercept and no trend as well as Narayan (2005), table Case III: unrestricted intercept and no trend. The lag length selection is based on the Schwartz Bayesian Criterion (SBC).

Source: Compiled by the authors

$$\Delta e_t = \gamma_{1,0} + \sum_{i=1}^{p} \gamma_{1,1i}\Delta e_{t-i} + \sum_{i=0}^{q_1} \gamma_{1,2i}\Delta dm_{t-i} + \sum_{i=0}^{q_2} \gamma_{1,3i}\Delta dy_{t-i} + \sum_{i=0}^{q_3} \gamma_{1,4i}\Delta dr_{t-i} + \theta_{1,1}e_{t-1} + \theta_{1,2}dm_{t-1} + \theta_{1,3}dy_{t-1} + \theta_{1,4}dr_{t-1} + \mu_{1t}, \quad (3)$$

where Δ depicts the first difference operator, γ_0 stands for the drift component and μ_t designates the residual of white noise. dm_{t-i}, dy_{t-i} and dr_{t-i} exemplify the money supply differential, the real income differential and the relative short-term interest rate, respectively.

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

$$\Delta e_t = \gamma_{1,0} + \sum_{i=1}^{p} \gamma_{1,1i}\Delta e_{t-i} + \sum_{i=0}^{q_1} \gamma_{1,2i}\Delta dm_{t-i} + \sum_{i=0}^{q_2} \gamma_{1,3i}\Delta dy_{t-i} + \sum_{i=0}^{q_3} \gamma_{1,4i}\Delta dr_{t-i} + \varphi_1 EC_{t-1} + \mu_{1t}, \quad (4)$$

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 φ . The value of φ 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[3]. 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 significant 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.

Tab. 3: **ARDL estimates and model diagnostic tests results**

Model 1 (5,1,5,0)			**Model 2 (5,0,5,1)**		
Panel (i): ARDL Estimates					
Regressors	**Coefficients**	**t-statistics**	**Regressors**	**Coefficients**	**t-statistics**
ΔConstant	0.0271	0.6579	ΔConstant	-0.0387	-0.8365
$\Delta LEXC_{t-1}$	-0.1566**	-2.1980	$\Delta LEXC_{t-1}$	-0.2512***	-3.1760
$\Delta LEXC_{t-2}$	-0.3020***	-4.0433	$\Delta LEXC_{t-2}$	-0.3636***	-4.3824
$\Delta LEXC_{t-3}$	-0.2691***	-3.3210	$\Delta LEXC_{t-3}$	-0.3576***	-3.8072
$\Delta LEXC_{t-4}$	0.4724***	5.8104	$\Delta LEXC_{t-4}$	0.4884***	5.2458
ΔLDSM2	-0.2476***	-5.6517	ΔLDDM2	0.0103	1.3135
ΔLDRGDP	-0.6745***	-13.0866	ΔLDRGDP	-0.8700***	-21.3546
$\Delta LDRGDP_{t-1}$	-0.1945***	-2.7785	$\Delta LDRGDP_{t-1}$	-0.3122***	-4.0247
$\Delta LDRGDP_{t-2}$	-0.2050***	-3.0248	$\Delta LDRGDP_{t-2}$	-0.2897***	-3.7824
$\Delta LDRGDP_{t-3}$	-0.2439***	-3.6045	$\Delta LDRGDP_{t-3}$	-0.3061***	-3.9305
$\Delta LDRGDP_{t-4}$	0.5184***	8.0182	$\Delta LDRGDP_{t-4}$	0.5215***	6.8518
ΔDMMR	-0.0013*	-1.7686	ΔDMMR	0.0001	0.0635
EC_{t-1}	-0.0299*	-1.8632	EC_{t-1}	-0.0402*	-1.8554
Panel (ii): Diagnostic Tests for ARDL Estimation Results					
Serial Correlation	3.8492 [0.427]		Serial Correlation	2.6441 [0.619]	
Functional Form	0.0078 [0.930]		Functional Form	0.0385[0.844]	
Normality	0.4784 [0.787]		Normality	2.4973 [0.287]	
Heteroskedasticity	1.4654 [0.226]		Heteroskedasticity	1.2885 [0.256]	
CUSUM	Stable		CUSUM	Stable	
CUSUM of Squares	Stable		CUSUM of Squares	Stable	

Notes: The Regressor is LEXC. Asterisks (***), (**) and (*) 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 designate Ramsey's RESET test utilising 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

[3] To conserve space, the unit root tests results are not presented here but can be made available upon request.

Since long-run relationships exist in the monetary models, the estimation of the long-run 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. LDDM2 is statistically significant at the 5 percent level and DMMR is statistically significant at the 10 percent level.

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

Model 1 (5,1,5,0)			Model 2 (5,0,5,1)		
Regressors	Coefficients	*t*-statistics	Regressors	Coefficients	*t*-statistics
Constant	0.9068	0.6177	Constant	-0.9623	-0.9178
LDSM2	0.1666	1.0536	LDDM2	0.2563**	2.2490
LDRGDP	-0.7268***	-3.0192	LDRGDP	-0.7987***	-3.9771
DMMR	-0.0427	-1.5740	DMMR	-0.0544*	-1.7502

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.

Source: Compiled by the authors

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:

$$e_t = -0.9623 + 0.2563(m_t - m_t^*) - 0.7987(y_t - y_t^*) - 0.0544(r_t - r_t^*). \quad (5)$$

Based on Equation (5), the signs of the coefficients for the money supply 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.

For the relative short-term interest rate, the increase in the domestic interest rate contributes to the reduction of demand for money as the inflation rate is expected to increase.

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 aggregate 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.

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 macroeconomic variables to monitor the exchange rate movement.

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

Dependent Variable: LEXC			
Model 1		Model 2	
	F-statistics [*p*-value]		F-statistics [*p*-value]
LDSM2	31.9413 [0.000]***	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.

Source: Compiled by the authors

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.

[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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